ORGANIZATIONAL CULTURE: A COMPARATIVE ANALYSIS FROM THE TURKISH CONSTRUCTION INDUSTRY

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ABSTRACT

With the worldwide globalization trends, studies of organizations and their organizational cultures have gained more importance. However, there remains a limited empirical understanding of organizational culture in the context of construction.

This study examines the cultural profile of organizations operating in Turkish Construction Industry. The data reported are from 107 contracting and 27 architectural firms. In the study, Cameron and Quinn's OCAI (Organizational Culture Assessment Instrument) was used to compare organizational cultures of the sampled firms. The findings show that the construction industry has been dominated by companies as clan and hierarchy type organizations. In addition, the analysis reported here indicates organizational culture differences in terms of firm type, size, and age.

Keywords: organizational culture, construction sector, Turkey

1. INTRODUCTION

Understanding of organizational culture is fundamental to understanding what goes on in organizations, how to run them and how to improve them (Schein, 1992). Organization culture is defined as the shared assumptions, beliefs and 'normal behaviors (norms) present in an organization. Most organizational scholars and observers recognize that organizational culture has a powerful effect on the performance and long-term effectiveness of organizations. Cameron and Quinn (1999) propose that what differentiates successful firms from others is their organizational culture.

With the worldwide globalization trends, special attention has been given to the study of organizations and their cultures. Empirical studies of organizational culture have been carried out across various countries and industries. Within the construction context, culture studies also have attracted interest. For instance, Maloney and Federle (1991, 1993) introduce the competing values framework for analyzing the cultural elements in American engineering and construction organizations. Zhang and Liu (2006), examine organizational culture profiles of construction enterprises in China. Ankrah and Langford (2005) highlight the cultural variability between organizations in the project coalition.

This paper aims to describe cultural profile of organizations by referring to results of a questionnaire study. The study was designed to analyze the current dominant culture types of organizations in the Turkish construction sector.

2. LITERATURE REVIEW

Despite different definitions of organizational culture, there is a general consensus among organizational researchers that it refers to the shared meanings or assumptions, beliefs and understandings held by a group. More comprehensively, Schein (1992) defined organizational culture as, "*a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration that has worked well enough to be considered valid and therefore to be taught to new members as the correct way to perceive, think and feel in relation to those problems.*" Similarly, Deshpandé and Webster (1989, p.4) proposed that organizational culture is "*the pattern of shared values and beliefs that help individuals understand organizational functioning and thus provide them with norms for behaviors in the organization.*" As identified by these definitions, the concept of organizational culture is concerned with the values, beliefs, assumptions, and norms that inform organizational processes and behaviors.

Many writers have proposed a variety of dimensions and attributes of organizational culture. Among them, Hofstede has been very influential in studies of organizational culture. Drawing on a large sample of 116,000 employees of IBM in 72 countries, Hofstede identified four dimensions of culture. These four dimensions used to differentiate between cultures are: power distance, uncertainty avoidance, masculinity/femininity and individualism/collectivism. Beyond these, Hofstede (1997) also identified the process/results oriented, employee/job oriented, parochial/professional, open/closed system, loose/tight control and normative/pragmatic dimensions of culture. These dimensions have seen adaptation and application in studies of organizational culture (Sødergaard, 1996)

Other comprehensive studies into organizational culture have been carried out, notably by Trompenaars and Hampton-Turner (1993) who conducted extensive research into the attitudes of 15,000 managers over a 10 year period in 28 different countries. They proposed five cultural dimensions: Universalism/ particularism; Collectivism/ individualism; Neutral/affective relationships; Diffuse/specific relationships; Achievement/ascription

When dealing with a multitude of dimensions, typologies are employed as an alternative to provide a simplified means of assessing cultures. In this regard, typologies have been developed to use in studies of organizational culture. Notable contributors to the use of typologies include Handy (1993, 1995) who identified the club, role, task and person typologies and Quinn (1988) who identified the market, hierarchy, adhocracy and clan typologies of culture.

Since the culture is regarded as a crucial factor in the long-term effectiveness of organizations, it becomes important to be able to measure organizational culture. In response to this issue, a range of tools designed to measure organizational culture have been developed and applied in industrial, educational, and health care settings over the last two decades. All of them examine employee perceptions and opinions about their working environment (the so-called "climate" of an organization) but only a few, such as the Competing Values Framework and the Organizational Culture Inventory, try to examine the values and beliefs that inform those views (Scott, 2003).

In this study, the Competing Values Framework (CVF) was selected to assess organizational culture. The CVF is based on two major dimensions. The first dimension emphasizes the organizational focus (internal versus external), whereas the second one distinguishes between the stability and control and the flexibility and discretion. These two dimensions create four quadrants, each representing a major type of organizational culture (see Figure 1). The cultural values represented in the four quadrants have existed in the literature (see Cameron and Quinn, 1999 for detailed information).

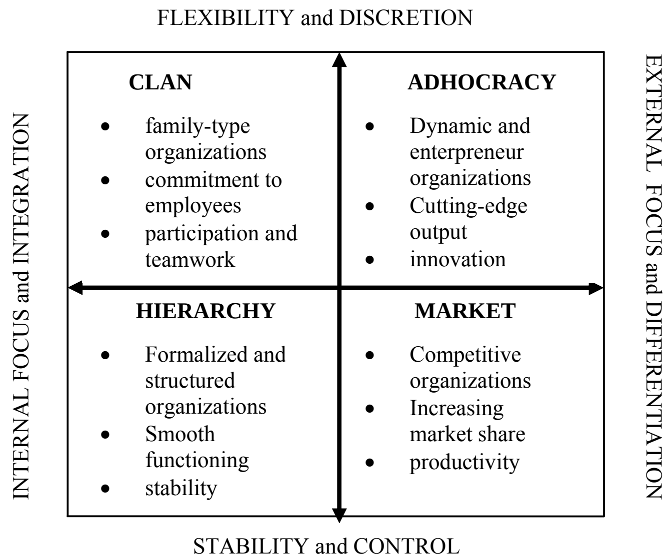

Figure 1. The Competing Values Framework (Cameron and Quinn, 1999)

3. RESEARCH METHODOLOGY

In this study, Quinn's OCAI (Organizational Culture Assessment Instrument) was used to diagnose organizational culture of contracting and architectural firms operating in the Turkish Construction Sector. A number of 351 firms were contacted, and only 134 of them participated in the study giving a response rate of 38.18.

Sample

Table 1 shows the characteristics of the sample in the study. For the purpose of this study, companies having fewer than 50 employees were classified as small, those with 51-150 as medium and those with more than 150 as large. 46 per cent of the respondent companies could, therefore, be classified as small, 25 per cent as large and 28 per cent as medium. The contracting firms in the survey were generally medium and large-sized whereas the architectural practices were small in size.

Table 1. Characteristics of Sample

Characteristics of Sample	Frequency	Percentage
Number of Firms		
Contracting	107	79.9
Architectural	27	20.1
Total	134	100.0
Number of respondents		
Contracting	723	87.5
Architectural	103	12.5
Total	826	100.0
Gender		
Female	207	25.1
Male	619	74.9
Total	826	100.0
Age of respondents (years)		
30 & under	220	26.6
31-40	292	35.4
41-50	199	24.1
51& above	109	13.2
Missing	6	0.7
Total	826	100.0

Construction of the questionnaire

The questionnaire comprised two parts. Part I contained questions regarding personal characteristics of all respondents. Part II was adopted from the "Organizational Culture Assessment Instrument (OCAI)" developed by Cameron and Quinn (1999). The OCAI is based on a theoretical model titled the "Competing Values Framework". The "Competing Values framework is based on six organizational culture dimensions (dominant characteristics, organizational leadership, management of employees, organizational glue, strategic emphases, and criteria of success) and four dominant culture types (clan, adhocracy, market, and hierarchy). The OCAI was chosen because it has been tested and proved to be most valid and reliable in measuring organizational culture.

Responses were scored on a 5-point Likert scale. In this scoring system, for each of the five response categories (completely true, mostly true, partly true, slightly true, never true) a score of 1-5 was assigned, with the highest score of 5 being assigned to 'completely true'.

Reliability coefficients (Cronbach alpha) were calculated for each of the different culture types being assessed by the instrument. Coefficients were .89 for the clan and adhocracy cultures, and .86 for the market and hierarchy cultures.

4. RESULTS AND DISCUSSION

A cultural profile score for each organization was obtained by averaging the respondent's rating for each cultural type across the six dimensions. This provided an indication of the cultural orientation of sampled firms based on the four cultural types. The average scores for all the participating companies are shown in Table 2. As is seen from the table, the dominant culture of the sample is Clan culture. Respondents identified Hierarchy type as the next most dominant in their organizations. These predominant two cultures were followed by Adhocracy and Market, respectively.

Table 2. Mean Scores on the Organizational Culture Dimensions for the sample

Dimension	Clan	Adhocracy	Market	Hierarchy
Dominant characteristics	3.61	3.19	3.58	3.04
Organizational Leadership	3.39	3.38	2.86	3.84
Management of Employees	3.84	3.13	3.17	3.66
Organization Glue	3.83	3.69	3.09	3.25
Strategic Emphases	3.53	3.75	3.64	3.90
Criteria of Success	3.66	3.52	3.36	4.04
	Average of the six dimensions			
Cultural profile of the sample	3.64	3.44	3.28	3.62

Scale: 1=strongly disagree, 2= disagree, 3=neutral, 4=agree, 5= strongly agree.

Figure 2 shows a graphical presentation of the mean scores in each of the four culture types for the sample using the competing values framework axis and quadrants. As is seen from the figure, the sampled firms tend to have values consistent with employee focus or clan culture and internal process or hierarchy culture. The values consistent with external orientation and results focus are emphasized to a lesser extent.

This finding contributes to our understanding of the alignment between national and organizational cultures. According to Hofstede's (1980, 2001) model of national culture, Turkey has been described as being high on the collectivism and power distance value dimensions. This suggests that organizational cultures in Turkish firms are characterized by both unequal (or hierarchical) and harmonious, family-like (clan) relationships. The finding is also consistent with the earlier observations of the Turkish society. Trompenaars and Hampden (1998) found Turkey to have the steepest hierarchy in its organizations. Turkish organizations are also described to be of the family-type (Trompenaars & Hampton-Turner, 1998). Another explanation of this finding is that the nature of state-business relations in Turkey appears to be a key factor which shapes organizational culture of the firms in the construction industry.

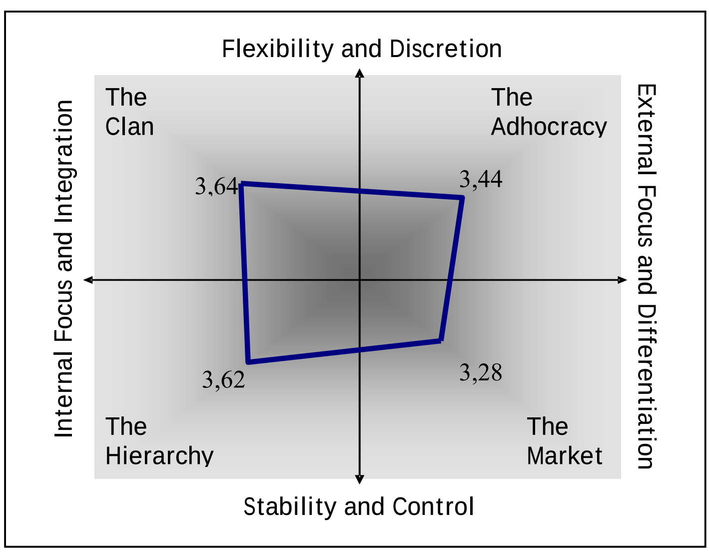

Figure 2. The Overall Cultural Profile of the Construction Industry

Independent sample t-tests were conducted on the overall scores for each of the four culture types to compare architectural and contracting firms. Items were randomly pulled from the larger group in order to have equal sample sizes. The results, which are presented in Table 3, revealed a significant difference for the market culture type between contracting and architectural firms. This type is more dominant in the contracting firms than in the architectural practices ($t=3.849$, $p<0.0001$). This may be attributed to the characteristics of the contracting firms operating in more uncertain and unpredictable markets and environments, where market cultures are essential for survival.

Table 3. Cultural profile scores for firm type, size, and age

		Culture Types			
	n	Clan	Adhocracy	Market	Hierarchy
Firm type					
Architectural	27	3,75	3,39	2,93	3,47
Contracting	32	3.62	3.46	3.37	3.66
t-value		*-1.193*	*0.590*	*3.849****	*1.671*
Firm Size					
Small	62	3.72	3.48	3.25	3.65
Medium	38	3.80	3.55	3.41	3.82
Large	34	3.33	3.25	3.19	3.35
F-value		9.201***	3.507*	1.592	7.553**
Firm Age					
≤15	45	3.62	3.45	3.37	3.60
16 - 25	46	3.87	3.69	3.42	3.86
>25	39	3.47	3.21	3.06	3.44
F-value		6.919**	9.233***	3.172	5.505*

* $p< 0.01$ **$p<0.001$ ***$p<0.0001$

Analysis of variance (ANOVA) test was performed to examine organizational culture differences by firm size and age of the firm. A post hoc Scheffé test was used to identify significant differences among subgroups. Three of the ANOVA results for firm size were significant. Scheffé test, at a significance of $p< 0.05$ level, revealed that the mean scores for large firms for clan and hierarchy cultures were significantly lower than those of small and medium-sized firms. This finding failed to support Cameron and Quinn (1999), who related the internal process model to large organizational size, and were inconsistent with many scholars who reported that larger organizations are characterized by numerous hierarchical levels, standardized procedures, increased specialization, limited flexibility and bureaucratic control (Child, 1974; Keats & Hitt, 1988; Lawler, 1997; Mintzberg, 1979). Analysis of Variance was also significant for adhocracy or open systems model. The difference was between medium and large sized firms.

Significant group differences were also found in terms of organizational age. Scheffé tests, at a significance of $p< 0.05$ level, indicated that organizations in operation between 16 and 25 years scored significantly higher on clan, adhocracy, and hierarchy cultures than older ones. This finding was inconsistent with organizational life cycle theories in which it is proposed that more hierarchical and bureaucratic structures evolve as organizations grow and age (Greiner, 1998; Kriesi, 1996).

The preceding findings may imply that organizational cultures are shaped not only by contextual factors, but also by cultural profile of organizational members. Thus, further research is needed to determine the generalizability of this study's findings.

A k-means cluster analysis was used for combining sampled firms into clusters (groups) that describe cultural configurations of firms with similar cultural characteristics. In order to determine the appropriate number of groups, a hierarchy cluster analysis was first conducted, using Ward's method and squared Euclidean distance as a distance measurement. Results from the hierarchy cluster analysis showed that there are three underlying patterns of cultural types among sampled firms. This number was then used as seed points for the non-hierarchical k-means analysis. Table 4 presents the characteristics of each of the groups obtained, using the culture types. Firms of the first cluster obtained low scores on market, and moderate scores in the others. 45 organizations are characterized with cluster I. Cluster II comprised organizations with low scores for the four culture types. 25 organizations belong to this group. Cluster III contained the largest sample, with 64 organizations. In this group, there was a high emphasis on hierarchy and clan cultures and to a lesser extent adhocracy and market cultures.

Table 4. Description of the three cultural clusters

	Cultural clusters			
Cultural types	Cluster I (n=45)	Cluster II (n=25)	Cluster III (n=64)	F-value
Clan	3.62	2.83	3.98	108.508***
Adhocracy	3.21	2.76	3.87	167.741***
Market	2.92	2.79	3.73	102.916***
Hierarchy	3.47	2.82	4.04	182.701***

n= number of samples, ***p<0.0001

A close look at the data shows that there are similarities between the clusters. It is interesting to note that the firms in the three clusters had higher scores for clan and hierarchy culture types when compared to market and adhocracy types. This finding is inconsistent with the assumptions of Dasmalchian et.al (2000) that environmental unpredictability has a positive effect on market culture and a negative one on the clan culture. Dasmalchian et.al suggest that organizations operating in more unpredictable and uncertain markets are more likely to develop a value system that emphasizes results orientation and market focus, and de-emphasizes the culture of hierarchy and bureaucracy.

5. CONCLUSION

This paper presents the findings of a questionnaire survey conducted among organizations in the construction sector with the view of establishing their current cultural profiles. However, the conclusion of the study is limited to the sample studied. All companies are Turkey-based companies and therefore reflect the bias of the national culture.

The results reported in this paper indicated that most of the sampled organizations in the Turkish construction industry tended to have a mix of clan and hierarchical cultures, which did not match the demands of their competitive environments. What the data tell us is that companies within the two sub-sectors emphasized stability and teamwork instead of maintaining productivity and innovation. Yet, they may find it difficult to survive in a fiercely competitive industry such as construction due to a mismatch between their culture and environment.

The study of organizational culture in the construction industry is still in a fledgling stage. We believe that studies of this sort will serve not only to enhance our understanding of organizational culture in the construction industry, but will ultimately point toward several issues that need to be investigated in future research.

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INNOVATION PROCESSES IN CONSTRUCTION: TWO CASE STUDIES

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ABSTRACT

The importance of innovation in construction is increasing. However, until now construction research has mainly focused on the implementation of new ideas and disregarded the interdependencies to previous phases of the innovation process. This paper presents the results of two case studies concerning the whole process of generating, developing and implementing new technologies in construction. The cases revealed institutional leadership and managing part-whole relationships as main problems that prevent a faster introduction of innovative technologies into construction. The paper concludes that fostering innovation in construction requires the early integration of application knowledge into the technology development process and the timely creation of a supportive institutional context.

Keywords innovation process, integration, supportive context

1. INTRODUCTION

Innovation is becoming more and more a key competence in the competitive environment of construction. Several studies have already focused on the barriers to and enablers of innovation in construction firms and projects (Tatum, 1987; Slaughter, 2000; Ling, 2003; Bossink, 2004; Blayse and Manley, 2004). However, most of these studies only address the implementation of new ideas and the management of the implementation process. There is a lack of viewing the innovation process in its totality, i.e., from recognition of new opportunities until the successful use of a new solution in practice. The emphasis on the implementation phase disregards the interdependencies between the different stages of innovation processes. The importance of addressing the whole innovation process has long been recognized in the general literature (Leonard-Barton, 1995; Van de Ven, 1986; Von Hippel, 1988). Therefore, we argue that for an increased innovation rate in construction, a process view is necessary that incorporates the generation, development and implementation of new ideas. We will use the four central problems in managing innovation as described by Van de Ven (1986) to analyze two cases of technology development processes in construction and, thereby, to reinforce our argument. In the following, we first outline these four problems. Then, we describe the innovation processes of the two cases and discuss them with regard to the ideas of Van de Ven. Finally, we summarize our main findings.

2. PROBLEMS RELATED TO THE MANAGEMENT OF INNOVATION

Van de Ven (1986) defines the process of innovation as "the development and implementation of new ideas by people who over time engage in transactions with others within an institutional context" (1986:591). Within this process, Van de Ven recognizes four central problems in the management of innovation: *drawing attention to new needs and opportunities*, *managing ideas into good currency*, *managing relationships*, and *institutional leadership*. These four areas of attention will be discussed in the following subsections.

Managing attention

Managing attention concerns the commonness of existing practices. For successful development and implementation of innovative ideas, people should pay attention to changing environmental conditions and customer needs. "Well-managed companies are not only close to their customers, they search out and focus on their most demanding customers" (Van de Ven, 1986:596). In technology development processes, successful implementation depends on the way the innovation deals with problem sources. Creating an understanding of these problem sources involves knowledge of the environment in which the innovation will be used and of the interaction with its environment (Leonard-Barton, 1995). Gathering this information and knowledge is a conscious effort, and managers need to trigger people to pay attention to shifts in the environment and identify "applications for which users have a need but for which they would be incapable of imagining a solution" (1995:198).

In construction, managing attention seems underdeveloped, as incentive structures are missing that favor innovation (Winch, 1998). Firms are accustomed to working according to specifications and are rarely rewarded for taking on risks with innovative ideas. In recent years new procurement forms have been introduced which ask firms to provide services associated with the goods they plan and construct (Ivory et al., 2003; Gann and Salter, 2000). These new forms of delivering construction projects are seen to offer a business environment that encourages innovation. However, we believe that a prerequisite to capitalizing on these opportunities is paying much more attention to the client needs in the early phases of construction processes as well as developing a sense for cross-project trends and demands.

Managing ideas into good currency

'Managing ideas into good currency' is to make sure that the ideas are implemented and institutionalized. This area of attention must be considered as a collective achievement in which different groups try to gain influence, power and resources to develop the idea, and consequently, the idea gains the legitimacy and power to change/challenge existing practices (Van de Ven, 1986). Within this collective achievement, internal and external stakeholders and sources are mobilized (Zahra and Nielsen, 2002). Integration of these diverse sources within the development process is necessary for successful implementation and commercialization of technology (Zahra and Nielsen, 2002).

In construction, professional clients and suppliers often play a major role in innovation processes (Pries and Janszen, 1995; Gann and Salter, 2000). This complicates the legitimization of ideas, as clients and suppliers often possess important knowledge and skills that are needed in the process. Furthermore, clients and suppliers will be more receptive to a change in practices if they are involved in the innovation process (Leonard-

Barton, 1995). Therefore, attention should not only be paid to the needs of the client. Considerable client and supplier involvement seem to be important factors in technology development and implementation in construction.

Managing part-whole relationships

In the process of managing an idea into good currency, the involvement of diverse specialists and partners leads to a proliferation into multiple transactions or relationships (Van de Ven, 1986). Managing these part-whole relationships is necessary to enable the integration of the divided tasks and interdependent relations among specialists and partners. Leonard-Barton (1995) offers several strategies for managing specialization in order to integrate diverse knowledge sets. Joint technology development has several benefits in terms of pooling complementary capabilities and accessing new markets and technologies (Powell, Koput and Smith-Doerr, 1996). However, there are several drawbacks to external sources of knowledge and skills. There is a potential loss of proprietary knowledge; partner firms might free ride or use joint activities to acquire skills of others (Siriram and Snaddon, 2004). Knowledge creation and technology development also require considerable learning by doing, which requires time and resources of the partners (Zahra and Nielsen, 2002).

In construction, the drawbacks mentioned seem to be important issues in technology development and implementation, as construction processes appear to be temporary coalitions of changing parties. This can severely impede the development of new ideas requiring large investments and, thus, a longer payback period. Furthermore, firms often only form project-based cooperation with a lack of actors brokering new ideas so “that those that improve the parts and complement the whole go forward and those that favor subsystem optimization at the cost of whole system suboptimization are quashed” (Winch, 1998:275). As a result, the implementation of system changing ideas is hampered.

Institutional leadership

Implementing and institutionalizing innovation is not an individual activity. “Instead, it is a network-building effort that aims for the creation, adoption, and sustained implementation of a set of ideas among people who, through transactions, become sufficiently committed to these ideas to transform them into “good currency.”(Van de Ven, 1986:601) Institutional leadership is concerned with the creation of a context, both intra- and inter-organizational, in which innovation can prosper. This context includes laws, government regulations, distributions of knowledge and resources, and the structure of industry in which the innovation is located.

Nam and Tatum (1997) have identified the client as main institutional leader in fostering the implementation of construction innovation. Ling (2003) has shown the importance of senior management involvement in creating a climate supportive of implementing innovation in construction projects. However, Keegan and Rodney Turner (2002) have pointed out that construction and engineering firms have a low desire for innovations. The traditional methods of project management seem to stifle efforts in developing and implementing construction innovation. In addition, regulatory and procurement policies have a strong influence on the direction of innovation processes in construction (Gann and Salter, 2000). Detailed contractual agreements and undifferentiated usage of regulations constrain a firm’s possibilities of finding new solutions.

The literature review seems to indicate several problems in the management of technology development and implementation in construction. In the following, we describe and discuss two case studies of innovation processes in construction in terms of the four problems identified by Van de Ven.

3. THE DEVELOPMENT OF A THERMAL CONVERSION UNIT TO REMOVE COAL TAR FROM RECYCLED ASPHALT

Case description

In 1992, the use of coal tar in new road constructions was prohibited, because coal tar has a high degree of polycyclic aromatic hydrocarbons. The use of recycled coal tar containing material was still permitted, although this was a temporary situation. In anticipation of a future prohibition of the use of all coal tar containing material, four road construction firms (Alliance) developed a technology in the mid-1990s to remove coal tar from recycled asphalt. The development started as a promising opportunity because there were no competing technologies or competitors and government agencies were committed. However, the technology never delivered. The aim of the case study is to determine the factors leading to this failure. The case study is based on semi-structured interviews and document analysis. Key managers in the technology development project were interviewed, and historical documents (reports, professional papers) were analyzed. The interview protocols evolved from open to semi-structured. The questions relate to the individual's version of how this technology development process evolved. Probing questions were asked to establish why decisions were made and what – in hindsight – could have been done better

The technology is derived from a combustion process used for the processing of minerals, food, and chemicals. Initial tests took place in early 1998 on a small-scale thermal conversion unit (TCU). Based on these test results, Alliance decided to build a full-scale TCU. This full-scale TCU would be built on an existing asphalt production plant, in which the TCU could support the furnace of the asphalt production plant. This had several advantages:

- Efficient use of energy, enabling a substantial reduction in fuel consumption
- Re-use of cleaned material as aggregate in new asphalt
- Combined use of existing facilities, such as filter installation for flue gases, personnel, and equipment

Before the construction of the test facility commenced in 1999, Alliance convinced the Ministry of Spatial Planning, Housing and the Environment (SPHE) and Directorate-General for Public Works and Water Management (DG) of the feasibility of the TCU. The SPHE agreed on a prohibition of the use of coal tar containing asphalt by January 1, 2001. The DG would supply a sufficient amount of coal tar containing asphalt, if the processing costs were acceptable. A small engineering firm, licensee of the combustion process, did the design, engineering and construction of the TCU. A project group of innovation managers of Alliance managed this engineering firm. In addition, a group of asphalt production managers from Alliance assisted the engineering firm in the integration of the TCU and asphalt production plant for the pilot runs, which started in late 2000 and continued to 2004. In this period, there were recurring problems in the transfer of the coal tar containing material through the TCU, because of design flaws.

Furthermore, the discontinuous nature of asphalt production limited the optimal use of the TCU.

Case discussion

The first case describes the development of a technology to deal with an environmental problem, coal tar. The TCU, which is a technology that leaves only clean asphalt minerals, is a technically sound idea. However, a sound technology is not enough to bring it into operational acceptance and general deployment. This case illustrates the importance of institutional leadership. Institutional leadership involves inter- and extra-organizational contexts. Both of these contexts were managed poorly. Alliance did not secure a sufficient amount of support "from its larger community" (Van de Ven, 1986:601). The SPHE did not provide enough safeguards to prevent inexpensive alternatives. For example, the SPHE allowed temporary storage of coal tar containing material without demanding a bank guarantee. This resulted in low rates for the cleansing of coal tar containing material and influenced the feasibility of the TCU. Moreover, since competing technologies emerged during 2001, the SPHE had no need to provide additional guarantees and safeguards to stimulate the development of technologies. Alliance itself also failed in providing a supportive intra-organizational context. They did not develop clear joint goals, strategies and procedures and failed to become a "vehicle of group integrity" (Van de Ven, 1986:601). This is illustrated by increasing internal conflict among the four road contractors and accusations towards the supplier of the TCU about the technical problems. Furthermore, the personnel of the asphalt plant was not convinced of the added value of the TCU, and some of them saw the TCU as an intrusion. Their primary concern was to produce asphalt. Van den Ven recognizes that "top management's critical contribution consists in strategic recognition rather than planning" (1986:603). In this case senior management failed to provide strategic recognition.

This lack of shared vision and commitment was not a problem in the early development stages when there were no competing technologies and Alliance thought the SPHE was willing to protect their market. In 2001 the development of the TCU became increasingly problematic and competing technologies arose. The absence of a shared vision and commitment started to show. Two of the road contractors pulled back their share in Alliance and were unwilling to invest more resources. The absence of a supportive culture with shared values and rituals seriously limited the ability of Alliance to "transform the structure and practices" of their environment (Van de Ven, 1986:605).

4. THE DEVELOPMENT OF A SPRAYABLE WATERPROOFING MEMBRANE FOR TUNNELING

Case description

The second case concerns an innovation process which aimed to overcome the disadvantages of conventional sealings in tunneling such as leakiness, complicated corrections of imperfections and intricate applications. This could be attained by developing a sprayable, elastic membrane which connects the inner and outer shells of the tunnel and, thereby, creates a bonded system. That is, the membrane changes the constructive relations of the inner and outer shells. Single-shell constructions are possible with significant savings of material. Moreover, since the membrane is sprayable, automatic application of it becomes possible, which may improve the efficiency of the construction process. However, the product entry on the market was two years behind the schedule. The case study aimed at determining the influences that lead to this delay. The innovation process took place within a Swiss supplier of construction material. Interviews were conducted with the head of the R&D department, the project manager and the marketing manager. The different views of these persons on the course of the project revealed the main problems and factors responsible for the delay. Documents (product specifications and project reports) were analyzed to support the findings from the interviews. With the help of group discussions at the beginning and the end of the research involving the interviewed persons, individual experiences were reconstructed and validated.

The innovation process can be described as a typical R&D process including three phases. Basic research represented the first phase. Through experimental and theoretical work, new knowledge about sealings was gained without any orientation towards a specific application. That is, a first product profile was built up which fulfilled the requirements of tunneling only partly. The second phase covered applied research. Here, tunneling as the field of application was defined. Requirements on the product resulting from this choice could be defined. With the help of laboratory tests, it was examined whether the product met these requirements. The third phase comprised the development of a marketable product. Here, the product was tested under real conditions during ongoing tunnel constructions. These field tests provided further requirements necessary to ensure the applicability of the membrane. However, in the transition from basic to applied research, crucial effects of the product on the tunnel structure and the construction process were neglected, and a very incomplete product profile was generated. This partial product profile in turn caused field and lab tests with a poorly conceived product. As a result, the product composition changed several times, product features already tested had to be verified again, and trade-offs between product features occurred. Consequently, important product requirements could only be recognized during the tests, which led to numerous product modifications and knowledge gaps regarding the verification of product characteristics. Additional and unscheduled development work was the result, accompanied by irritated internal and external customers confronted with a continually changing product. Finally, this need of additional resources could be met only insufficiently, which caused a two-year delay.

Case discussion

The development process described above revealed that the management of part-whole relationships was the main problem causing the significant delay.

The idea of a sprayable waterproofing membrane for tunneling not only changed the existing way of protecting the tunnel against water, but also altered the way of constructing the tunnel. That is, the initial idea led to a complex set of interdependent requirements that had to be fulfilled to develop and implement the innovation successfully. These requirements concerned, on the one hand, the membrane itself and, on the other hand, the whole tunnel construction and the construction process. For example, at the beginning it was thought that the membrane need not be fire resistant, because it is situated between two concrete shells. However, the field tests revealed that due to the application process, the inner tunnel shell is not covered by the membrane for a rather long time. Fire resistance became an important demand, which was followed by an essential product modification. Furthermore, the connection of inner and outer tunnel shells through the membrane modified the static behavior of the construction completely. Normally both shells are regarded as separate systems, whereas the membrane creates a bonded system that shows very different mechanical characteristics.

Concentrating on the membrane alone and neglecting the interdependences to the whole tunneling system led to several extensive loops of modifying and testing. Although running through feedback loops is intrinsic to innovation, these part-whole relations call for an organizing approach that integrates “all essential functions, organizational units, and resources needed to manage an innovation from the beginning to the end” (Van de Ven, 1986:599). The innovation process of the investigated case lacked this consistency of “iterations of inseparable and simultaneously-coupled stages (or functions) linked by a major ongoing transition process” (Van de Ven, 1986:599). Particularly, the involvement of application knowledge only took place after much effort had already been put into building up a product profile. Finally, crucial characteristics were missing and other characteristic were redundant. Besides the late inclusion of application knowledge, the spread of this knowledge over several autonomous parties of the construction process was neglected. Moreover, the fact that for the success of the innovation the membrane had to be implemented first during an ongoing construction project was disregarded. That is, the first usage of the membrane required innovative engineering bureaus, contractors and clients that were willing to take the risks associated with an application without prototyping. Thus, the early detection of these lead users and their involvement in the innovation process at the transition from basic to applied research may reduce unexpected delays and errors in certain development phases that complicate further errors and rework in subsequent phases. It is obvious that not all requirements can be determined in advance. However, an early provision for application knowledge (e.g. through workshops) and supportive measures (e.g. Quality Function Deployment) may stimulate discussion about the essential parts of the innovation while not losing view of the whole technical and social system in which the innovation is embedded. Especially in construction, this may remove conservative behavior preventing a faster diffusion of new ideas.

5. CONCLUSION

This paper presented the results of two case studies concerning innovation processes in construction. Both cases showed that successful construction innovations not only require an appropriate management of their implementation, but also need an adequate management of the generation and development phase. Moreover, through the initial phases of the innovation process, conditions must be provided that allow an effective and efficient implementation. Based on the four central problems of managing innovation provided by Van de Ven, we could find that the creation of institutional leadership and the management of part-whole relationships have a great influence on these conditions. Institutional leadership is necessary to ensure the commitment and culture necessary to implement innovations. The management of part-whole relationships ensures that the effects of an innovative idea on the technical and social system the innovation is part of can be recognized in time and more accurately.

It is obvious that two single cases can only to certain extent shed light on the problems related to innovation processes in construction. More research with a comprehensive view on construction innovation is needed. Especially the early phases of innovation processes should be considered more deliberately.

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IN QUEST OF LEADERSHIP IN THE CONSTRUCTION INDUSTRY: NEW ARENAS, NEW CHALLENGES!

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ABSTRACT

Research in construction has not paid much attention to project leadership. This is due to the traditional focus of researchers on technical and managerial features of construction projects. In this paper, the authors build their arguments on the basis of the greater challenges which the construction industry faces in modern times. These include both industry-specific challenges and others within the operating environment of construction. In addition to these challenges, the rapid growth and development of the construction industry in many countries poses new leadership demands. These challenges call for a change in the perception of the importance of leadership in the effective delivery of projects. To highlight the crucial need for a new breed of construction project leaders, the authors introduce the recent construct of 'authentic leadership' in the specific context of construction projects. It is argued that authentic and genuine leaders are needed by the construction industry under the contemporary circumstances; and that such leaders have greater potential to perform effectively. The paper underlines the need for, and potential benefits of, authentic leadership development in construction professionals, and discusses the practical and research implications.

Keywords: Authentic Leadership, Leadership Style, Challenges, Project Management, Construction Industry

1. INTRODUCTION

With increased emphasis on project management systems, construction firms are now seeking professionals with better management and leadership skills rather than technical skills (Dulaimi, 2005). However, educational institutions and construction firms continue to produce and develop managers lacking in leadership skills. Some researchers note that the construction industry needs major changes in the way it operates today (Winch, 1998; Koskela and Vrijhoef, 2001). This is due to: promotion of individuals from lower ranks without formal education and training; traditional academic curricula which do not cover the development of individuals as leaders; and the conventional task focus of the industry. Moreover, the industry has focused on management, to the exclusion of leadership (Skipper and Bell, 2006). Thus, construction project managers are barely perceived as leaders and are mostly termed as managers (Russell and Stouffer, 2003). Their day-to-day work involves the management of activities and achievement of short-term goals of the project. They have to remind themselves that they are required to attain the traditional triangle of key performance indicators: on time, under budget, of specified quality. This conventional attitude hinders them from behaving as leaders and inspiring the project team to perform better. Bonasso (2001) suggests that this conventional system produces engineers who frequently do not see widely or deeply enough in the designs they produce, and ignore issues such as environmental and cultural degradation caused by engineering works. The reasons cited for this include: technically focused curricula in engineering education; limitations of the standards of performance; the requirements in standards and codes; and budget and time limits (see, for example, Carrato and Haryott, 2003; Dulaimi, 2005; Arcila, 2006).

Owing to the reasons discussed above, the construction industry faces an undersupply of ‘project leaders’ although it has produced a large number of ‘project managers’. There is a need for leadership development in conventional managers in an industry which has received enormous impact from changes in the business environment at both the national and global levels. Within the industry, the developments include the formation of collaborative alliances and partnering relationships.

The present authors argue that the construction industry is in a new arena of a challenging socio-economic, cultural, political, and business environment. In addition to this complex array of challenges, many recent corporate scandals and instances of management malfeasance in the business world also call for a different breed of project leaders. There is also the need for a fresh understanding of leadership motives, new measures to gauge the implicit drives of project leaders, and practical and authentic performance standards. Moreover, there should be a positive cultural environment in construction firms, and leaders who have positive values, morality, ethics, convictions, and aspirations. The leaders should be capable of changing the conventional paradigm of management in the industry, and setting exemplary standards for other businesses to follow. To achieve this goal, the present authors argue that the construction industry also needs to concentrate on developing a new breed of future project leaders through authentic leadership development. These leaders would not only be good managers of projects but they would also be leaders of people. The authors present a model of “Authentic Project Leadership Development”, discuss the research and practical implications of the model and offer suggestions for authentic leadership development in the construction industry.

2. LEADERSHIP RESEARCH IN THE CONSTRUCTION INDUSTRY

Research has shown that the project manager is one of the most important success factors of projects (Odusami, 2002; Toor and Ogunlana, 2005; Long *et al*., 2004). Hynes and Love (2004) cite examples from earlier research and note that the site managers have an impact on the overall quality and cost of the project and the quality of the individual site manager may affect the project cost by up to 10% (Herbert *et al*., 1970). Leadership is one of the most important subjects in management studies (Toor and Ogunlana, 2006). However, many authors have not been able to articulate the idea of leadership despite the large volume of research and literature on the area (Giritli and Oraz, 2004; Ket De Vries, 2003). Particularly in the construction industry, not much work has been done on leadership (Odusami *et al.*, 2003; Keegan and Hartog, 2004; Chan and Chan, 2005). Cleland (1995) mentions the limited coverage of ‘leadership’ in the Project Management Body of Knowledge (PMBOK) and notes the subject as “*terra incognita*”, or “the unknown territory”. Even the latest version of the PMBOK includes very little discussion of leadership. When the authors searched the leading journals in the domain of construction and project management with the keyword “leader”, less than 30 studies could be found. The keyword “leadership” produced less than 150 results. Dulaimi and Langford (1999) argue that studies on leadership in the construction industry concentrate on investigating the motivational factors and the personal characteristics of project managers. A few studies actually focus on leadership development in construction managers.

The lack of focus on leadership is not limited to construction research. Practising construction project managers are hardly seen as leaders of project teams (see Bresnen *et al.*, 1986). A more recent poll of the American Council of Engineering Companies (cited in Russell and Stouffer, 2003) revealed that very few people view consulting engineers as community leaders while a large percentage of respondents perceived them as technical consultants. Several reasons have been given to explain why the construction industry has not undertaken a significant amount of research on leadership and its practical uses in the industry. For example, Langford *et al.* (1995) opine that the low volume of leadership studies in construction is due to the lack of understanding of knowledge on the industry on the part of social scientists and a lack of understanding of social sciences by those in the industry.

3. UNIQUE CHALLENGES OF UNIQUE INDUSTRY

The uniqueness of construction is probably the most often mentioned feature in publications on construction project management. The uniqueness comes from the distinct features of construction products (Drewer, 2001). This uniqueness of construction also makes construction project management a distinct discipline as it poses considerable challenges in various contexts, including: industry specific challenges and general, environment challenges (socio-cultural, economic, technological, legal and regulatory, environmental, and ethical). Industry specific challenges include: poor social image of construction; fluctuating construction activity (Ofori, 1993); greater private-sector participation in infrastructure projects; globalization of construction leading to increased foreign participation in domestic industries (Raftery *et al.*, 1998); growing size of projects; the need to integrate an increasingly large number of construction processes (Ofori, 2003); fast track nature of projects (Kwakye, 1997) and multi-project environments (Toor and Ogunlana, 2006); widening application of franchising in the industry; increasing vertical integration in the packaging of projects; increasing trend of strategic alliances (Ofori, 2003) such as joint ventures, consortia, mergers, acquisitions, and partnering relationships. Some other researchers note challenges such as: the gap between research and practice (Ofori, 1993; Chemillier, 1988); and the need to attain the highest client value as well as its creation, capturing, and distribution (Huovinen, 2006). Recently, Songer *et al.* (2006) note that the construction industry faces major leadership challenges including: lack of quality people owing to difficulty in attracting talent; ageing workforce; and other workforce issues such change or transition; teamwork and communication; training and education (Songer *et al.,* 2006). These challenges and the need for rapid changes in the business culture have led to the widespread adoption of flattened organizational structures and empowerment strategies. To improve the operational flexibility of organizations, several new structures have emerged such as: networks, collaborations, federalist structures, the shamrock structure, and virtual organizations (Bolman and Deal, 1997).

Socio-cultural challenges include: spreading wave of terrorism; wars; political upheavals; other security problems; increased private participation in infrastructure projects; and cross cultural issues. Economic challenges include funding difficulties; uncertain economic conditions; threats of high inflation due to increased energy prices; fluctuating stock values and exchange rates; and cash flow problems. Technological challenges include: increased use of information and communication technology (ICT) such as in e-procurement; technological gap between developed and developing countries, leading to matters of technology transfer; and technological innovation and advancement. Legal and regulatory challenges include: different legal systems, litigation procedures, and arbitration methods within and across countries. Sustainability and environmental challenges include: increasingly stricter environmental regulations; increased awareness of the need for sustainable construction, such as deconstruction of the built items. Ethical challenges include: corruption in both developing and industrialized countries; and fraudulent, unethical and unprofessional practices in professions (see Toor and Ofori, 2006).

The above discussion shows that the construction industry needs to focus on the development of project managers who possess good leadership qualities as well. Such project managers have a leadership style which best suits their inner selves as well as the teams they lead and the projects they manage. In the next section, the leadership style of construction project leaders is discussed.

4. LEADERSHIP STYLE IN CONSTRUCTION PROJECTS

Discussion of leadership should include the appropriate leadership style for business and project leaders. Leadership style is a joint outcome of the leader’s self-related information, personality traits and the underlying motives (Toor and Ofori, 2006a). Over the last several decades of research on leadership, a number of leadership styles have been proposed for organizational leaders such as: transactional, transformational, laissez faire, charismatic, democratic, autocratic, consultative, joint decision making, authoritative, participative, servant, tyrant, task oriented, relationship oriented, production-oriented, employee-oriented, performance or maintenance, directing, coaching, supporting, delegating, authority-compliance, impoverished management, country club management, team management, middle of the road management, and so on.

Researchers have explored leadership styles suitable for construction professionals. The least preferred coworker (LPC) measure of Fiedler’s (1967) contingency model of leadership has been widely used. In one of the earliest studies, Monaghan (1981) observed that project managers, who were high in task and low in people consideration, produced an acceptable level of commercial performance. Another study described project managers as “socially independent” (see Bresnen *et al.*, 1986) although the calculated LPC scores suggested the task-oriented behavior of the subjects (cited in Dulaimi and Langford, 1999). Seymour and Elhaleem (1991) noted that the effectiveness of project managers is fairly synonymous with task-oriented leadership. Rowlinson *et al.* (1993) examined variations of leadership styles employed by the same construction managers in different circumstances. They found that project leaders tended to use a supportive style in feasibility study and pre-contract stages of works and a directive style as construction progressed. Dulaimi and Langford (1999) also considered the project managers in their study as socially independent. They noted that the project manager’s personal orientation and the situational variables were independent of one another. Their results show that the personal orientation of the project managers has no influence on their behavior.

In another study of construction site managers, Fraser (2000) found that those who scored highly on the effectiveness scale favored team-style leadership; those managers following a production style of leadership scored the lowest of all; and those using a compromise leadership style had middle-range effectiveness scores. Contrary to earlier studies, in a study of project managers in Bangkok, Thailand, Ogunlana *et al.* (2002) found that the relationship-oriented leadership style was considered to be more important than the task-oriented style for project managers. Fellows (2003), in a study of the quantity surveyors in Hong Kong, observed that they were mostly relationship orientated and tended to adopt the supportive style of leadership. They noticed that the expressed preference for relationship orientation was stronger amongst contractors than consultants. In their survey of leadership styles of construction professionals in Turkey, Giritli and Oraz (2004) observed that: (i) female and male managers were similar in terms of their transactional leadership behavior but their transformational practice was significantly different, suggesting the task-oriented style of both sexes in a gender-congruent context; and (ii) managers in higher positions were stronger in pacesetting style than those in lower management positions, indicating that senior managers led by example, yet exerted tight control over poor performance of their subordinates.

Chan and Chan (2005) found that all transformational factors (charisma—attributes and behaviors, inspirational motivation, intellectual stimulation, and individualized consideration) and contingent reward of transactional factors (contingent reward, management-by-exception, active and passive) were highly correlated with the rated outcomes (such as leader effectiveness, extra effort by employees, and employees’ satisfaction with the leaders). The study revealed that well-perceived leadership styles of the building professionals were inspirational motivation, idealized attributes, intellectual stimulation, idealized behaviors, contingent reward, and individualized consideration. Chan and Chan (2005) recommend that building professionals should promote the use of transformational leadership in their interactions with employees in the workplace for greater employee performance and satisfaction. Toor and Ogunlana (2006) observed that the attributes of transformational leaders were rated high as compared to those of transactional leaders. They also observed that the use of authority and punishment was rated among the lowest of leadership behaviors. They condensed the leadership behaviors into what they term as ‘Four Rs’: resolving, reverent, rewarding, and revolutionary, and argued that the ‘Four Rs’ were critical for the success of construction project leaders on the large construction projects.

The discussion so far reveals that there has been no general agreement on what leadership style best suits construction professionals and project managers. The reasons are clear: no one best leadership style can be considered to be the best in all circumstances and at all times (Fiedler, 1967; Vroom and Jago, 1988); context is important when it comes to measuring management knowledge (Chanlat, 1996), and effectiveness of leadership style (Fellows *et al*., 2003). Moreover, most of the identified leadership styles are self-centered, task-centered, relationship-centered, or change-centered. These styles do not tell if the effort behind the leadership is genuine, authentic, reliable, and truthful. Leaders can pretend, and put such styles on show for certain personal purposes. Therefore, there is need for a leadership which is selfless, altruistic, future-oriented, self-regulated, and to put it simply, authentic.

Another important question is whether characteristics such as task- and/or relationship orientation, clarity of vision, intellectual stimulation, active or passive management, and so on, are sufficient for an effective leader. Furthermore, most of the leadership styles which are offered do not consider questions such as: how the leader develops a particular style; why the leader chooses to adopt a certain style; why some styles work within some teams but fail within others under similar conditions; whether there is an ideal set of qualities to constitute a best leadership style; how a leader switches from one style to another; whether it is possible to retain credibility by switching styles frequently; how a leader can have several styles at the same time if he is working on different projects; etc. To address these questions, there is need to recognize the root construct of leadership which can provide a broader base for understanding leaders, leadership and leadership development. Inspired to answer the intricacies underlying the concept of leadership, experts such as George (2003) and Luthans and Avolio (2003) have presented the construct of 'authentic leadership' as a solution to contemporary leadership challenges and future leadership demands. In the next section, the notion of authentic leadership is discussed in detail, together with its potential application in the construction industry.

5. NEW LEADERSHIP FOR PROJECT MANAGERS

The need for effective leadership in construction projects is undeniable in the increasingly complex environment. Large and international construction ventures require individuals who have integrity, comprehension of the situation, a passion to lead, zeal to bring about change, and understanding of the demands of both projects and society. Although several forms of leadership are suggested in the literature, many mainstream leadership researchers now believe that 'authentic leaders' are the solution to the leadership crisis in the modern business world. Attributes of authentic leaders encompass: positive energy, high sense of integrity, moral character and self-discipline, clear purpose, concern for others, confidence, hope, optimism, resilience, and personal values (George, 2003; Luthans and Avolio, 2003; Avolio and Gardner, 2005; Luthans and Avolio, 2003).

Some recent researches also propose that the construction industry needs to develop individuals who are not only good managers but who also have genuine and authentic passion to lead the projects. Such leaders are not self-centered and project stereotypes; rather, they are motivated by the wellbeing of their subordinates, other colleagues, their organization, and society at large. They have the highest sense of responsibility and while accomplishing their goals they do not forget their moral obligations towards their organizations, society, and future generations. They have a balanced way of living and futuristic style of leadership. They are strict on their moral values and do not compromise on their principles. They build an environment of mutual trust, optimism, altruism and transparency within teams. Figure 1 illustrates how of such a leader is developed.

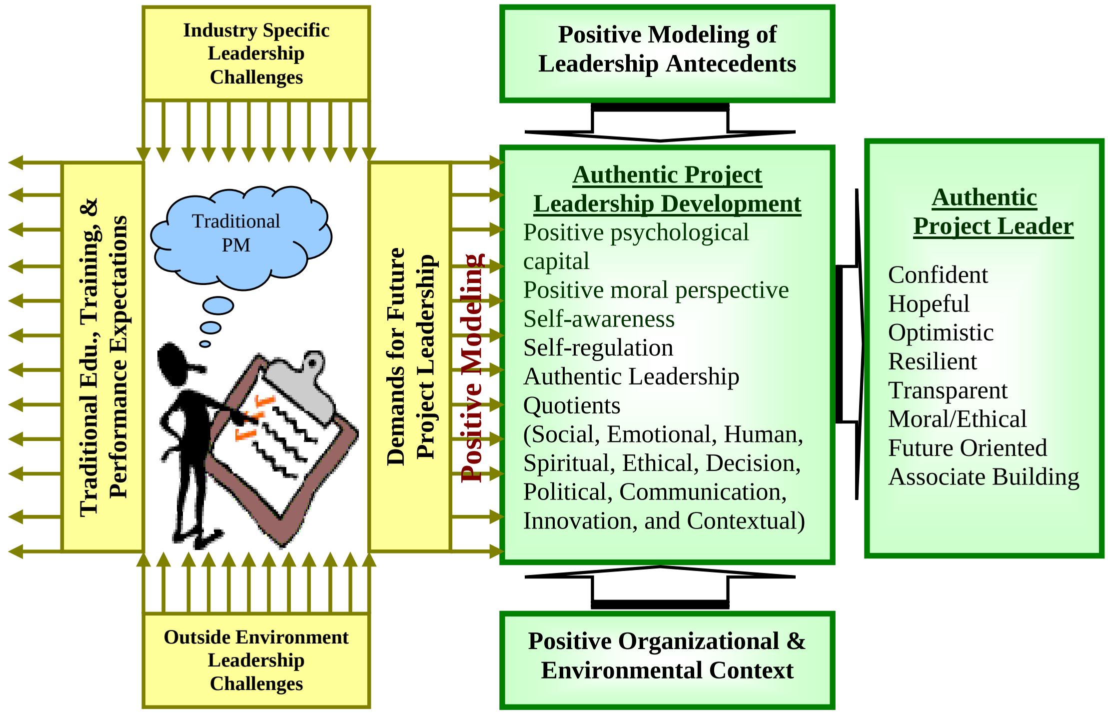

Figure 1. Authentic Project Leadership in the Construction Industry

6. AUTHENTIC PROJECT LEADERSHIP DEVELOPMENT

Figure 1 depicts the traditional construction project manager who is surrounded by a set of forces. There are passive and active forces, contemporary leadership challenges, and leadership demands of future construction projects. Passive forces comprise traditional education, training, passive organizational and industry culture, and traditional performance expectations. These forces compel the project manager to remain conventional, conform to situational demands, and accept the existing circumstances. Contemporary leadership challenges include those which are specific to the industry, and those which are in its environment. These challenges have been discussed above. The active forces consist of demands and expectations of future business and project leaders. To meet these demands, project leaders should be optimistic, future-oriented, resilient, moral, creative, innovative, and transparent. Future leaders should also be able to demonstrate veritable performance and create a positive environment in their organizations. Contemporary leadership challenges and active forces together inspire the traditional project manager to develop as authentic project leader (APL) through authentic project leadership development (APLD). The model shows that APLD is dependent on positive mediation of leadership antecedents, highly developed organizational context, and positive external environment. A highly developed and positive organizational context will support the type of self-awareness and self-regulation required of leaders to develop higher levels of authentic leadership potential (Luthans and Avolio, 2003). The authors argue that positive self-development of the project leader is influenced by the external environment which may include: other organizations, project stakeholders, socio-cultural and economic factors, political situation, and other outside influences.

Positive mediation of leadership antecedents refers to positive impact of trigger events which activate the leadership schema in individuals. Toor and Ofori (2006b) describe these antecedents as: biological, physiological, psychological, socio-cultural, spiritual, economic, educational, occupational, and contextual. Combined positive mediation of leadership antecedents under positive organizational and environmental context is central to the development of positive leadership characteristics. These attributes include: positive psychological capital, positive moral perspective, positive self-development (self-awareness and self-regulation), and authentic leadership quotients (social, emotional, spiritual, ethical, decision, flexibility, communication, technical, and innovation).

7. ATTRIBUTES AND IMPACT OF AUTHENTIC PROJECT LEADERS

APLD model suggests that positive influence of various social enjoins with positive psychological characteristics to generate positive organizational behaviors in individuals who eventually develop as authentic project leaders. These leaders are confident, hopeful, optimistic, resilient, transparent, and moral/ethical and futuristic (Avolio et al., 2005; Gardner *et al.,* 2005; May *et al.,* 2004) and having all these characteristics they turn their associates into leaders themselves (Luthans and Avolio, 2003). They have strong comprehension of cultural sensitivities, and are highly motivated and self-aware. They understand the demands of project from the client's as well as user's perspective and give their best input to make the project a success for all stakeholders. They possess the highest level of integrity, deep sense of purpose, courage to move forward, passion and skill of leadership (George, 2003). Authentic project leaders understand that "the profession of engineering calls for men with honor, integrity, technical ability, business capacity, and pleasing personalities" (Schaub and Pavlovic, 1983). They demonstrate professionalism and have the attributes of professional ideals which Lawson (2004) considers as: knowledge, organization and the ethics of service. They also practice high standards ethics and morality. They attend to the development of their followers, and act as their role models to turn them into future leaders (Avolio and Gardner, 2005). They engage in monitoring follower performance and correct followers' mistakes by teaching and coaching them (Bass and Steidlmeier, 1999).

Authentic project leaders are not only good in human and social capital (Avolio and Luthans, 2006); they are also competent and knowledgeable about their own field. Gardner and Schermerhorn (2004) believe that the insights of authentic leaders are committed to building highest level of organizational capacity through individual performance. Their behaviors become examples for other to follow and accomplish the maximum level of performance. Authentic leaders are highly influential in enhancing others' ability to perform better by providing support and creating conditions that stimulate the individuals "to work hard, even extraordinarily hard, to perform at one's very best" (Gardner and Schermerhorn, 2004). Authentic leaders challenge their followers by setting high performance standards through their own examples. By demonstrating commitment, devotion and dedication, they become the role models of veritable performance.

Although, being human, they make mistakes; they take the responsibility for them, and learn from their errors (George, 2003). Through the wisdom they obtain from their experiences, they able to reflect on a situation, evaluating and making choices (Kupers, 2005). They are guided by a set of transcendent values (Schwartz, 1994) which mediate their decisions about what is right and fair for all stakeholders (Bass and Steidlmeier, 1999; Luthans and Avolio, 2003; May et al., 2003). Michie and Gooty (2005) believe that authentic leaders are concerned with the interests of all stakeholders as they live with self-transcendent values such as benevolence (honesty, responsibility, and loyalty) and universalism (equality, social justice, and broadmindedness). These characteristics show some of the features of transformational, charismatic, servant, spiritual, and ethical leaderships. It because proponents of authentic leadership call it “root construct” and believe that it underlies all forms of positive leadership though it is distinct from other leaderships in many respects (see Avolio and Gardner, 2005; George, 2003). Hence, authentic leaders can be transactional, transformational, directive, or participative, and still be defined as authentic leaders (Hughes, 2005).

Implications

The model presented here emphasizes the need for a change in the overall philosophy with which contemporary construction project managers function. The study calls attention to a more humanistic and genuine approach of project leadership and leadership development. Discussion in the paper focuses on the importance of authenticity and its relevance to professional leadership development at all levels of project organizations. It is argued that the appreciation of leadership authenticity will help to develop effective leadership for future projects, and also result in a culture which is based on positive organizational behavior, organizational scholarship, conducive culture, self-transcendent values, mutual respect and understanding, mutual welfare, and veritable performance.

Another advantage of authentic leadership is its sustainability in comparison with other forms of leadership. Since authentic leadership is a root construct and is achieved through a deep sense of self-awareness and self-regulation, there is a high likelihood that it will be sustained and nourished in individuals and organizations. Authentic leadership development of individuals will also develop a positive organizational culture which will eventually enhance the satisfaction and performance of employees. It will also build trustworthy and enduring relationships among leaders and their followers.

The authentic leadership construct also emphasizes on followers’ development and authentic followership development. Authentic leaders are not self-centered. They act as role models of their followers and focus on their development as leaders. Studies have shown that when followers are treated fairly, they are more committed and likely to display positive attitudes (Rhoades, et al., 2001 cited in Gardner et al., 2005). This positive attitude of leaders as well as trust of followers in leadership results in positive organizational outcomes (e.g., Dirks and Ferrin, 2002) such as development of positive organizational behavior (Luthans, 2002) and positive organizational scholarship (Cameron *et al.,* 2003). Authentic leadership development of project leaders will also benefit the leaders by improving their performance and effectiveness; it will have a profound and long lasting positive influence on overall organizational culture and performance. Authentic leadership development will create an environment of trust and positive relationships which are keys to the success of teams working on construction projects.

Recommendations for Future Research

It is necessary to study the level of leadership authenticity in construction project leaders at various levels of organizations and across different countries. Studying different industries in terms of authenticity can help to improve leadership practices by mutual learning. A comparison of the construction industry with other industries can also help to gauge the need for professional and leadership development. An international consortium of construction leadership researchers could be formed to take up the task. This consortium can be similar to the GLOBE Project (House *et al.*, 1994). Research is required into leadership development initiatives through leadership interventions. These should be multi-level cross-sectional and longitudinal studies which can give deeper insight into leadership challenges and needs in construction projects.

Future studies on leadership can examine the impact of authentic project leaders on their fellow employees and on the success of the projects they lead. These studies can also focus on how the authenticity of leadership is perceived differently in different contexts such as: culture, religion, ethnicity, and gender. Another dimension on which project leadership research can focus is the organizational context, with categorization by type of organization (contractors, architects, designers, quantity surveyors and so on), size of organization (small, medium, large; local, multinational, and so on), and focus of organizational activity (building, roads, and so on). This multi-level and multi-dimensional analysis will help in the effort to comprehend specific leadership needs and demands of organizations belonging to different contexts; and what influences the tactics leaders use to be more effective and successful in different contexts. It is proposed that the model presented in this paper should be the subject of discussion and research in the construction industry. The concept authentic project leaders and how such leaders should be further developed, with specific regard to the construction industry, should also be subjects of extensive research.

8. CONCLUDING REMARKS

The paper laments the dearth of research on leadership in construction. It is suggested that the traditional behavior of construction project managers is due to several factors which are inherent to the construction industry. It is argued that there is the need for a major shift in the way the project managers function and lead the projects. They need to develop as effective leaders rather than managers. Contemporary challenges and future leadership demands ask for a change in the way that project leadership has been perceived so far. The paper presents a proposal for authentic project leadership development at all levels of construction organizations. It is necessary to develop this concept further, and undertake research to test the construct throughout the construction industry. Authentic leadership must be made part of organizational culture. Authentic leadership development in project leaders is a solution to the 'leadership crisis' the construction industry is considered to be facing.

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DEVELOPING AN INNOVATION ASSESSMENT TOOL FOR CONSTRUCTION COMPANIES

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ABSTRACT

In the UK, the construction industry has been characterised as slow in the adoption of technological innovation, advanced business practices, and also new ways of working, which has been said to contribute to low productivity and poor performance. Many studies have shown that construction companies are not able to deliver on their potential to innovate.

Against this background an innovation assessment tool is proposed to provide a rapid online assessment of innovative practices and competencies in construction companies. The objective of the tool is to initiate a process leading to the effective implementation of a strategy/best practice guidelines and to allow construction companies to: assess their innovative performance; help them to focus on the areas where they want to make progress; integrate innovation related strategies/best practice guidelines into overall competitive strategies; and benchmark their innovation performance with peers and within the construction industry.

This paper describes the development of the proposed assessment tool for theconstruction industry and reviews existing innovation assessment tools and models, from within and outside of the industry. The content will be of interest to both academics and practitioners.

Keywords: Assessment tool, Competencies, Construction industry, Innovation, Models

1. INTRODUCTION

The construction industry contributes to the UK economy, providing a tenth of the UK's gross domestic product (GDP) (Lenard and Abbott, 1998) and employs up to 1.5 million people (Pearce, 2003). However, compared to other industry sectors, the construction industry is not perceived as socially important and therefore, has not been a high priority for national government (Lenard and Abbott, 1998). It is perceived as old fashioned and conservative (Fairclough, 2002). The construction industry is slow in the adoption of technological innovations and new ways of working (Winch, 2003). Certain sectors of industry have traditionally invested in Research and Development as a means to support "innovation" and therefore growth - sectors such as aero-space, automotive and pharmaceutical have strong innovation cultures (Dikmen, 2003). Other sectors, notably including construction, have weak innovation cultures and are accused of being conservative and non-innovative (Larsson, 2003), with a passive approach to research investment. In his review of the state of Innovation and Research in UK Construction, Fairclough (2002) highlighted many issues, which the industry would have to address in order to deliver on its potential to contribute to the wider economy. Not least of the issues raised is the almost total absence of R&D from the boardroom agenda of the biggest construction organisations. Construction is project based, with each project being unique (Beatham, 2003). Projects are generally to be carried out by multiple parties, where each party is a separate organisational entity that possesses its own interests and expected end rewards from the project (Dulaimi et al, 2003). This has created a range of problems and the industry has become highly inefficient compared to others (Anumba and Evbuomwam, 1995).

Through the Latham (1994), Egan reports (1998) and Accelerating Change (2002), UK Government has supported major reviews of the way in which UK Construction performs and some ambitious targets were set for performance improvement. With the growing importance of the internet, both large and SME's companies are increasingly leveraging the internet to achieve competitive advantage (Cheng et al, 2003). Internet based tools such as project extranets are used to manage construction projects and can be used to monitor, control and store project information and make it available to all participants of the construction supply chain (Alshawi and Ingirige, 2002). In spite of these documented benefits, construction companies have been relatively slow in the uptake of these tools in their working practices (ITCBP Intelligence, 2003).

To improve the situation an innovation assessment tool called iCon is proposed to provide a rapid web-based assessment of innovative performance, practices and competencies for construction companies. The objective of the tool is to initiate a process leading to the effective implementation of a strategy/best practice guidelines and to allow construction companies to: assess their innovative performance; help them to focus on the areas where they want to make progress; integrate innovation related strategies/best practice guidelines into overall competitive strategies; and benchmark their innovation performance with peers and within the construction industry.

Innovation in Construction

The Department of Trade and Industry (DTI) have acknowledged the work of Rogers, (1995), Fairclough, (2002) and Jones et al, (2003) defining innovation as a 'successful exploitation of new ideas' (DTI, 2003). 'Innovation is seen as a major source to improve competitiveness and is perceived to be a pre-requisite for organisational success and survival' (Egbu, 2004). Most stakeholders expect innovation to offer benefits in one or more of following areas; capital and operational expenditure, quality, performance, market share, competitiveness, customer service and value (Glass, 2002). Tatum (1991) points out that construction companies need to innovate to win projects and to improve the financial results of these projects. The construction industry needs to innovate more frequently to boost its competitiveness so it can meet the ever increasing client demands of both national and international marketplaces (Larsson, 2003). However, there are many barriers and limitations to construction innovations (Dulaimi, et al, 2005).

2. REVIEW OF ASSESSMENT MODELS AND TOOLS

There are several tools/models, which have been used for the last few years to self-assess organisations' performance and capabilities. These assessment tools or models have different underlying goals and definitions. For example, the Department of Trade and Industry (DTI) in the UK and the Construction Excellence have produced Construction Industry Key Performance Indicators (KPIs) that underpin a number business excellence models (CE, 2005). The KPIs were successful in promoting the use of a performance measurement within the construction industry (Beatham, 2003). In recent years the power of Information Communication Technology (ICT) has driven large and SMEs companies from all sectors to search for ways of monitoring and improving performance (Neely and Hii, 1998). Over recent years there has also been increasing recognition that a more holistic approach to performance is required, such as the European Foundation of Quality Management (EFQM) Excellence Model; the Balanced Scorecard; an assessment system such as Key Performance Indicators (KPIs) and benchmarking (CE,2005); in managing sustainable construction (BRE, 2002), and a guide for managing innovation (CIDEM, 2002). The above models have been developed using well-established principles that underpin a number of business excellence models. While such models are useful in themselves, innovation appears to be present in them is an unclear, unstructured manner so there is a need to develop a web based innovation assessment tool for the following categories such as leadership, management, people, processes, IR investment and technology to compliment such existing models.

Several assessment tools were reviewed; These are briefly described and compared below.

Table 1: A Comparison of Innovation assessment tools.

Assessment Tools	Comparison of innovation assessment tools
ISDT (Innovation Self-assessment Diagnostic Tool) www.innovation.gov.uk	This diagnostic tool was designed and developed by Department of Trade and Industry (DTI), The tool was designed to help companies identify themselves with some of the better behaviours that promote innovation and identify specific areas of poor performance and look for advice in these areas.
GIS (GoInnovative System) www.goinnovate.com	GoInnovative system helps organisations to innovate and to develop innovation as a core competency without significantly altering their organisation's current methodologies.
OAT (Organisational Assessment Tool) www.innonet.org	This tool was designed and developed by Innovation Network. The tool was designed to help companies understand their organisational strengths, and to throw some light on areas in need of improvement.
RAT (Readiness Assessment	This tool was designed and developed at Leeds/Birmingham University, The tool was designed to

Tool) (Burgess & Shaw, 2004)	help senior business managers in identifying area of current organisational weakness etc.
Verdict (Verify End-user e-Readiness Using a Diagnostic Tool) (Ruikar, 2005)	This construction specific tool was developed at Loughborough University, and is an internet based e-readiness application that assesses the overall e-readiness of end-user construction companies for using e-commerce technology.

Of these assessment tools, most conceive organisational improvements in general as supporting innovation, some of them are under development and some are being used on a commercial basis. However, the assessment tool that is most relevant to this study after appropriate modification is Verdict (Verify End-user e-Readiness Using a Diagnostic Tool) (Ruikar, 2005). Verdict is an internet based e-readiness application that assesses the overall e-readiness of end-user construction companies for using e-commerce technology. It comprises a series of statements that fall into four categories, namely, people, process, management and technology.

On their own, Verdict's four parameters may not be sufficient for an assessment whether it is e-readiness or innovation assessment in the construction industry or indeed for any other industry sector. This would require leadership in order to drive policies and strategies and to successfully implement it. The other parameter missing from Verdict is IR investment which is one of the key determinants of innovation or technology in any industry. Therefore, there is a need to develop a web-based innovation assessment tool specifically for construction companies, which includes IR investment and addresses the leadership questions, as explained below.

3. KEY DETERMINANTS OF INNOVATION IN THE CONSTRUCTION INDUSTY

The proposed innovation assessment tool for construction companies (iCon) adopts a similar methodology to Verdict (Ruikar, 2005), wherein companies will be required to respond to the statements and on completion the construction companies whether they are SMEs or large companies will be presented with an innovation performance report, which includes a summary of their responses and best practice guidelines on areas for improvement.

According to Cheung et al, (2004), effective performance assessment depends on well-structured assessment parameters, which in turn are subject to the following questions what kind of data can be used and how to collect and interpret the data in a way that end-users can understand. To derive a reliable set of innovation performance parameters, the review covered the work of Goolsby, (2001) and others (Larkin, 2003; Emmett, 2002), which indicate processes, people and technology are the three key aspects the need to be considered for successful implementation of technological innovation. Emmett (2002) stated that "people, processes and technology need a leader" just as "an orchestra needs a conductor". Based on these, six innovation performance parameters can be identified for the development of the proposed innovation assessment tool for construction companies (iCon).

Leadership
The European Foundation for Quality Management EFQM (1999) assigns 10% of its weighting to leadership because most people react best to leaders who connect with them and are not hierarchical in their approach. Leaders also create the psychological environment that fosters sustained innovation at all levels (Karlsberg and Adler, 2005) They are expected to be able to; identify and overcome the basic barriers to innovation; create and deploy proven internal marketing principles to better incubate innovative projects; maintain a culture of continuous play etc. They can articulate their vision of the innovation to the rest of the company (Afuah, 2003). In the proposed tool, leadership issues will be assessed using both question aimed at leaders and subordinates.

Management
Management attitude is crucial to technological innovation and can play a part in achieving successful construction innovations and creating competitive advantage (Pries and Janzsen, 1995). A survey of construction industry professionals carried out by Buro Happold and Building Design Magazine established that 88% of the respondents believed innovation was not managed effectively (Cripps, 2002). Innovation is extremely complex and involves the effective management of a variety of different activities. To do so, management must believe in innovative practices and take such strategic measures sufficient to save its adoption. This must therefore be addressed in the tool. Pries and Janzsen (1995) have emphasised the crucial role of innovation management in achieving successful construction innovation and creating competitive advantage.

People
The UK construction industry has long experienced difficulties in meeting its skill requirements. Given the right atmosphere or culture, 'innovation will not readily take place without the right people being drawn to it' (Sturges et al., 1999). The people factor accounts for the social and cultural aspects related to the people within an organization and are important to its success (Ruikar et al, 2004). Egbu et al. (1999) examined the management of innovation in construction by surveying a number of companies which were identified as 'innovative'. They highlighted certain characteristics shown by all innovative organisations. These are: people are open-minded, willing to accept change, flexible in lines of communication, structure that allow top-down bottom-up and risk tolerant climate where it is accepted that lessons can be learned through mistakes. Clearly many of these characteristics would be difficult to engender in an industry based on adversarial, entrenched relationships (Gesey et al, 2005), therefore the people factor is important and is a key ingredient to innovation success and can effect overall performance of an organization and need to be addressed in this proposed tool.

Process
According to Sexton and Barrett (2003) the process of innovation means a series of actions and reaction forces which include management support (action), resistance to change from the staff/people (reaction), allocation of capital to purchase needed technology (action) and lack of appropriate work routines to coordinate and channel the innovation activity (reaction). The innovation process is not often an orderly process, but a process that is subject to peaks and troughs as the progress of the

innovation competes with the day to day variability of workload and the often acute pressures on finite staff and financial resources. “What is needed is a framework or process that can guide innovation activities from start to finish." (Dundon, 2002). Process change of any nature carries its rewards and risks but strong links between the different stages of the innovation process are critical to success and need to be addressed.

IR Investment

The amount of investment funding available for construction research has been declining steadily in recent years and is estimated to be less than 0.5% of the construction sector’s spending. By comparison aerospace invests 11%, automotive over 9% and pharmaceutical up to 13% of their revenues on research (ICE, 2003). A lack of continuing investment in R&D in the construction industry may be preventing innovation starting and continuing (Glass, 2002). Furthermore, the construction industry itself has clearly struggled with the notion of R&D as a tangible benefit, which may relate to the fact that the industry has traditionally been very slow to exploit innovation. At present, no construction organisations have been placed in the top 250 R&D investors list (Steele and Murray, 2001). Since the publication of the Egan report ‘Rethinking Construction’(1998), it has been accepted that for future growth within the construction industry to be sustainable it will become increasingly reliant on its R&D capabilities and it is very important that a better mechanism be developed for defining the industry’s long term R&D investment needs (Fairclough, 2002).

Technology

The technology factor covers all aspects relating to information and communication technology (ICT) and its capability of coordinating different activities within and cross organizations and also across industries (Laudon and Laudon, 2002). Kao (1997) explains the role of technology as a catalyst for and multiplier of creativity. Electronic tools for sharing information, including e-mail, intranets and knowledge management systems dramatically enhance people's ability to represent, organize and apply knowledge and ideas (Kao, 1997). According to Tidd et al, (2001) technological development does have its own internal logic, which helps define where companies will find innovative opportunities. Lloyd et al (2002) argued that an automated and web-based monitoring system can remove geographic barriers and reduce time in transferring data, in addition, it enables exchange of massive volumes of information at high speed and a relatively low cost (Deng et al, 2001), An automated and web-based innovation assessment tool is proposed to bring together the six aspects/ criteria cited (shown in Figure 1) and translate these into an effective tool to assess innovation end-users such as SMEs or large construction companies. Such a tool will also help to organise company performance data and can be easily retrieved via intranet/internet and database technology.

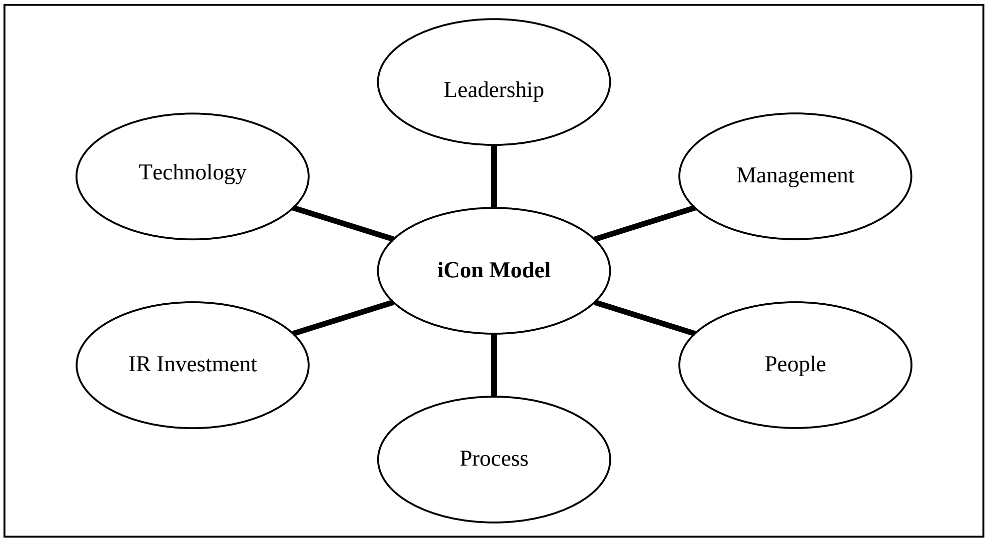

Figure 1: A proposed model for innovative construction (iCon)

Figure 1 shows the key determinants of innovation in the construction industry, such as; leadership, management, people, processes, IR investment and technology. Using the iCon model for innovation assessment within the construction companies, A survey questionnaire and interviews with a range of companies within the construction industry will be carried out to validate the model, its parameters and associated statements.

The iCon prototype was evaluated using an independent panel of reviewers including five academic researchers and fifteen industry practitioners who are aware of and supporting innovations in the construction industry. Evaluation was based on the functionality of the prototype application, its user-friendliness, presence of any errors in content or links, and its overall relevance to construction industry.

The iCon home page displays information about iCon including its aim and expected outcomes The main body of the prototype application comprises an innovation questionnaire which is distributed over six pages (one page for each of the above categories). Figure 2 shows a typical questionnaire page consisting of a series of statements relevant to a particular category; end-users click on one of the five possible responses.

Please tick the appropriate box to indicate your response						
Leadership		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	Senior management is fully supportive of the development of our innovations	○	○	○	○	○
2	Our leaders are aware of the potential rewards and risks of innovation practices	○	○	○	○	○
3	We recognise the benefits of being an innovative organisation	○	○	○	○	○
4	Our organisation has a director/manager at board level with overall responsibility for innovation and research (IR) issues	○	○	○	○	○
5	Teams here have a lot of discretionary power	○	○	○	○	○
6	Senior managers are "hands ready" knowing exactly when and when not to get involved	○	○	○	○	○
7	When problems occur, our leaders immediately act to provide appropriate support and guidance	○	○	○	○	○
8	Our organisation has an agreed set of operating principles/codes of conduct to support and facilitate the achievement of its long term vision of innovation	○	○	○	○	○
9	Our company has a vision and/or mission statement, which sets the organisation's direction in relation to innovation	○	○	○	○	○
10	Our company has a definition of innovation in construction for internal and external use	○	○	○	○	○
11	Our organisation has a detailed map for managing its key innovation issues with associated level of priority, actions, impacts and outcomes	○	○	○	○	○
12	Our organisation has short, medium and long term action plans to deliver its innovation policy with defined objectives, targets, performance indicators and list of personnel responsible for delivery action plans	○	○	○	○	○
13	Our organisation has a process to evaluate and manage its supply chain innovation issues	○	○	○	○	○
14	Our leaders promote innovation as a competitive edge for the company	○	○	○	○	○
15	Our leaders are directly involved in the development of an innovation culture in order to bring about continuous innovation improvement	○	○	○	○	○

Previous Next Reset

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Figure 2: A typical iCon questionnaire page

4. CONCLUDING COMMENTS

A number of assessment tools/models have been discussed and an innovation assessment model iCon is proposed as part of this research to help construction companies assess their innovation capabilities. The model is to initiate a process leading to the effective implementation of a strategy/best practice guidelines and allow construction companies to: assess their innovative performance; help them to focus on the areas where they want to make progress; integrate innovation related strategies into overall competitive strategies; and benchmark their innovation performance with peers and within the construction industry etc. Fairclough (2002) critically suggested that it is important that a better mechanism be developed for defining the industry's long term research needs. This lack of innovation and research can be explained by the lack of recognition of a number of key determinants of innovation in construction industry, such as leadership, management, people, processes, IR investment and technology. Taking this in to account, the iCon system is built around the assumption that a company will be better able to manage innovation if it measures and improves itself against these six headings, hence iCon is structured around these headings. It is proposed that the iCon tool provides a means for companies to become more innovative organisations.

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INNOVATION STRATEGY: CHOOSING A CENTRAL OR DECENTRAL APPROACH IN CONSTRUCTION BUSINESS?

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ABSTRACT

A construction process is often complex and requires a large number of skills and responsibilities, which can be organized in different ways. Construction companies differ in their philosophy in how to manage and control the construction processes effectively and efficiently. It seems that their organizational structure and its control systems create different organizational cultures that influence the way a company functions. In this paper a comparison is made between the organizational cultures of two Dutch construction conglomerates, and it discusses its implications for organizational learning and the ability to innovate. The analyses and outcomes are based on several in-depth interviews within both companies, companies (A) and (B).

Construction company (A) is centrally controlled; decisions are made centrally in the aim to maximize efficiency and reliability. The organization of the construction proces is tightly structured in a hierarchical way, and responsibilities are well defined. The employees are judged on the way they fulfill their tasks.

Construction company (B) is organized differently, authority is decentrally organized and the headquarter merely guides and supports. Within this company, construction proceses are managed by people with broad responsibilities that overlap. The organization is kept together by mutual trust and loose control, employees are highly involved by what is happening within the organization.

Both construction companies have invested in facilities to support organizational learning. The different organizational cultures result in a different organizational development and innovative opportunities. Company A's innovation activities are shed away from production activities which improves the development of specialised knowledge. Company B's decentral and integrated approach to innovation development ensures that the company as a whole develops a dynamic and innovation oriented culture.

Keywords: Culture, Centralization, Decentralization, Construction business, Innovation.

1. INTRODUCTION

This paper investigates the perspectives of two large Dutch construction contractors known for their effort to innovate. However, both firms have obtained different strategies and organizational structures to reach their innovative goals. Within the analysis, implications connected to the firm's strategic and structural decisions are uncovered.

With this paper, insight is provided into how two firms try to tackle a few basic problems of the construction industry and how they have implemented their innovation strategy. These basic problems are: innovation management, culture, functional integration, learning and competence development. These problems are longstanding and are connected with the development of the industry as a whole. The Dutch construction industry is a moderately dynamic industry. The structure of the industry is stable and changes occur relatively linear and predictable. It is for this reason that the construction industry is generally seen as a conservative one in which developments go slowly. The two Dutch construction firms that are dealt with in this paper possess a more than ordinary proactive attitude, still they face many difficulties. The firms struggle to combine a performance oriented organization with an active market stance and innovation.

Construction contractors are production driven companies that focus on efficiency and aim to control the risk of their projects. In addition, as construction principals cover a large percentage of the industry's sale and employees, they influence the way construction takes shape. The development of the construction process is an extensive and time-consuming activity that is important for the quality, and the cost and time efficiency of the industry as a whole. The relatively slow development of the construction process is deeply rooted; it is reflected in the industry's decline in construction value-added as a proportion of GDP over the last 25 years (Gann, 2000).

It is a paradox that construction contractors are often efficiency-driven organizations but do not prioritize full attention to the development of their most important process. Optimization does primarily take place within subunits responsible for only a part of a project. This results in overall sub-optimization, because successful construction process management requires the cooperation of numerous subunits, possibly from different companies, with distinct responsibilities and competences. It is the involvement of these many different competences and skills that makes development difficult. Currently knowledge-exchange processes and innovation are not stimulated within construction projects due to differing organizational cultures. Innovation within projects depends for a large part on the construction contractor's innovative competences and culture. The construction contractor is a dominant party during a constriction project as it is the systems integrator and manages the process in which the construction takes place. For this reason, construction contractors are the focus of this paper.

Poor communication and ambiguous project information is a weakness of the construction industry (Jones and Saad, 2003). The construction industry is a short term, project, and result oriented industry that does not allow much slack. For this reason, innovative ideas are sometimes crippled before they reach full development.

Therefore, innovation in construction requires strategic support and involvement from management levels.

This paper provides two case-studies with contrasting perspectives of how innovation can be put on the strategic agenda of a construction conglomerate: A *central* and a *decentral* innovation-approach.

In the case-studies within this paper the organizational structures and leadership styles are described and analyzed, including learning routines of the two differently organized companies. To emphasize the findings of these case studies, theory has been blended together with insights from practice. This paper's research results are presented in the discussion-section. To accentuate the lessons from our practical research, findings are concentrated in a conclusion-section.

2. BACKGROUND AND METHODOLOGY

This paper is the result of a research project that is undertaken in the year 2005 for the Dutch research organization PSIB (PSIB, 2003). PSIB initiates and supports research on innovation in the Dutch construction industry. The organization emphasizes process and system innovations that have a profound impact on the industry's progress. Our project focused on the conditions that a construction firm should create in order to become a sustainable innovative firm. The project focused on the organizational cultures of construction firms that have shown promising innovative behavior.

The selection of case firms was a decisive step in the development of knowledge from case study research. A selection was made of fourteen cases as the population to base our research findings on. The selected cases determine the generalizability of findings and the external variation that is brought into the research (Eisenhardt, 1989). When knowledge is developed based on case study research, cases should not be chosen at random. Through a number of steps, we tried to find the best practice companies of the Dutch construction industry.

Construction companies were selected that have received recognition with International and Dutch innovation and/or construction prizes. However, we were unsure whether the prizes were awarded to the companies that possess the most innovative organization forms, because these prizes are often awarded on rather 'soft' grounds. To narrow down our population of companies, the companies were tested on six harder criteria, such as:

- *uniqueness of innovation;*
- *corporate importance of innovation;*
- *return on investment from innovation;*
- *development of innovation and strategic advantage from innovation;*
- *number of innovations;*
- *innovativeness compared to market.*

The final selection of fourteen companies was done with the help of four experts with longstanding professional experience within the Dutch construction industry. Four of the fourteen selected companies were subject of a more thorough investigation by in-depth case-studies on company-level. This paper represents the findings of two of these case-studies, being both within large Dutch contractors. Within these two construction contractors, we conducted a number of semi-structured interviews at strategic and operational levels. The interviews were undertaken by a researcher and a scholar experienced in the industry. The interviews were preceded by document analysis on the companies' strategy and key projects that were the subjects of the interviews.

3. INNOVATION DEVELOPMENT AND COMPANY CULTURE: TWO CASE-STUDIES

Introduction of the two companies A and B

Company A is one of the largest integrated construction contractors of the Netherlands. The company is active in housing and utilities construction as well as the development and realization of infrastructure. The company is structured around over 30 subsidiary-companies, all situated in the Netherlands. Complementary, the company possesses an advice and services division that includes an advice and engineering company. Innovation is undertaken in centrally structured companies that serve the 30 subsidiaries with new knowledge and skills. The company distinguished oneself with new concepts that bring new ways for using the Netherlands' scarce land surface, such as bridge-shaped office buildings, floating greenhouses, etc.

Company B is also one of the largest construction contractors of the Netherlands; moreover it has also activities abroad. Activities are organized in a network of more than 20 independently operating development and production companies situated in the Netherlands and abroad. The company is active in housing and utilities construction. Company B manifests itself as a precursor of process developments with a decentralized innovation development approach. For a number of years, the company has invested in integral process management courses for all of its managers.

The two companies A and B are compared on the following three key-issues:

- *Innovation management;*
- *Culture and organizational integration.*
- *Organizational learning and competence development.*

Innovation management

Within construction, a strong polarization between exploitation and exploration is present. The exploitative activities of construction emphasize results, certainty, a short term orientation, and a tight schedule. The nature of these activities is in contrast with explorative activities characterized by search, variation, risk taking, experimentation, play, flexibility, discovery, and innovation.

As e.g. James March (March, 1991) believes, organizations that engage fully in exploitation and exclude exploration are likely to find themselves trapped in suboptimal stable equilibrium. Both exploration and exploitation are essential for organizations, but they compete for scarce resources. Especially for production focused construction contractors, it is hard to combine explorative activities with daily efficiency driven routines. Choices must be made between gaining new information and improving future returns which involve the allocation of resources to the search of uncertain alternatives, and using the information currently available to improve present returns (March, 1991). Exploration will reach a higher priority when one is not satisfied with its current results.

Both company A and B have created organizations active in research and development of new knowledge and practices. However, it is especially the *evolution of new conceptual ideas*, in which company A and B differ:

- Company A has a special business development company that signals new market developments and trends. Its trendwatching function has to make sure that market-chances are detected and taken up quickly. Company A has separated its knowledge creation activities and its production activities within different organizations.

  The management of the Business Development: "*Production companies are insufficiently equipped to quickly react to new developments in the market*." And further: "*Business development is especially active in the pre-development of innovative projects with advice, analysis and research. The realization of innovative projects is done with the help of other innovation focused organizations. At the beginning of 2004, we made the decision to separate all innovative activities from the production companies.*" For the infra division, the pre-development is done by Business Development, the development of innovations that are closer to operational activities are developed within Spatial Development, and realization is done by the production companies themselves. This has resulted in a clear separation between exploration and exploitation within the total organization.

  The advantage is e.g., that the ideal circumstances can be created for the specific goal of the organization. Innovation activities obviously require a different atmosphere, dynamism, culture and people, as Tijhuis described (Tijhuis, 2002a). The management of Business Development mentioned it as follows: "*It took some adjustment from the production companies; they were also used to develop some nice projects themselves. It was nice, but it cost them a lot of money to do these projects. We had to go 'lean and mean'. When looking at the development of knowledge, culture, and dynamism, the separation proved successful. It are two completely different functional worlds.*"

- Company B, on the other hand, has a 'Knowledge Centre', tasked with the development of vision, strategy and guidance for the independent production companies. Knowledge Centre's function is to stimulate innovation at operational level. Though, the organization develops new knowledge for e.g. collective purchase, performance measurement or 3D calculation and integral process management. Additionally, the organization has developed a process protocol for implementation by the production companies.

  Knowledge Centre shares its knowledge through courses that are periodically held for all people within the production companies. The essence of company B's approach is that the actual innovations that are focused on the production process, take place decentrally at the production companies. Knowledge Centre observes whether the production companies adequately assimilate the knowledge it develops and supports to narrow the gap between the actual and the aspired level of operation. The essence of new knowledge creation is its translation to daily activities.

Knowledge Centre's managers provide courses, and strategically support the production companies; they also take care that the development of new knowledge is followed quickly by an implementation at the operational level. The implementation of innovations goes together with the development of its employees at operational level. The management of Knowledge Centre: *"It is a concern to make the aspired changes practical. The managers that play a role in the management of the construction process are properly trained. In this way we make steps forward together with the production companies."* The innovative progress that the company makes is limited to its employees at operational level. *"The innovative path that we are going through is connected to the development of our employees' consciousness."*

<u>Results:</u>
Company B strives for continuous innovation of the construction process at strategic and operational level, whereas company A has separated explorative activities from efficiency driven exploitative activities. Organizations that focus on exploitation and drive out variance increasing activities reduce an organization's ability to innovate and adapt outside of existing trajectories (Benner and Tushman, 2003). Innovation is a central engine of organizational adaptation. Company A's chosen innovation strategy has consequences for the cultural development of its production companies.

Culture and organizational integration
Innovation in construction requires the involvement of the entire construction process. It is through this entire process that a company creates value and can create distinguishable qualities. Different functional teams are involved in a construction process. When a construction process is adapted, it affects many people's activities. For this reason, the functions that are involved in construction need to cooperate and understand one another well, before sustainable process innovations can be created. Involvement in innovation and creativity can be facilitated by an organization's culture. Moreover, organizational culture and actively involved senior managers as visionary or mentor for innovation are primary distinguishing features for an innovative company (De Brentani, 2001).

Schein describes 'culture' as something that "manifests itself at three levels: the level of deep tacit assumptions that are the essence of the culture, the level of espoused values that often reflect what a group wishes ideally to be and the way it wants to present itself publicly, and the day-to-day behavior that represents a complex compromise among the espoused values, the deeper assumptions, and the immediate requirements of the situation" (Schein, 1996). Hofstede describes organizational culture as the collective programming of the mind which distinguishes the members of one organization from another (Hofstede, 1998).

It is very hard to get cross-functional teams to work well together, because each member has an own functional culture and, as a consequence, they have difficulty communicating with each other, reaching consensus and implementing decisions. People from different functional groups have difficulty in cooperating and learning from each other because they have different goals, and more fundamentally, possibly assign different meanings to the same words.

Schein relates the learning problem to the lack of alignment among three cultures, two of which are based on occupational communities (Schein, 1996):

1. *the culture of operators;*
2. *the culture of engineering;*
3. *the culture of CEO's.*

1. The culture of operators: The operator culture is based on human interaction, and most line units learn through experience that high levels of communication, openness, mutual trust, understanding, and teamwork are essential to getting the job done efficiently. Most operations involve interdependencies between several elements of the process; operators must thus be able to work in cooperation (Schein, 1996).

2. The culture of engineering; An engineer represents the basic design elements of the technology underlying the work of the organization and has the knowledge of how that technology is to be utilized. Engineers often want the operators to adjust to the language and characteristics of the particular solution being implemented by them and are quite impatient with the operators' "resistance to change" (Schein, 1996).

3. The culture of CEO's; The executive worldview is built around the necessity to maintain an organization's financial health and is preoccupied with boards, investors, and the capital markets. The perception that they have to manage the organization from afar ensures that they start to think in terms of control systems and impersonal routines.

The differing worldviews of the three organizational cultures can cause ineffective communication and understanding. Operators, engineers and executives think differently and accordingly all too often do not understand each others' problems. An important consequence of this conflict is the less than efficient flow of knowledge through the organization. In construction, a number of different functions need to cooperate before innovations are fully adopted, functional integration therefore is highly important.

- Company A's central innovation and decentral production activities ensure that both organizations develop separately. The organizational cultures of these separate organizations cannot influence one another. Communication between engineers tasked with innovation, and operators' working at the production companies is only targeted to express needs for new knowledge. The functional communication prevents that the engineers from influencing the culture at operational level. As a result, the adoption of specialized knowledge at operational level is not optimal.

  The executive level is involved in the innovation activities of the company. The top management invests heavily in innovation and develops an innovation vision that binds and stimulates the entire organization.

  The company believes in the functioning of a free market. The production companies pay the knowledge developing organizations for the knowledge that they use and implement in projects. This strategy stimulates proactive entrepreneurship. It leads to a results oriented organizational culture. Director of company A's engineer company: *"We have a fantastic structure and mutual internal cooperation that fits the market well. We keep each other sharp."*

The development of the employees at operational level is a bottleneck for the implementation of innovation at company A. The low level of synergy between the different functional cultures makes the cultural development at the production companies difficult. On the other hand, this functional separation does improve the efficiency and results orientation of the separate functional organizations.

- Company B's top management is convinced that he innovativeness of its doughter companies is connected wih the cultural development that takes place within these organizations. In cooperation with a respected Dutch Business School, the company educates the management of its independent companies in integral contruction process management. The management has the task to spread the knowledhge through the operational levels of the company. The continuous development of the organization is facilitates by two-yearly excursions, organised to openly discuss operational effectiveness and problems. One of the topics discussed during these meeting is cross-functional communication.

  The excusrions showed that the solidarity whithin the company was good. Talkng about one's problems in an informal and impartial environment improved camaraderie and mutual undertanding. After one of these excusrions, the management took the decision to cross out the role of the project leader; from that moment onwards project developer, engineer en constructor depended on each other. This led to better communication. After people learned how to deal with each other, efficiency and job satisfaction significantly improved.

  This re-organization and broadening of employee roles initiated a cultural development within the doughter organizations. Not every employee accepted the organizational changed with the same enthusiasm and energy. Inevitably, some people had to be replaced. At the moment, company B's independant companies have become energetic organizations that adopt innovations relatively quickly and show a proactive market stance. Company B's CEO assigs a lot of responsibility at low organizational levels: *"this is the CEO's style, this creates participation."*

<u>Results:</u>

Company A's (central) innovation strategy balances the development of general skills and specialised skills. Innovation and production both take place in a specific environment. Betweeen these two functional world, communication is limited. The functional focus of prevents people from influencing each other. Coordination of innovation and production activities is not optimal and the adoption of specialized knowledge at operational level is not easy.

Company B advocates a mix with guidance and vision from above with freedom at operational level. The (decentral) empowerment of employees at operational level and frequent communication between the different functions ensure that company B is a better integrated organization. As a result, the companies can relatively quickly implements innovations. Additionally, a greater involvement from people at the different functions make sure that activities and newly developed ideas are well coordinated, which improved effectiveness and responsiveness of the organization.

Organizational learning and competence development

Actual innovation does only take place whenever developed ideas are profitably implemented at operational level. The market is dynamic; a sustainable innovative organization requires organizational learning. A sustainable innovative company learns and facilitates the continuous development of its employee's competences.

People can learn and improve their insight through interaction with one another. A learning organization is characterized by motivated units that are intimately connected to one another; social interaction is essential (Huber, 1991). The connection and motivation of subunits is highly important for the development of the construction processes where different competences and skills have to be combined to one effective process. Developers, designers and constructors all have their own distinct activities and communities of practice. These groups of people need one another to organize construction activities well; a better understanding of each other's activities and problems creates understanding and experiential learning through which the construction process can be improved.

Within communities of practice, groups of people are informally bound together by shared expertise and passion for a joint enterprise. These people share their experience and knowledge in informal, free-flowing, creative meetings that foster new approaches to problems (Wenger and Snyder, 2000). However, the collusion of people from different functional subunits requires effort. Without a support from the organization, the required involvement to learn from each other will not come about. Both case companies are innovative; though reach completely different levels of employee involvement.

The Hawthorn studies in the 1920's showed that employee involvement increases both productivity and motivation. Bessant and Caffyn showed that employees who receive good feedback and can monitor their own performance, are more effective (Bessant and Caffyn, 1997). For organizational learning, an effective intra-organizational transfer of knowledge and experiences is important; it is essential that people understand one another.

To sustain one's competitiveness, a company should developed learning routines to hone its employee's competences. Eisenhardt and Martin argue that experiential learning is an important learning mechanism for the development of competences, especially in moderately dynamic markets (Eisenhardt and Martin, 2000). Also in developing markets this is an essential practice, as Tijhuis described (Tijhuis, 2002b). Practice helps people to understand processes better and develop skills effectively. In this perspective, mistakes can play an important role in the evolution of skills. Experience in closely related but different situations is effective in sharpening competences.

- Within the knowledge creation companies, periodic gatherings for managers keep everyone up to date of the latest ideas and concepts. It is a way to inform everyone about innovations and create reception and enthusiasm for new directions. Generally though the company confirms that involvement in innovation is not excellent. "*Innovation touches everyone, but not everyone is yet involved. This still requires continued investment.*"

Within communities of practice, several bi-monthly meetings are organized such as regional management meetings and regional commercial meetings. During the regional commercial meetings, market developments and the development of required competences are discussed. But during these meetings, regional managers also discuss their experiences with their current and past projects and talk about how managers can help one another.

Company A's executives believe that their separation of innovation focused activities has resulted in more effective competence development. *"Because of the separation, competence development is now structurally realised, but primarily at individual lavel."*

Strategically, the company develops its competences through cooperation with companies that internationally possess specialised knowledge. *"We do not have to develop everyting ourselves. To sharpen our knowledge in new construction contracts we cooperated with a Spanish part that has extensive experience in this field."*

- Company B has organized its organizational learning at the level of the individual daughter companies. Four times a year organize the organizations sessions during which experiences from projects are shared and discussed. *"In this way the discussion with each other is stimulated and people can learn from each other."* With these sessions, the management tries to show that performances can be improved when people cooperate closely. Also, engineers and constructors are stimulated to become involved early to arouse cross-functional sharing of experience and insight. Cooperation between developers, engineers and constructors has needed time, but now people meet up with each other very frequently and informally. *"Some conversations are very short, others can be very intensive."*

  To create a feeling of trust and corporate understanding, the management discusses and explains organizational changes twice a year. *"You have to talk to your employees and convince them of the changes. A behavioral change demands a conscious development."* Learning and proactive involvement is stimulated by the management. When an employee has developed him or herself or has had an above average input into the innovativeness of the organization, a bonus is given.

  The knowledge and experience from the daughter companies is shared with a central database. This database is consulted by employees when they require more insight into an unknown topic. The digital system has to improve the prediction and calculation of costs and improve the quality of the end product. Little knowledge is centrally developed. Only highly specialized knowledge, such as 3D calculation, is centrally developed before employees at operational levels are educated during internally organized courses.

  Within the organizations, communities of practice have been created at small scale. Engineers have their informal meetings and developers meet every Friday to discuss market developments and trends.

Results:
Company A organizes organization wide gatherings to improve the diffusion of new knowledge. Though, learning at operational level is not optimal as the development of specialized knowledge happens at a higher level within the organization. Operators are inspired with innovative ideas, but at the same time they are hampered in their development by an orientation on tasks and efficiency and possess a limited degree of freedom. It will be hard to implement process innovations.

Company B consciously aims at the development of its operational employees. Through open communication, stimulating management and a freedom to act, employees have been empowered to innovate the construction process of the organization. Frequent meetings ensure that experiential learning takes place within individual organizations.

4. DISCUSSION

The two cases described showed typical organizational cultures and examples of progressive operational development. Besides, the selected companies were willing to provide honest and unrestrained insight into their strategic and daily operation. The overall research included 14 companies and showed us that different strategies can lead to an innovative construction company. A few findings of the overall research deserve attention for further discussion:

- *Innovative construction companies are characterized by an organizational culture that involves its employeesin the creation of added value through innovation. Key values are: market and customer focus, a long term orientation, and a participative leadership style aimed at empowerment.*
- *Innovative companies acknowledge a multidisciplinary approach. This approach helps them to develop competences to integrate concept development, design and realization.*
- *Competence development is stimulated by matrix-like organizational structures that stimulate inter-organizational cooperation and knowledge sharing between different disciplines.*
- *Innovative construction companies constantly develop their skills to structure and control their approach of integral product and process design.*

The two construction contractors described in this paper show pronounced visions to develop their culture and organize change. Investment in knowledge creation and innovation is a prerequisite for organizational development. However, it proves more difficult to arouse employees to implement innovations quickly and develop their competences. It requires a lot of effort before a company becomes a learning entity at different organizational levels. The case studies showed that it is highly important to invest in meetings and communication structures to get people at operational level together, understand one another, share experiences and learn how to improve the construction process.

5. CONCLUSIONS

This paper has investigated how two large Dutch construction companies have executed their innovation strategy. The case-studies showed a few things:

1. *Cultural development at operational level is crucial for the adoption and implementation of innovation.*
2. *Cultural differences between the innovation- and production-aimed organizations disturb communication and a quick implementation of new ideas and knowledge.*

Company A displays a control and efficiency focused strategy where new knowledge is created centrally in specifically created organizations. This creates good cultural conditions for the organization's different functions. The centrally organized innovation-activities (which are separated from production-activities) create strong focused organizations, where economies of scale are utilized. On the other hand, Company B's strategy is focused at employee development; whish stimulates a quick adoption of new ideas and knowledge. Centrally, the company develops vision and conceptual ideas for innovation that have a guiding function for the development of the organization.

3. *Frequent communication arouses participation in innovation and stimulates knowledge development. In relationship to this, it often means that the culture of the people involved has to change; otherwise innovative developments hardly can be sustained.*

With the guidance and support from the top management, the independent companies are charged with the implementation and fruition of innovation. The management involves everyone in innovation through frequent communication, open discussions and education. Regular meetings (where people can freely share their experiences and voice their problems and concerns) facilitate the personal development and improve job satisfaction.

4. *The integration of the different functions decentrally in the organization creates a dynamic and energetic environment, that allows the individual companies to respond quickly to market changes.*
5. *The person-oriented culture provides an organization the ability to continuously learn and develop over time. This requires the active involvement of the employees, and a well developed organizational structure and leadership.*

To conclude, both *central* and *decentral* approaches for an innovation strategy display organizational advantages (e.g. efficiency innovation development vs. market responsiveness) that have long-term effects on the company's operation and development. This comparison between two typical innovation management strategies shows that a number of basics should be implemented to ensure the developed innovations are implemented effectively. The underlining idea is that it will be hard to implement innovations without also developing your organizational culture. Furthermore, companies A and B show practices that will stimulate the implementation of any innovation strategy. Company B shows that careful attention to employee development, together with employee empowerment, arouses employees to implement ideas much faster. But, you cannot empower all innovation initiatives. Company A shows that basic innovation ideas are best developed at a higher, strategic organizational level. The company also shows that a strongly developed innovation vision is stimulating and provides a necessary alignment of goals.

The two construction companies that have been studied in this paper have both been innovative in the past few years. Company A has been able to develop a number of innovative business concepts such as floating houses. Additionally, the company gained publicity with a number of innovative asphalt types. A few new asphalt types are asphalt on a roller and a new noise reducing asphalt. Company B is known for its well developed construction processes, supported by 3D modulation systems. The company did receive an award for its harmoniously organized construction processes that did dramatically improve job satisfaction over the years.

Our research findings are based on a study of two Dutch construction companies. The small number of cases analyzed in this paper makes it hard to generalize its findings for a large number of Dutch construction companies. However, this research displays two cases where a central and a decentral organization of innovation are transparently observable and clearly shows the consequences of these choices. It are typical cases that show that these organizational decisions can have a long term impact on a company's development path. It are these consequences that provide construction companies with essential insight on how to develop an innovation strategy that can be effectively implemented.

6. ACKNOWLEDGMENT

The paper is based on a large explorative research undertaken in the year 2005: "Best practices of innovative behavior". This research is part of the national Dutch PSIB-Programme on Revaluing Construction (PSIB, 2003). The aim of the research was to investigate practices of innovative behavior. During the research, a number of conditions for innovations were identified and investigated more closely at four companies. Two of those companies are the subject of this paper. The research is limited to the Dutch construction industry. The authors wish to thank the PSIB and the companies involved for their willingness to participate into this research project. The Dutch reports can be obtained by contacting the authors.

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MEASURING ORGANIZATIONAL CULTURE IN CONSTRUCTION SECTOR - FINNISH SAMPLE

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ABSTRACT

Multiculturalism brings new challenges to project execution in global market place than to projects executed in the home market area. Project participants come from different national and ethnical backgrounds in addition to other cultural divergence (e.g. professional, industrial, and organizational). Culture is a particular group's response to its environment and it is expressed by group's individual members (Hofstede 1997). Cultures' manifestations are visible (e.g. language, clothing, and values), but often the attention is arrested only on these visible issues, ignoring the fact that every culture has 'hidden' values and beliefs that even a member of that culture cannot describe. Cultures have several dimensions; visible artifacts, values and basic assumptions (Schein 1985).

The purpose of this paper is to describe the underlying values of the construction sector in Finland. This knowledge can be used in practice, when there is a need to for example implement safety regulations to the whole industry or move to more effective practices. The focus is, on the one hand, in organizational culture and, more focused, organizations acting in construction sector. On the other hand this survey consists of only Finnish respondents from a Finnish construction related companies. This gives even more focused viewpoint to Finnish national culture. The paper consists of two parts. First, the organizational culture of construction sector companies has been investigated with the Organizational Culture Assessment Instrument developed by Cameron and Quinn's (1999). The tool is based on the Competing Values Framework. The questionnaire was translated to Finnish and conducted together with The Confederation of Finnish Construction Industries RT. The questionnaire was web-based and sent to around 600 respondents.

Second, the characteristics of a Finnish national culture have been summarised from several sources. For example Geert Hofstede's work (1980) has been regularly quoted also among Finnish researchers and this paper includes a literature survey of that material extended by the knowledge gained through previously conducted case studies. This paper promotes also the Finnish research effort concerning the management of cultural diversity in global construction projects.

Keywords: construction sector, Finnish, organizational culture

1. INTRODUCTION

Fast changing business environment requires companies to be in a constant change. This is nowadays true in all fields of business activities. The rapid change is becoming a bigger challenge. Forming organization into a new structure or changing business strategy does not happen easily. Change is not just adopting new systems and methods, but it requires changes in underlying assumptions and values, hence organizational culture. In this paper, there is the assumption that culture is something an organization has (cf. culture is an element that organization is, Smircich 1983). To be able to change, one must know the values affecting to the current situation. Several studies have tried to explain the success of the successful organizations (e.g. Kotter and Heskett 1992). Elements like competition, monopoly position or high market shares have been proved in practice to not explain success very well. The basic assumptions and values, hence organizational culture, are proved to be the most important element of competitiveness (Cameron and Quinn 2006).

Competing values framework (Quinn and Rohrbaugh 1983) is only one theory that tries to explain organizational effectiveness (see more Cameron 1986 and Cameron 2005). Cameron and Quinn (2006) see organizational culture something that organization has (cf. Smircich 1983). The framework emphasizes multiple perspectives and types of measures to evaluate the effectiveness of the organization. Hence, there is no universal model of effective organization. This basis is also supported by contingency theory (e.g. Lawrence and Lorsch 1967). There is an on-going international research effort to understand on industry level of what kind of “valueset” (if there is any) guides nowadays more and more global way of business actions in construction sector. The Organizational Culture Assessment Instrument (OCAI), which is based on the competing values framework, was seen to suit well for the international survey, as well as being available for researchers all around the world (see more about the reliability and validity of OCAI in Cameron and Quinn 2006).

In this paper, the organizational culture has been bound to national culture and a specific industry (construction) that are considered here relatively constant (cf. McSweeney 2002). Also the situational effects on culture are dismissed here, because the ultimate purpose is to understand underlying values on general level (in the future also the national differences), not related to single cases or events. Also, the type of generalisation of an average tendency (used in this paper) has been criticised (McSweeney 2002), but it is believed to be the best available method so far.

The concept culture is often defined unified way. However, for example organizational culture differs from national culture. Organization’s members have a possibility to join and leave the organization, hence the influence of organizations culture, but same could be argued not to happen conserning national culture (Hofstede 1997). The nature of, for example, national and organizational cultures is different. On the other hand there is a debate if the organizational culture can be treated as a one entity. Especially the large multinational companies, which are geographically dispersed can have many sub-cultures (Alvesson and Berg 1992).

There is a relation between the two above-mentioned cultures. Earlier research has found that at the national cultural level, the values are in a bigger importance compared to organizational cultural level, where the practices have the major role (Hofstede 1997). In fact, how a specific culture can be separated as an objective of a research? Hofstede (1997) claimed that when most of the factors (e.g. organization, occupation) are same, the national culture is a rational explanation for unfolding differences. Here these two cultures are not separated resulting the overall organizational culture in Finnish construction sector.

Meyerson and Martin (1987) differentiated three perspective for cultural change: integration, differentation, and fragmentation. All these elements are present in organizations. Cameron and Quinn (2006) look culture from integration perspective. Hence people in organization share a common culture. They rationalize this by the view that the strenght of culture is its ability to bring people together (positivistic view). Differentation and fragmentation perspectives consider organization culture as a collection of many competitive sub-cultures or an ambiguous and unknowable entity (Meyerson and Martin 1987).

Geert Hofstede conducted his famous research about cultural differences already during 1960's and 1970's and the results were published at 1980 (Hofstede 1980). Lots of data were analysed and as a conclusion four cultural dimensions were found that had variation across the nations. In his later studies Hofstede found a fifth dimension, which has been widely discussed since. In this paper, the description and analysis of Finnish cultural values is based mainly on the Hofstede's study, which is the only large-scale research that includes also Finland.

The environment affects on organizations (Scott 2001). Especially construction has been, and still is firmly, a local business. Yet, the amount and size of the "megaprojects" has increased (e.g. Miller and Lessard 2000, Flyvbjerg et al. 2003). The players on this field are becoming international and this way the globalization affects also on construction sector. This is a preliminary attempt to reveal the underlying assumptions and values that is needed in order to know in what direction the whole industry is going.

2. MEASURING THE ORGANIZATIONAL CULTURE

The competing values framework

The Organizational Culture Assessment Instrument OCAI –tool is based on the theory about Competing Values Framework developed by American researchers Kim S. Cameron and Robert E. Quinn (Cameron and Quinn 2006). The purpose of the theory is to help understand organizational phenomena, such as organizational design, stages of life cycle development, organizational quality, leadership roles and management skills. Organizations are functioning in fast changing environment, which requires organizations to change as well. To be able to change the organizations need to know their current situation and the direction, where they want to be in the future.

Several studies relate to the assumption that organizational culture is one of the most important factors creating company's competitive advantage (e.g. Kunda 1992). The culture can be defined in several different ways and often there are even opposite or competitive values in the background of an organization. Competing Values

Framework is one theoretical model to explain organizational culture. OCAI-instrument does not include everything that can affect on organizational culture, it has been used in more than a thousand organizations and it has been found to predict the organizational performance. The theoretical model is based on several indicators of effectiveness, which differentiate from each other by two dimensions, hence forming four main clusters (Figure 1). First criteria of effectiveness emphasises flexibility, discretion, and dynamism from stability, order and control. The second dimension differentiates an internal orientation, integration and unity from external orientation, differentiation and rivalry. There are no right or wrong answers. More important is that organization's culture is in line with the organizational phenomena mentioned above.

The answers indicate of what the employees think of being the contributors of efficiency. The elements like the age or size of the organization affect the answers. Respondents from different organizational units might give very different answers; hence they have different view of the culture in the organization. However, usually only one of the main clusters becomes more dominant than the others. Culture also changes over time without conscious efforts.

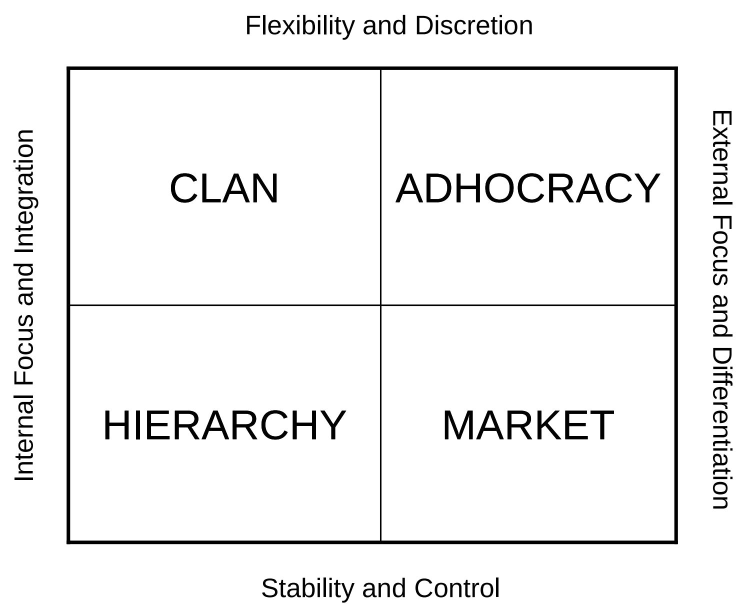

Figure 1 The Competing Values Framework (Cameron and Quinn 2006)

The four major culture types
The four main clusters of effectiveness (major culture types) are called CLAN, ADHOCRACY, HIERARCHY, and MARKET (Figure 1). These types differentiate among the dimensions mentioned above. For example some organizations are seen effective by their members, when the organization is adaptable and changes when ever needed. This can actualise for example by constantly changing organizational structure or product mix. On the other hand, the governmental organizations are often seen effective, when they act stable and predictable. Organizations can also be viewed effective when their internal characteristics are coherent, hence the organization acts

consistently. On the other hand, some values when an organization acts strongly along the external influences.

The area in upper left is been described as CLAN culture (Figure 1). These types of organizations are like extended families that have shares values and goals. The employees are committed to the company as well as the company to its employees. The work is done by teams that can have quite autonomous roles and the customers are seen as partners. The ADHOCRACY culture describes the effectiveness criteria in upper right corner (Figure 1). Young organizations have typically this culture. In adhocracy culture, the environment forces the organizations to be very flexible in their actions. Employees are motivated to be innovative, creative, and entrepreneurial. Unlike market culture, the power has been separated between individuals and teams. However, the external factors guide the development of this type of organization.

In the lower right corner is the MARKET culture (Figure 1). The activities are externally oriented, but the power is centralised unlike in ADHOCRACY. The effectiveness of this type of company is viewed through, for example, profitability and market shares. The main values are competitiveness and productivity, which are measured also between the organizational units and even between individuals. The last quadrant in lower left represents HIERARCHY culture, which is very typical for organizations in the public sector and relatively old organizations. This type used to be the ideal form of organization, because it is stable and consistent. However, the relatively faster changing environment emphasises nowadays other cultural elements. On the other hand, for example governmental organizations still need to act predictable and reliable. The rules and procedures need to be same for all employees.

The realization of the survey

The Internet link to the questionnaire was sent to 600 white-collar workers in Finnish construction companies, out of which 200 responded. The representativeness of the sample has limitations, which are dealt at the end of this paper. The questionnaire included two parts; first respondents were asked to evaluate current situation, then the preferred situation in the near future. The respondents gave their answers based on their feeling about the issue. The questionnaire has been divided into six dimensions. These dimensions have been obtained from the framework called a psychological archetype developed by psychological theorists (e.g. Mitroff 1983). It has been pointed out that people make sense of the world around them in a similar way. Cameron and Ettington (1988) give more thorough explanation between the framework and OCAI-instrument.

The six dimensions are as follows: I Dominant characteristics, II Organizational leadership, III Management of employees, IV Organization glue, V Strategic emphases, and VI Criteria of success. Each dimension include four alternatives (Cameron and Quinn 2006), which correspond with the four cultural types. The respondents rated each of the four alternatives by being either very important (1), important (2) or not important (3). The analysis consisted the amount of “very important” responses. The alternative, which has gotten the most of “very important” responses, is being rated as 3, second most 2, third 1 and fourth 0. The common way of using the OCAI tool is by formal interviewing. However, because of the time constraint, the Internet was used. On the other hand, the need was to gain overall picture of the values in construction companies in Finland. The use of computers and

Internet is very widely spread in Finland. In practice, everybody has the opportunity to use Internet freely.

3. THE ANALYSIS OF THE RESPONSES

Background of the respondents

Some of the organizations act internationally or are Finnish sub-units of international organizations, but only one of the respondents was not Finnish by the nationality. Around 80% of respondents were men and 94% of all indicated to being Christian. As a comparison, 80% of Finns are Christian and belong to the Finnish Lutheran Church. The next biggest is Finnish Orthodox Church (1,1%), whereas 13,5% do not belong to any religious communities. 7% of the respondents were over 60 years old. Major groups were 51-60 years old (almost 40%) and 41-50 years old (almost 40%) respondents. The rest were 40 and under. The educational backgrounds varied a lot from basic training to licenciate.

The answers were divided and analysed by two different classes; first classification was by the sub-industry consisting housebuilding (50%), construction products (30%) and other (20%, e.g. special contractors, machinery rental service). The other classification was by the size of the company; over 500 employees (60%), 100-500 employees (30%) and under 100 employees (10%).

Results by sub-industry classification

The Figure 2 represents the results from housebuilding sub-industry. The respondents viewed current organizational culture as MARKET type in concerning dimensions I and II. The CLAN culture was most mentioned in dimensions III, IV and V. In dimension VI the HIERARCHY culture was mentioned most often. The preferred situation is quite unanimous. The CLAN culture was mentioned concerning five out of six dimensions. Only in the VI dimension, the HIERARCHY culture was most mentioned. In the current situation the CLAN and MARKET cultures were as strong, but in the future, the values related to CLAN culture will strenghten.

The responses in the construction product sub-industry varied only a little from housebuilding sub-industry. The Figure 3 shows the results in construction product sub-industry. The MARKET culture was strongest considering the dimensions I and IV. The CLAN culture was strongest in dimensions II and V. The ADHOCRACY culture was emphasised in dimension III and the HIERARCHY culture in dimension VI. The preferred situation was again seen more like the CLAN culture. Only in dimension I, the ADHOCRACY culture dominated and in dimension VI, HIERARCHY culture.

Figure 4 represents the responses from other construction related sub-industries indicated also the strong role of MARKET culture (dimensions I, II and III). The CLAN culture dominated dimensions IV and V, whereas the HIERARCHY culture was strongest in dimension VI. The preferred situation emphasised again the CLAN culture (dimensions IV and V). The ADHOCRACY culture was strongest in dimensions I, III, and V, and the HIERARCHY culture in dimension VI.

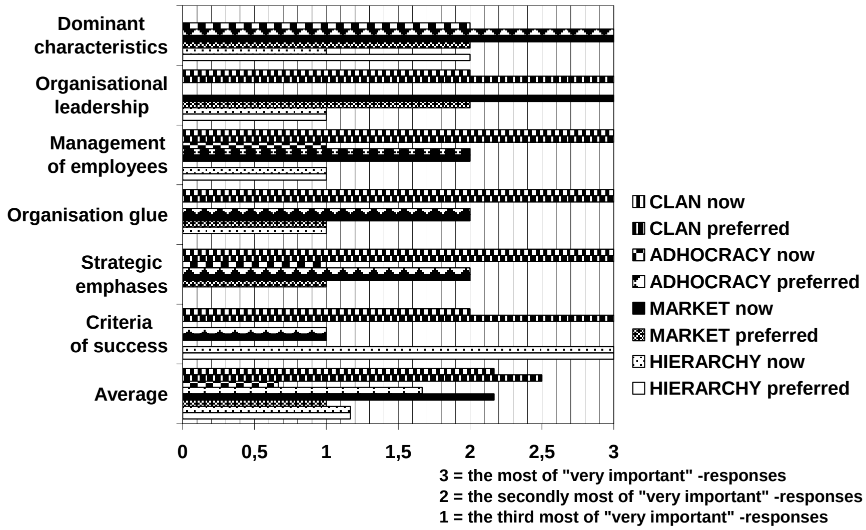

Figure 2 Organizational culture in housebuilding sub-industry

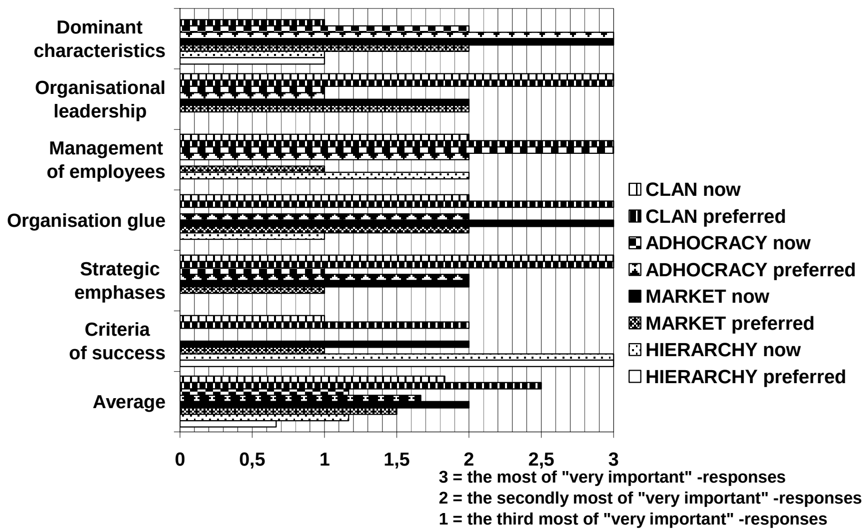

Figure 3 Organizational culture in construction product sub-industry

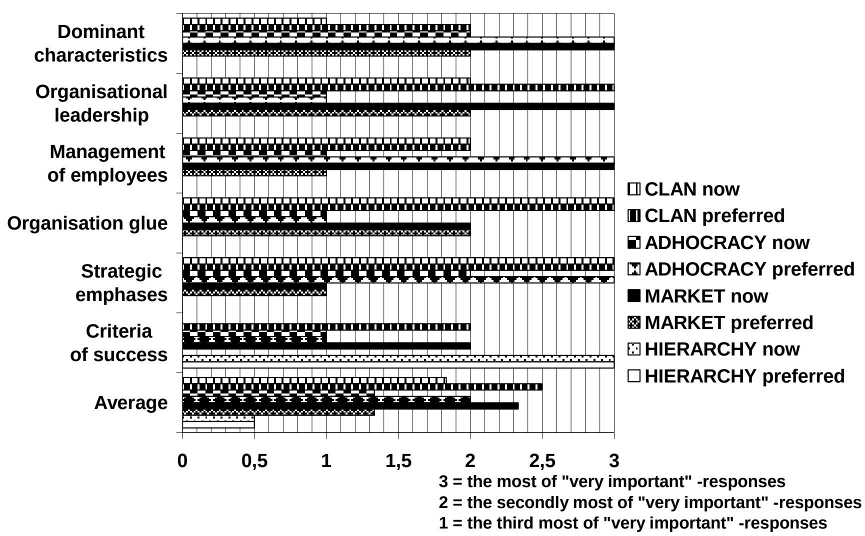

Figure 4 Organizational culture in other construction related sub-industries

Results divided by amount of employees

The Figure 5 represents the situation in companies that employ under 100 person. In the I and IV dimension the CLAN culture was the strongest. In the dimension II and V the ADHOCRACY culture was strongest, but in dimension II the MARKET culture as well was strongly emphasised. The HIERARCHY culture was strongest in dimensions III and VI. The preferred situation strenghten the position of CLAN culture, which is the strongest in all of the dimensions.

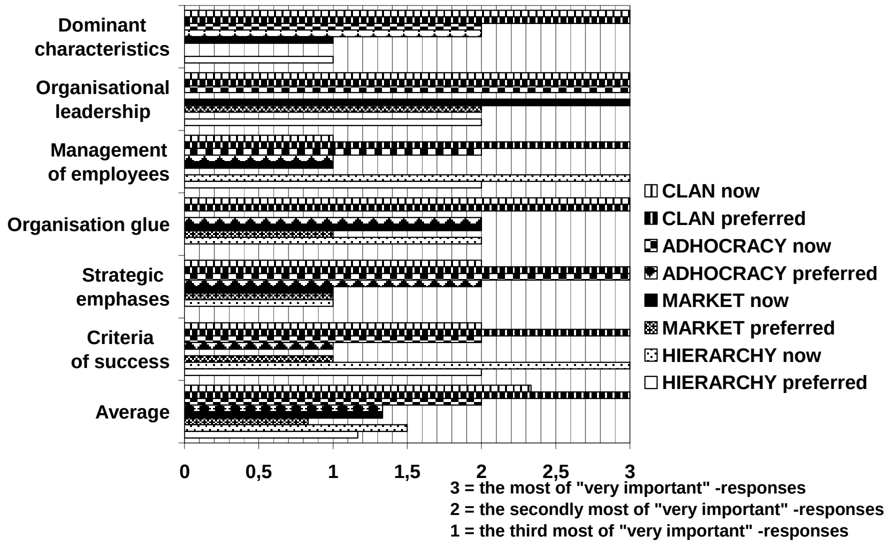

Figure 5 Organizational culture in companies employing under 100

Figure 6 represents the responses from companies that employ 100-500 persons. The MARKET culture was the strongest in dimensions I, II and IV, whereas the CLAN culture was the strongest in the dimensions III and V. Again the HIERARCHY culture was dominating the dimension VI. In the preferred situation the CLAN culture was dominating the dimensions II and IV and the ADHOCRACY culture was emphasised in the dimensions I, III and V. The HIERARCHY culture dominated the dimension VI.

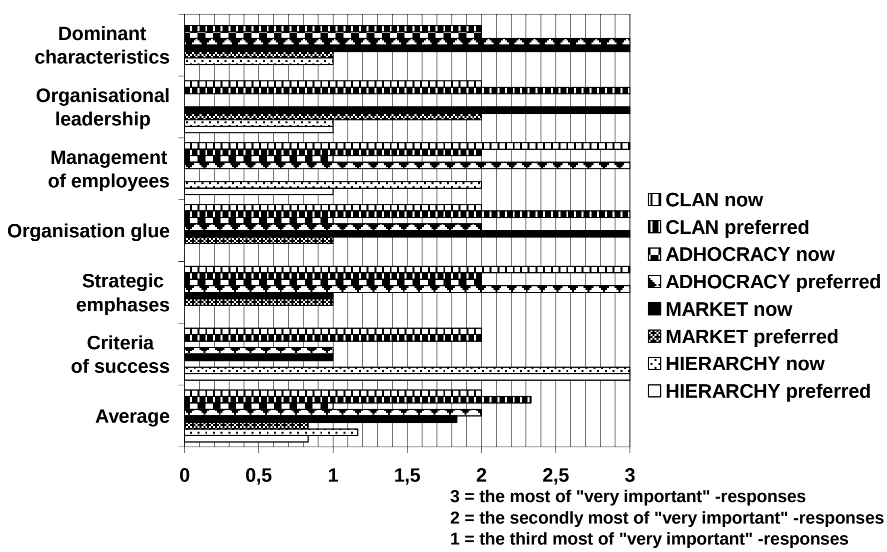

Figure 6 Organizational culture in companies employing 100-500

The Figure 7 includes the responses from companies that employ more than 500 persons. This group was relatively big compared to the last two groups. The MARKET culture is emphasised the most (dimensions I-V), whereas the HIERARCHY culture dominated the dimension VI. The preferred situation followed the familiar pattern, where the CLAN culture was strongest (dimensions II-V). The ADHOCRACY culture was seen the strongest in the dimension I and the HIERARCHY culture in the dimension VI.

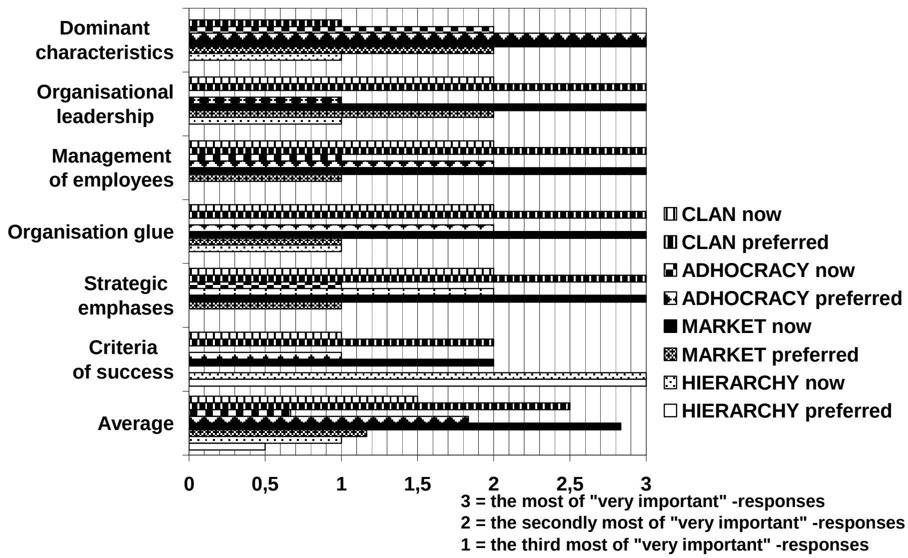

Figure 7 Organizational culture in companies employing over 500

The sensitivity analysis

The method presented here was not exactly as the original OCAI analysis. First of all the individual respondents answered in relation to their own organization, but the results are used to valuate the underlying values of the whole industry on a national level. An average tendency is believed here to give relatively real picture about the current, as well as the preferred situation in the industry. The classification into two different parts gives a bit more detailed information about the responses. Even if the respondents were asked to estimate the alternatives with three part category, only the “very important” –responses were analysed in this study. The results are not analysed by using actual statistical methods, but the purpose here was to get an idea what is the current situation in Finnish construction sector. These results will be then compared to the international results.

4. FINNISH NATIONAL CULTURAL CHARACTERISTICS

Culture as a concept has been described in many ways. One of the most used definitions is that culture is a particular group’s response to its environment and that it is expressed by group’s individual members. On the one hand culture can be differentiated from human nature, and on the other hand from personality, but exact boundaries cannot be determined. Culture is shared ideas of acting, thinking, and feeling - these are not inherited but learned (Hofstede, 1991). It takes time for a group of people to learn a common set of ideas. Most of people do not recognize their own behavioral background, which is the basis to learn how to respond to cultures of others.

Finns are very homogenous group from their ethnical background. According to Hofstede's survey (1980), which has been conducted already several decades ago Finns have low power distance, medium uncertainty avoidance, high femininity compared to masculinity and Finns are more individualistic than collectivistic. Also Tixier's (1996) study emphasises the last dimension. Following Table 1 introduces the Finnish scores in the Hofstede study at 1980 and in the fourth column the indication of current situation based on the subjective valuation of the author. The fifth dimension was defined later and it included only 23 countries. Finland was not among them.

Table 1 Finland's scores according to Hofstede study (Hofstede 1980)

Dimension	**Score rank**	**Score (scale)**	**The preliminary indication of the cultural development**
Power distance (PDI)	46/53	33/(11-104)	≈
Individualism (IDV)	17/53	63/(6-91)	↑
Masculinity (MAS)	47/53	26/(5-95)	↓
Uncertainty avoidance (UAI)	31/32 / 53	59/(8-112)	↓
Long-term orientaton (LTO)	-	-	(↓)

The overal development in Finland has closely followed the development in Western neighbours Sweden and Norway. During the 1990 Finland tooked the leading position in business on the coat-tails of Nokia. Already during the 1980, the influence of US has been strong in Finland. Finnish culture has moved towards more individualistic, masculine and risk taking dimensions. Power distance was already on relatively low level and it seemed to stayed at that same level. The original level of LTO is unknown, but "the quarter economy" has left its marks also to the Finnish society by shortening the durability of, for example, products and relationships. The conclusions drawn here, hence cultural indications, are preliminary results of several years study investigating the role of culture in large and multinational projects conducted by Finnish companies.

5. CONCLUSIONS

The overall organizational culture in Finnish construction companies, based on this study, is very market oriented. The elements of the national culture support this result (e.g. IDV, UAI). The key elements are the productivity and competitiveness. Individuals are rewarded when the financial result is good or new market shares have been won. Also the internal competition between units and individuals is hard. The power has been centralized, and there exists several tools and procedures for different purposes. The external market environment guide the actions, but it is seen also as a threat.

The preferred situation among the respondents is also very clear. People in the industry would like the culture be as the CLAN culture. Compared to the current situation, the values will emphasise more the internal focus and integration. The employees are the most important resource for the company and their welfare is important. The customers are like partners, where the success of the company is measured by how satisfied the customers are. The changes in environment mean new business opportunities and are seeing as a part of everyday life. Even if the nature of the CLAN culture can be seen as a collectivistic, the focus is still in the closest working environment. Hofstede (1991) defines individualism as taking responsibility also on the family and those in the close relationship.

The responses addressed relatively clearly only one cultural type. This means that construction industry is operating quite effectively. Effectively in a sense that the values of people are congruent. Because the positions of respondents were not clear, the following trends might tenable:

- the respondents in the higher managerial positions evaluate the organizational culture more often as CLAN culture than the repondents in the lower levels
- MARKET and HIERARCHY cultures are usually relatively stronger than ADHOCRACY and CLAN cultures. The change from the latest two to the first-mentioned requires more investments than other way round

Large part of the respondents were from companies that employ more than 500 employees. The construction sector in Finland, as well as other countries, consists of big amount of small companies. However, the big companies have relatively more power compared to the whole industry, so these results are relatively tenable. Notable in the results is the role of ADHOCRACY culture. In the companies that employ under 100 persons, the trend of this culture is opposite than in other groups. Also the HIERARCHY culture was without exeption the strongest in the dimension VI, Criteria of success.

Hofstede did advanced study that despite several efforts has not completely been replicated even today. The national culture in this study was treated more like a context, even if changing slowly. Finns as other nationalities are more and more influeced by globalisation. Coping with other cultures as well as taking advantage from multiculturality will definitely give the competitive advantage to the companies in the construction business.

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CHALLENGES OF STANDARDISING THE INNOVATION MANAGEMENT IN THE SPANISH CONSTRUCTION INDUSTRY

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ABSTRACT

Construction industry is judged as non-innovative, even though, construction works are project-based and each project always needs to adapt procedures and materials. Spain is the fifth country in the European Union in terms of production in the construction industry, with figures very close to that of United Kingdom, France or Italy. In spite of that, the Spanish construction industry is particularly non-innovative: its investment in innovation is eight times less than the European average. In order to solve this problem, a new set of standards (UNE 166000) was issued to encourage the technological innovation in a continuous and methodical way. This normative implies a change of scenario where innovation can be regarded as any other business management process and, consequently, it can be standardised. Systematisation is performed through certification by a recognised body. Companies can attain certification applying UNE 166001 for R&D&i projects and UNE 166002 for R&D&i management systems. The later standard can also be integrated very easily with the quality management standard ISO 9001. Until now very few companies in the Spanish construction industry have obtained any certification. Nevertheless, this situation may change radically in the near future due to the companies' needs to exhibit proof of their R&D&i progress in the bidding procedure for public works and services.

Keywords: Certification, Spain, Standardisation, Management

1. INTRODUCTION

The construction industry accounts for 10% of Gross Domestic Product (GDP), approximately, in developed countries (Crosthwaite, 2000). According to SEOPAN (2005), values for the European Union (EU-15) range from 6.7%, in Sweden, to 16.6%, in Ireland; production in construction accounted for more than one billion of euros (10^{12} €) in 2004. Civil works represents only 21% of the total, whereas building renovation and maintenance, residential and non residential building complete the whole (SEOPAN, 2005).

Even though the construction industry has not been widely analysed as other sectors (agriculture in the past, and manufacturing and services nowadays), it is blamed as non innovative (Tucker and Borcherding, 1977; Shenhar and Dvir, 1996; Jones and Saad, 2003; Blayse and Manley, 2004). Despite that, other authors enlighten the characteristics of the industry as opportunities that could be used to enhance innovation in one way or another (Tatum, 1989; Groàk, 1994; Slaughter, 1998; Gann, 2000). Recently, some specific books, that highlight the importance of innovation in the construction industry, were written by Gann (2000), Jones and Saad (2003), and Manseau and Shields (2005).

Instead of the construction industry, Gann and Salter (2000) use the concept of construction process. This process displays the five traditional phases of the facility life cycle: feasibility, design, construction, operation, and divestment. The tangible product is the built infrastructure. Nam and Tatum (1988) reveal the main features of this construction product: immobility, complexity, durability, costliness, and high degree of social responsibility. Gann and Salter (2000) also elaborate the idea of a project-based industry materialised by companies that work by projects. For each phase of the process different kinds of projects are needed and, consequently, specialised project-based companies appear.

Spain is one of the major countries in the European Union with respect to the volume of production in the construction industry, along with Germany, France, United Kingdom, and Italy. The main Spanish construction companies also get first-class contracts in Europe and America: the new semi-floating breakwater for Monaco Harbour, the Öresund bridge linking Denmark and Sweden, the Trakia motorway crossing Bulgaria from Serbia to the Black Sea, the Ting-Kan bridge in Hong Kong, the Trans-Texas corridor, and the east side access Manhattan tunnels, among others. In spite of that, the Spanish construction industry is especially non-innovative. Spanish spending on R&D&i activities, as percentage of GDP, is half of the EU-15 and one third of the United States (CICYT, 2003). When referred to construction, Spanish investment in innovation is approximately eight times less than the EU-15 average (Villar-Mir, 2001). Furthermore, until some months ago, no initiative was taken to prompt the innovation in the industry, as it happened during last decade in United Kingdom through the Latham (1994) and Egan (1998) reports, and the later Movement for Innovation (http://www.constructingexcellence.org.uk).

Applying the commitments adopted by the European Union at Lisbon in 2000 (CICYT, 2003), the Spanish government has just issued the program Inventiveness-2010 (Ministerio de la Presidencia, 2005) to bridge the gap of research, development and innovation with the western economies. Fiscal incentives are given to enterprises that invest in R&D&i activities. Additionally, some public agencies are rewarding construction companies in the bidding process if these companies show up proof of their innovation; this reward can be up to 25% in the final score of the bidding (http://www.fomento.es).

In this paper, we are going to display a new scenario where innovation is seen as another business management process capable of being systematised; this way, innovation can undergo standardisation in accordance with an external certification body. First, the apparently exclusive terms of innovation and standardisation are evaluated. Later, the new Spanish normative UNE 166000 is deeply analysed, mainly from two approaches: R&D&i projects and R&D&i management systems; a comparison with the standard ISO 9001 is also provided. Finally, the main conclusions of our work are stated.

2. INNOVATION VERSUS STANDARDISATION

Currently, the construction industry is applying flexible processes and holistic methods (Jones and Saad, 2003). Project management is the usual way of managing work in design and construction companies; nowadays, this is viewed as an innovative way of management in other sectors too (Hobday, 2000). These features (flexibility, holistic and project-based approaches) encourage innovation, but they are rather opposed to standardisation. Thus, are they compatible? And, is it possible to standardise?

Kondo (2000) affirms that innovation and standardisation are not mutually exclusive. For this author, in order to achieve a good harmony between them, work standards have to clearly specify the "true aim of the work" and afford "freedom in the means and methods" (p. 9, Kondo, 2000). He proposes that manuals should be oriented to beginners for training or to experienced workers for know-how. In this same direction of thought, Edum-Fotwe et al. (2004) present a case study of a British public agency that manages innovative solutions for the health sector by means of standardisation; standards offer the baseline for reliable performance, whereas significant elements of innovation are captured and added to the standards. No further literature was found relating innovation and standardisation.

Nevertheless, several papers were discovered about the relationship between innovation and quality management. Kanji (1996) displays a simple model where each kind of innovation undergoes the quality management process to become successful innovation; several examples are given to enhance the idea. Keogh and Bower (1997) present a case study to detect links between quality management and innovation in the oil and gas industry. Bossink (2002) investigates the supportive use of quality tools in the management of innovation; he finds that these quality tools, ISO 9001 standard among them, are very useful for the management of innovation.

In 1989, BSI issued the standard BS 7000-1 "Design management systems: guide to managing innovation"; it was republished ten years later. This standard gives advice on "the development of innovative and competitive products that will satisfy customer's perceived and talent needs in the long term future" (p. 1); it goes beyond design management, but it does not cover continuous improvement. However, more than a typical standard, BS 7000-1 can be considered as an academic paper addressing key issues on managing innovation related to design: roles, types, processes, organisation, tools and techniques. Another standard, BS 7000-4 ("Design management systems: guide to managing design in construction", published in 1999 by BSI), deals with specific issues on managing design in construction. Three main features have to be highlighted from the analysis of these British Standards. First, their scope is product design (even the BS 7000-4 that is focused on construction). Second, they provide a framework for managing innovation, but not in a systematic way. Finally, they rely on ISO 9001 standard as complementary support.

In western and developing economies most companies innovate, not only in the construction industry but also in other sectors. However, the core difficulty is continuous and methodical innovation; random efforts and intermittent brainwaves are not enough. Innovation has achieved a critical point where it is not a gift anymore but a professional feature; thus, it has to be planned, organised, directed and controlled, as any other managerial activity (Pellicer and Yepes, 2005). ISO 9000 standards series can serve as a basis for it; nowadays, many companies are applying these standards to their business processes in the construction industry (Koehn and Datta, 2003).

Systematic innovation presents many advantages for project-based companies in the construction industry:

- Efficient exploitation of resources and know-how.
- Improvement of organisational activities.
- Achievement of goals and objectives previously fixed.
- Differentiating factor for competitiveness and business status.
- Technology transfer.
- Tax deduction.
- Enhancement of employees' motivation.
- Enrichment of stakeholders' satisfaction.
- Identification of changes and new opportunities through technological watch.
- Integration with other ISO standards.

3. UNE 166000 STANDARDS

In order to induce the systematic innovation in the Spanish economy, the experimental standards UNE 166000 were issued in 2002 by AENOR (the responsible body for developing Spanish standards); this year, the main standards have been edited in a definitive version. This new normative aims to enhance managing the methodical innovation, especially in medium and small enterprises. These standards comprise:

- UNE 166000: 2006. "R&D&i management: terminology and definitions of R&D&i".
- UNE 166001: 2006. "R&D&i management: requirements for R&D&i projects".
- UNE 166002: 2006. "R&D&i management: requirements for R&D&i management systems".
- UNE 166003 EX: 2003. "R&D&i management: competence and evaluation of R&D&i projects auditors".
- UNE 166004 EX: 2003. "R&D&i management: competence and evaluation of R&D&i management systems auditors".
- UNE 166005 IN: 2004. "R&D&i management: application guide of UNE 166002: 2002 EX to equipment sector".
- UNE 166006 EX: 2006. "R&D&i management: technological watch system".

Certification can be obtained for innovation projects (UNE 166001) and for innovation management systems (UNE 166002). The former can focus on planning or execution. The latter is thought to develop the integration of R&D&i within the quality management systems ISO 9001. Nowadays, these standards are mainly used in Spain; recently, they have also been introduced in Mexico, Brazil, Italy and Portugal.

In the Spanish construction industry, following the Inventiveness-2010 program, public agencies are evaluating innovation through the bidding process for works and services contracts issued by the central government; the measurement of innovation is based on UNE 166000. The pace for innovation in the industry is increasing, even though it is going to take some time to reach the EU-15 average. For instance, at the end of 2005 only one out of 42 certified companies was a construction firm. At the beginning of this year, there were 32 application forms on administrative queue waiting for a positive decision to obtain certification; 10 out of those 32 forms were from firms in the construction industry.

4. CERTIFICATION FOR INNOVATION PROJECTS

Standard UNE 166001 is a reference for defining, documenting and developing R&D&i projects. It includes the relevant aspects of managing the project and exploiting its results. This standard aims to facilitate the systematisation of R&D&i projects. Thus, every type of organisation, especially medium and small enterprises, can identify innovative activities, develop and document them in a methodical way to obtain a sound and well regarded achievement in innovation. Furthermore, this innovation can be certified and displayed for acknowledgment, whenever it is necessary. Companies particularly pursue fiscal and tax incentives in order to improve its resources, products and processes. In these R&D&i projects, results may differ significantly from the initial goals; even though these results can be of better value if they get more innovative consequences. Innovative outcomes could be: incremental or radical; modifications of something existent or completely new; products or processes; or oriented to consumption, industry or management.

A potential innovative project needs a person in charge, with well-defined tasks. Then, the R&D&i project is documented as follows: (1) main report; (2) scope of work; (3) budget; (4) document control; (5) project monitoring; and (6) exploitation plan. The main report includes: summary, methodology, goals and planning to measure them, impact and opportunity regarding R&D&i. The current state of the art of the product, process and technology is also summarised. Foreseen scientific and technical advances, intellectual property protection and laws and regulations affected are emphasised too.

Scope definition comprises the work breakdown structure and the product breakdown structure or, in other words, the organisational hierarchy of project tasks and project results, respectively. It also includes: allocation of human resources, identification of critical milestones, assessment of risks, supervision of project tasks and results. It is recommended to display flowcharts: either bar charts or network charts.

The project budget is based on cost estimating and previous scheduling. Resources, task duration and their relation through the work breakdown structure are needed to obtain actual costs; cost traceability is also essential. Document control and project monitoring close the project management cycle. Project monitoring, according to this standard, demands regular reports to explain results, costs and deviations.

Finally, UNE 166001 asks for exploitation of results in order to use, disseminate and protect them. The plan includes: identification of the new product or process, definition of stakeholders and markets interested in their use, protection of outcomes (if appropriate), economic exploitation of results, foreseen costs according to several scenarios, and benefits of the project related to business competitiveness.

Figure 1 explains the certification process for R&D&i projects. The process starts when the applying company sends an application form and documentation to the certification body. The next steps follow: the application is processed and the documents are analysed; the certification organisation reports on compliance with UNE 166001; an external expert is selected (if adequate). This expert evaluates the project and hands out a technical report; if it is positive, the certification body issues a proposal for certification.

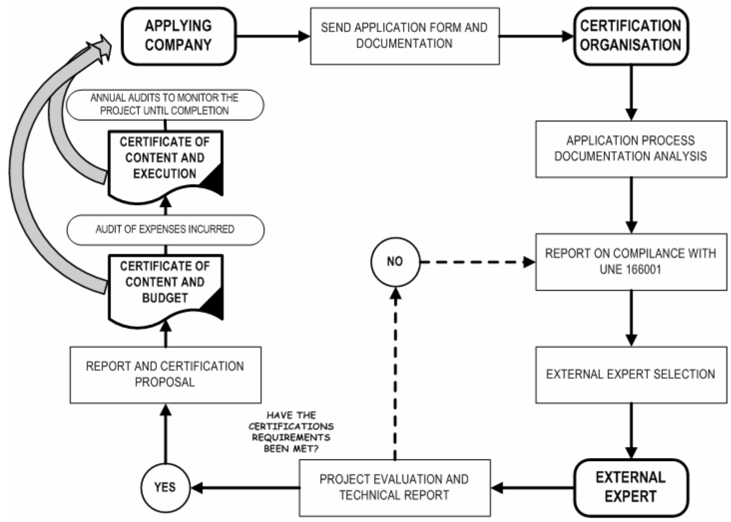

Figure 1. Certification process for R&D&i projects

This standard classifies innovation projects into two types: based on content and budget; or based on content and execution. The first focuses on projects that have not been implemented yet, but the company is interested in showing its innovative contents to clients or any other stakeholder affected. The second kind of projects underlines the actual budget spent while the project is under execution or when it has already been implemented.

5. CERTIFICATION FOR INNOVATION MANAGEMENT SYSTEMS

Standard UNE 166002 sets up the bases for systematisation of R&D&i in companies. It also acknowledges certification by an independent organisation. This normative is designed to integrate R&D&I management systems with other management systems that already exist in the company: quality (ISO 9000), environment (ISO 14000) or safety and health (OHSAS 18000). The requirements of UNE 166002 are based on process management, using the well known methodology PDCA ("plan-do-check-act"); these requirements are general and applicable to every enterprise, whatever its type or size. Five major features are developed in the standard: R&D&i management system and model; stakeholders responsibility; resources management; R&D&i activities; and measurement, analysis and improvement. They are explained in the next paragraphs.

A model of R&D&i process has to be established, documented, implemented and maintained by the organisation. A management system is also needed to improve the effectiveness following the requirements of UNE 166002. Documentation includes statements of R&D&i policies and goals, internal procedures and control records. Procedures comprise planning, operation and monitoring of R&D&i activities. It is absolutely necessary to attain control of documents and records in a similar way as stated in ISO 9001 standard.

Principals and executive officers agree to develop, implement, improve and review the R&D&i management system. They have to analyse and meet the expectations and necessities of the different stakeholders: suppliers, clients, employees, shareholders, regulation bodies, etc. R&D&i policies, planning and responsibilities are put into action with reliable communication channels and a sound organisational hierarchy. The R&D&i management unit is defined to run the system and the R&D&i projects; in some circumstances other subordinate R&D&i units can function for executing specific projects, developing new technologies or generating knowledge.

R&D&i management needs skilled resources that have to be properly allocated. Personnel motivation and training are essential to achieve the goals. Material resources and infrastructure are also important parts of this scheme.

There are several tools provided by the standard in order to develop the R&D&i activities: technological watch, technological forecast, creativity, and internal and external analysis, among others. Additional activities proposed are: identification and analysis of problems and opportunities; analysis and selection of R&D&I ideas; planning, monitoring, and control of project portfolio; technology transfer; R&D&I products; purchasing; R&D&I process results; and protection and exploitation of R&D&I activities results.

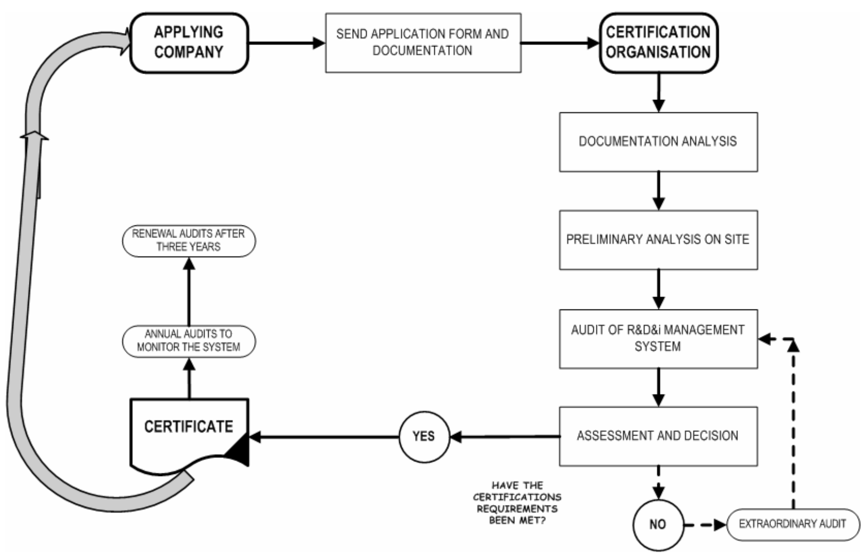

Figure 2. Certification process for R&D&i management system

Finally, the company schedules, plans and implements the monitoring process. It includes the measurement, analysis and continuous improvement of the R&D&i management system and the execution of its activities. They can be perfectly integrated in the quality management processes described by the standard ISO 9001.

The certification process for R&D&i management systems is shown in figure 2. Once the applying company sends the application form, the certification body analyses the documentation, visits the company's headquarters and performs a preliminary audit of the system. If the requirements are not met, then an extraordinary audit will be proposed to the company. Otherwise, the company gets the certificate; annual audits will monitor the system that will be renewed each three years.

6. COMPARISON BETWEEN ISO 9001 AND UNE 166002

UNE 166002 is compatible and complementary with ISO 9001; both could merge together in a common management system with different functions. Correspondence and comparison between UNE 166002 and ISO 9001 is displayed in the next table.

UNE 166002			**ISO 9001**
R&D&i management system	4.1	4	Quality management system
General	4.1.1	4.1	General requirement
Documentation	4.1.2	4.2.1	General
-	-	4.2.2	Quality manual
Control of documents	4.1.2.1	4.2.3	Control of documents
Control of records	4.1.2.2	4.2.4	Control of records
Management responsibility	4.2	5	Management responsibility
Management commitment	4.2.1	5.1	Management commitment
Stakeholders focus	4.2.2	5.2	Customer focus
R&D&i policy	4.2.3	5.3	Quality policy
Planning	4.2.4	5.4	Planning
Responsibility & authority	4.2.5	5.5	Responsibility & authority
Management review	4.2.6	5.6	Management review
Resources management	4.3	6	Resources management
Provision of resources	4.3.1	6.1	Provision of resources
Human resources	4.3.2	6.2	Human resources
Infrastructure	4.3.3	6.3	Infrastructure
Work environment	4.3.4	6.4	Work environment
R&D&i activities	4.4	-	-
Tools	4.4.1	-	-
Identification and analysis of problems	4.4.2	-	-
Analysis and selection of R&D&I ideas	4.4.3	7.2.1&2	Determination & review of requirements related o product
-	-	7.2.3	Customer communication
Planning & control of project portfolio	4.4.4	-	-
Technology transfer	4.4.5	-	-
R&D&i product	4.4.6	7.3	Design and development of product
Purchasing: process, information and verification	4.4.7	7.4	Purchasing: process, information and verification
-	-	7.5	Production and service provision
-	-	7.6	Control of monitoring devices
R&D&i process results	4.4.8	8.2.3&4	Processes & product
Protection and exploitation of R&D&I activities results	4.4.9	-	-
Measurement, analysis & improvement	4.5	8	Measurement, analysis & improvement
-	-	8.2.1	Customer satisfaction
Internal audit	4.5.2	8.2.2	Internal audit
Monitoring and measurement of R&D&i processes	4.5.3	8.2.3	Monitoring and measurement of processes
Monitoring and measurement of results	4.5.4	8.2.4	Monitoring and measurement of R&D&i processes
Control of results deviation	4.5.5	8.3	Control of nonconforming product

UNE 166002			ISO 9001
Analysis of data	4.5.6	8.4	Analysis of data
Improvement	4.5.7	8.5	Improvement

7. CONCLUSIONS

A spontaneous and random approach to innovation is not worthy any more; on the contrary, a systematic attitude to innovate is foreseeable. Standardisation and innovation are compatible concepts. Two styles of standardisation are analysed in the paper: BS 7000 and UNE 166000. On one hand, BS 7000-1 standard clarifies terms related to innovation and gives details on methodology; although, it is only a guide to manage innovation and it does not go further. On the other hand, UNE 166000 series establish a certification procedure for companies; requirements are defined and steps fixed, not only for specific projects but also for management systems. An additional feature of UNE 166002 is its compatibility with ISO 9001, thus both management systems (R&D&i and quality) can be combined together.

These UNE 166000 standards can also be applied to the construction industry. In fact, the Spanish government uses them as a tool to measure the innovation in the companies that bid contracts (works or services) for public agencies. These standards at a slow pace are certifying companies in the construction industry; nevertheless the number of application forms has escalated in the last few months. Hence, companies perceive the risk of not obtaining the certification for their near future.

It would be important that principals of medium and small enterprises in the construction industry did not regard these standards as an additional cost for the organisation and another barrier for achieving better contracts. However, this is pretty difficult to achieve because most of the firms in the construction industry do not consider innovation as a priority for business. The “old-fashioned” way of thinking by the main stakeholders in the industry is still an obstacle for innovation.

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DEVELOPING A FRAMEWORK FOR THE INCLUSION OF CULTURAL AND ECONOMIC REFERENCE IN SUSTAINABLE CONSTRUCTION

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ABSTRACT

This paper discusses the marked difference in the accepted use of the term sustainable construction between the developed world and developing countries.

Examples of cultural differences from an New Zealand perspective to the defining of sustainable construction, and referencing these examples to projects in Southern India is expanded upon in this paper.
The paper further contextualises by case study two different cultural approaches to socio/cultural public welfare housing projects. Discussion focuses on the fundamental problems faced by the basic need to provide shelter in a South Indian socio/cultural context and by contrast a Maori initiated housing project in New Zealand that adopted a whole of Government approach to address the communities housing issues.

A framework for comparing each countries claimed sustainability parameters including cost of construction and relative wealth per GDP capita purchasing parity, social discount assessment by measurement of impact on future generations with associated cultural justification of appropriateness is discussed as a possible framework for assessing buildings labeled as sustainable to be comparatively evaluated between countries.

Keywords: Sustainable Construction, economic sustainability, socio / cultural

1. INTRODUCTION

In the developed world many building environmental assessment schemes do not consider economics or costs of construction as being part of the definition of sustainable construction. The US Green Building Council's website definition of the LEED™ building assessment scheme states; "*The LEED (Leadership in Energy and Environmental Design) Green Building Rating System® is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings.*" The stated aim is for the development of high performance sustainable buildings, yet there is no consideration of cost of construction in the assessment criteria.

In contrast, in developing economies, to suggest that a building is sustainable without considering cost would be considered folly, as capital to fund projects is in short supply.

The developed nation's first generation building assessment schemes: BREEAM (UK), Greenstar (Australia), and LEED™ (USA) include no economic analysis. The Canadian GB Tool while being more comprehensive including some economic analysis is still structured in the first generation mould as mentioned by Cole (2005) the first generation tools originated in developed countries while developing countries are confronted with pressing social and economic concerns " *there domestic constraints on environmental progress are therefore qualitatively different from those in developed countries."*

Gibberd (2005) furthers the discussion on the contrast between the priorities and needs for developing countries and argues that basic human needs require attention in developing countries where as in developed countries emphasis is placed on resource depletion and environmental strategies.

Quite often buildings may be designed to have energy saving features and hailed as being "sustainable" but the cost to achieve these reduced energy consuming features may be prohibitively expensive. To put that in perspective, by way of example, the cost to supply and install a skylight system in the United Kingdom was comparatively calculated on exchange rate conversion on the supply and installation of the ventilated skylight as the equivalent of two complete houses in India.

Closer examination of some of the labelled sustainable buildings with analysis that includes cost of construction, gross energy requirement embodied energy analysis and full life cycle analysis often counters the claims made of broad sustainability (West 2006).

Of the many differences and variables required to be considered when evaluating or assessing building sustainability, the essential socio-cultural and economic sustainability references provide a graphic contrast between comparing a developing countries methodologies and consideration of sustainability to that of developed countries.

The authors believe that the case studies of economies and cultures of the two projects presented; one based in an indigenous community in New Zealand and the other a housing project in the southern Indian state of Tamil Nadu serve to contextualise the differences in economy, cultural and governmental approaches and a possible framework to assess and compare projects is discussed.

2. ECONOMIES AND CULTURE

A useful measure economists use when looking at per-capita welfare and when comparing living conditions or use of resources across countries is comparing a nation's GDP at purchasing power parity exchange rates. This is the sum value of all goods and services produced in the country valued at prices prevailing in the United States, in US dollars.

To elaborate and contrast the differences between various countries sustainability parameters, and the impact of their relative economies and culture, a comparison of the

gross domestic product (GDP) purchasing power parity (PPP) of India and Australia is examined below.
GDP - per capita ppp India $3,400 (2005 est.)
GDP - per capita ppp Australia $32,000 (2005 est.)
Source http://www.cia.gov/cia/publications/factbook/

The economic impact of a ten times purchasing power parity (PPP) between Australia and India by way of example, does not in itself describe the full imbalance that constitutes variations in economic sustainability. Opperman (2005) mentions the shortfalls of GDP analyses which do not evaluate socio- economic considerations including access to facilities, skill training and social betterment. The addressing of the training and enablement of communities is a socio-economic issue addressed in the New Zealand case study that was quite successful.

The enormity of sustainability issues in India compared to Australia and New Zealand can be better understood when considering these straightforward facts: Australia and New Zealand have a combined population of less than 25 million, while the Indian subcontinent has a massive and growing housing dilemma. 17.8% of the population according to the Census of India (2001) are classified as street dwellers / slum dwellers by the Indian government. That is a staggering 178,393,941 people without appropriate shelter.

The need to provide housing in these quantities is a tremendous humanitarian task that requires input at a global level. It is a task that surpasses the western philosophy of sustainability and transcends to a much higher level- the need to provide basic hygienic shelter (West 2003).

The definition of culture preferred by the authors is from (Hofstede 2003) who states Culture is… "the collective programming of the mind which distinguishes the members of one group or category of people from another. It is learned, not inherited. It should be distinguished from human nature on one side and an individual's personality on the other."

Private sector socio planning is based on capital decision (money spent as personal choice or speculative) with little concern for planning issues.
Therefore a socio / cultural justification assessment is required to be included in a universal assessment methodology. An adapted model as discussed by Gibberd (2005) that applies broader national sustainability objectives in South Africa i.e. national procurement policies that are required for the operation of the Sustainable Building Assessment Tool (SBAT) could be considered as a framework to be universally considered, or as demonstrated in the New Zealand case study a whole of government approach to socio/ cultural planning adopted in developed countries to disadvantaged sections of the community to address imbalances in the socio/ cultural context.

3. COMPARING VIA CASE STUDY- TAMIL NADU SLUM CLEARANCE BOARD (TNSCB)

The difficulties and derivations of building systems and methodologies are best elaborated by setting the scene and context of varying economic and cultural settings.

The author has localised case studies to reflect these issues, and background to one such culture in Southern India is described below.

Tamil Nadu is a state of southern India that has a population of 62,110,839 according to the 2001 Census of India of which 14,175,792 are classified slum dwellers- that is 22.8% of the population.

The main aim of the Tamil Nadu Slum Clearance Board according to its publication (Demand for Housing, 2002-03) is to clear the slums especially those located in flood prone and other vulnerable areas and to resettle them in self contained hygienic houses with basic amenities near the urban limits. That is to provide basic amenities like drinking water supply, roads, storm water drains, sewage disposal, street lights, etc. to all the slums.

The current approach adopted by the (TNSCB) to tackle this problem is to find funding and experiment with affordable housing designs

To prevent the recurrence of fire accidents in urban slums and to avoid the loss of human lives and properties, fire resistant materials are a necessary consideration. As an example of this, clay and cement brick / blockwork and ferro cement are used for roofing and side walls by the TNSCB. Under this programme Asbestos cement sheet roof houses with side walls have been provided to 45,308 families living in the slums in Chennai, and surrounding districts.

As with the great fire of London many timber dwellings were relegated as having fire protection issues and with so many dwellings in close proximity the potential for fire is a considerable socio/ economic issue to be included in the evaluation of or justification of building materials used in these densely populated locations.

Even in the traditional Maori buildings of New Zealand, which were made exclusively from natural resources, mainly timber, flax and other plant types such as Tukutuku wall panels (reed and timber), incidences of fire on Maori heritage buildings are now being addressed by the installation (where so directed) of active and passive fire protection systems (Duncan & Whiting et al 2004).

Local environment and climatic conditions also play a significant part in building design. In Chennai, the failure of the monsoon in successive years to provide adequate rains and exploitation of the ground water sources in Chennai city has lead to a severe and protracted water shortage.

The TNSCB has set as a priority the inclusion of sustainable water saving features into new developments. These water shortages are also an issue for locations in Australia. In this instance, some synergies of adopting water saving features can be shared between both countries.

As part of this programme the TNSCB has provisioned in designs to install rain water harvesting systems in tenemental areas in Chennai city- to ensure uninterrupted water supply. Furthermore, it is planned also to recharge the depleted ground water. *‘Promotion of housing activities designed to harvest sun and rain so that solar energy capture and rain water harvesting become everybody’s business.*

It is also a stated policy that *"All efforts will be taken to provide Solar Energy in the Housing schemes to harness solar water heating."* (Demand for Housing, 2002-03).

In modern day India, timber and plantations are not available in sufficient quantities to sustain the construction needs, and thus the use of timber has reduced dramatically. Even though timber is seen as a very environmentally useful product, economics preclude its use as a framing material.

The lack of timber utilised in Indian buildings is in direct contrast to New Zealand and Australia were timber, especially plantation timbers are the mainstay of domestic house building. The economics of timer plantations in India for the supply of material for future buildings is a macro economic study that needs to be conducted by the Indian government.

Presently, concrete and brick infill are the preferred choice of construction. Even to the degree of using prefabricated precast concrete doorframes that are quite unique, by Australian and New Zealand standards. Other innovative techniques employing concrete include half pipe high span roofing systems.

To evaluate suitable construction techniques, a cultural acceptance of materials must be considered also, as materials such as gypsum plaster wall sheets are seen by the Indian population as being cheap and flimsy materials, which will fail under India's trying climate i.e. monsoon rains.

The macro economic burden on the Indian economy to provide so much public housing has meant that, as many methods need to be employed as possible to reduce the cost of construction and construction materials.

The need now is to develop overall strategies that look at the total sustainability lifecycle and require a clear balance of economics and cultural appropriateness to be included in strategies and methodologies.

4. SOCIAL PLANNING AND CHANGE – SOUTH INDIAN CONTEXT

In the case of the TNSCB the planning of developments has been one of traditionally limiting size of dwellings to two storey's and creating large scale horizontal developments.

These developments have occurred on flood plains and land that is less than desirable for construction and has resulted in increased construction costs and added unnecessary burden to production efficiencies that have a dramatic affect on building sustainability.

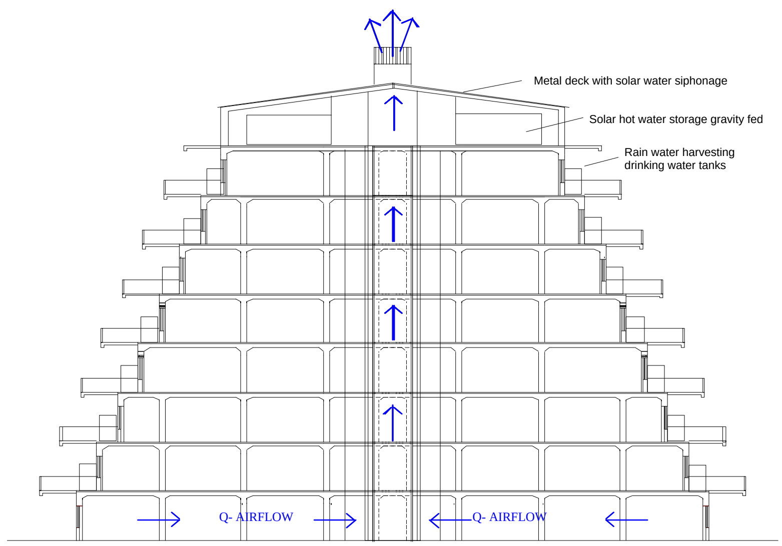
Social planning is also a major concern with little attention given to providing social amenities and commercial imperatives such as food supply and consumables.

To address these inadequacies most developed and developing nations have uniformly agreed to the economic reality of increasing density to minimize services, transport and material usage.

To alleviate this problem, economic sustainability and good design were critical. Present tenement design of the TNSCB as mentioned, limited public housing in Chennai to two storeys with little or no social design features incorporated. To counter this horizontal urban sprawl and its subsequent waste of valuable land and materials, an 8 storey cluster development consisting of commercial ground floor retail outlets and green space commons was submitted for consideration.

The designs were also culturally appropriate, being in keeping with traditional south Indian temple design (see below in figure 1) while offering , low energy consumption, efficient water reticulation (now mandatory) and suitable scale to start meeting demand.

The process for change and adoption of new designs in Tamil Nadu has been one that is evolving slowly and the author will continue working with colleagues in India and monitor progress.



Mahapalipuram- South Indian Temple design multi storey tenement

S West ©

Figure 1 Mahapalipuram / South Indian Temple design for sustainable tenements

5. SOCIAL PLANNING AND CHANGE – NORTHLAND, NORTH ISLAND NEW ZEALAND

The strategies and framework required for the development of sustainable buildings in a New Zealand context varied greatly from the situation and cultural demands associated with Tamil Nadu a state of over 60 million people. Government action initiated for New Zealand – (population 4 million) is not state Government- federally backed as is Tamil Nadu, but a whole of Government approach.

In 2002 the New Zealand Government initiated a "whole of Government" approach to address substandard housing in Northland (northern province of New Zealand), which had for the previous several decades been recognised as an economically depressed region. This whole of Government approach required all those government agencies charged with providing solutions to redress social disparity to work together, particularly addressing substandard housing amongst the Maori of Northland. Central Government made available substantial funding to those Rununga (tribal organisations) who could argue a case for such funding.

Te Rununga O Te Rarawa in the Northland town of Kaitaia was chosen to be the working model for the implementation of the "whole of Government" initiative. . The Rununga met all but one of the criteria for selection being, not having substantial housing stock amongst their people, predominately welfare dependant, and other such criteria. In addition they were required to demonstrate how they would develop sustainable and ongoing educational outcomes through addressing their housing issues.

With knowledge of this process and the operation in Northland, Unitec New Zealand approached the Rununga and offered to develop an educational package specifically designed to meet their housing needs without additional cost draw down on the government funding package provided, thus ensuring the maximum economic and social benefits.

Unitec were able to modify their current scholarship programme in carpentry and to make this available to the Rununga at premises provided by them in Kaitaia.

Unitec's unique approach was to create an agreement between the Rununga and the Government Housing Corporation that they would purchase the houses constructed by students recruited onto the scholarship from the Rungungas Rohe (geographical area).Such purchase funds to come from the Governments funding package.

In addition, Unitec helped the Rununga to obtain full funding from a philanthropic trust to cover the purchase of building materials on a revolving credit basis. Housing Corp purchased the houses at market rates, with the profits being redirected back into the Rununga.

Twenty students were enrolled in the year long building course which consisted of 70% house construction and 30% building theory. They obtained a nationally recognised Certificate in Applied Technology at the completion of the course. Students were able to obtain additional help in the areas of reading and writing from other agencies set up in Kaitaia at no cost to the parties involved.

The Rununga further developed a construction company which hired the graduates to continue their 'on site' training and apprenticeships in the building industry and in particular they became the catalyst to sustainable and restorative housing needs of the Rununga.

To date the programme continues very much in its original form with minor changes made to suit Northland Polytechnic who has assumed the role of the educational provider from Unitec after two years.

In the future it is hoped that building design featuring traditional cultural aspects can be incorporated into Rununga projects. Maori traditional wharenui- meeting houses consisted of mainly renewable timber and fibre products as can be seen in Figure No 2. The internal wall coverings or Tukutuku if correctly designed have the ability to offer some thermal insulation properties that may provide a revival apart from being aesthetically pleasing patterns.

The Kiataia projects are an example of Government providing proactive leadership in initiating low cost community based sustainable buildings. The outcome of the project proved to be an effective and innovative way of managing cultural and socio factors and achieving cost efficient sustainable housing were it was needed most in disadvantaged communities.

Figure 2 Raukawa Marae featuring all renewable materials in its construction.
(Photo source www.branz.co.nz/branzltd/publications/pdfs/SR128.pdf)

6. DEVELOPING THE FRAMEWORK TO INCLUDE COST & SOCIO/CULTURAL JUSTIFICATION

To help reach a consensus between nations as to what is sustainable construction, an agreed assessment scheme needs to be ratified that can measure comparative outcomes of energy efficiency, embodied energy, recyclability and include a socio /cultural justification component along with an ability to consider economic sustainability.

If two buildings are aesthetically pleasing, function in the same manor for the occupants, have similar energy ratings etc but one has a 50% reduction in cost / m^2/ occupancy level, then that cost efficiency ratio is a potentially valuable index for measuring and comparing buildings labelled as sustainable.

To develop a framework that will be acceptable to developing countries, cost control factoring must be bought into the assessment equation – Cost Efficiency (CE) to produce ongoing economically viable sustainable building designs i.e. Initial construction cost $/m^2 to build an energy efficient, low embodied energy building needs to be monitored against occupancy No's /m^2, comparing ongoing energy consumption plus the socio cultural benefit.

Materials and construction technologies utilized in countries needs to be further analysed and explained by way of justification of choice, based on issues such as local environment (availability), governmental and industry economic considerations, safety -fire rating and socio/cultural descriptors.

7. CONCLUSION

Cost efficiency of construction as a derivative of economic sustainability is a critical component of sustainable buildings often overlooked in the West, especially when buildings are hailed as sustainable by incorporating costly design components or marginal energy saving features, which are used to label buildings as sustainable.

Sustainability where it is needed most is in developing nations. The single most critical factor for developing nations in achieving housing (shelter) is the lack of capital, therefore "cost "of construction per m^2/ occupancy is a crucial component that must be firmly brought in to the sustainability equation along with the usual energy efficiency, renewability and recyclability considerations.

A whole of Government approach has been demonstrated in the New Zealand context as a successful framework for incorporating indigenous cultural and socio economic considerations into the sustainable housing debate at a local regional level for a disadvantaged community in a developed country.

An adapted and modified SBAT assessment scheme may be suitable for use in both developing and developed countries if included as a comparative component for the socio / cultural justification process.

A framework for comparing each countries claimed sustainability parameters including cost of construction and relative wealth per GDP capita purchasing parity and cultural justification of design and material choice will help to comparatively assess claims of building sustainability between countries.

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IDENTIFYING THE DETERMINANTS OF CONSTRUCTION INNOVATION

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ABSTRACT

This exploratory paper examines the drivers and obstacles to construction innovation. It is based on a large-scale survey of nearly 400 businesses in the Australian construction industry conducted in 2004, and twelve in-depth case studies of innovation on Australian construction projects between 2002 and 2005.

The paper argues that construction businesses can effectively improve their on-going competitive advantage through a more strategic approach to increasing innovation levels. It undertakes an analysis of innovation concepts aimed at making such ideas more accessible to construction industry stakeholders. It then draws on the survey and case study results to analyse the drivers of innovation success, together with the challenges often encountered. It concludes with recommendations for businesses to improve their innovation performance, focussing on the value of relationship-building exercises, particularly with clients, related businesses and employees.

Three priorities for business planning are suggested. Firstly, relationships are required with leading-edge clients in order for a business to be exposed to the pressure to perform beyond business-as-usual. Secondly, relationships are required with related businesses to successfully engineer joint approaches to innovation as a means of managing the risks involved. Finally, positive relationships with employees are needed to maximise the impact of training programs aimed at enhancing managerial and social skills to address non-technical obstacles to innovation.

For policy makers, the results draw attention to the need to improve the profitability levels of construction businesses, by providing an environment that is more conducive to innovation. Finally, the paper draws attention to the need for further research into construction innovation drivers and obstacles.

Keywords: Case studies, Client leadership, Innovation drivers, Innovation obstacles, Australia

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2. INTRODUCTION

Between 2003 and 2005, the BRITE Project of the Australian Cooperative Research Centre for Construction Innovation conducted a large-scale innovation survey of the Australian construction industry and undertook 12 in-depth innovation case studies. The stakeholders volunteering to take part in this research included over 400 businesses, 14 government organisations, eight industry associations and four universities.

This industry-focussed, exploratory paper draws on data provided by these activities to respond to calls in the literature for more fine-grained analysis of innovation processes in the construction industry (Winch 1998). The aim of the paper is to identify the drivers of innovation processes and the factors that impede successful innovation. This is undertaken in the Australian context, with the focus being innovation implemented on construction projects, rather than innovation implemented within construction businesses. There was no limit placed on the source of determinants, which may be at micro, meso or macro levels. The paper is intended to help construction businesses to improve the success of their innovation programs by understanding these forces and incorporating them into their strategic plans.

3. METHODS

The paper draws on data provided by the survey and case studies to provide a descriptive exploratory assessment of innovation drivers and obstacles in the construction industry.

Survey

The purpose of the survey conducted in 2004 was to examine innovation levels, types, strategies, drivers, obstacles and impacts. It covered the non-residential building and civil sectors, in the Australian states of New South Wales, Victoria and Queensland. The industry was defined broadly to include five groups — main contractors, trade contractors, consultants, suppliers, and clients from the public sector who regularly commission work.

Overall, 1317 questionnaires were distributed and 383 useable responses were returned, for a response rate of 29%. The survey covered ‘key’ organisations, which were defined as government clients, members of eight selected industry associations, and consultants and contractors appearing on the pre-qualification lists of the clients. The industry associations chosen for surveying were identified through an industry workshop in Brisbane, Australia in 2004 as those that made the most significant contribution to construction projects. The survey was distributed through the post to the contact person on the industry association membership lists and government agency pre-qualification lists. These people were mainly managers. For the government clients, forms were sent to managers in the civil and building agencies of the three states.

Case Studies
The case studies are based on the flagship Egan Demonstration Projects undertaken in the U.K., (Construction Excellence 2006) and all the innovations covered promote sustainable development in the sense that they save resources: water, energy, materials and the natural environment. Six case studies were carried out in 2003 and another six in 2005. Each one involved several personal interviews, each of approximately one hour's duration, with senior representatives of the main project stakeholders. The purpose was to demonstrate the benefits of innovation and highlight the nature of successful implementation strategies. The cases were nominated to the program through referrals from clients and through a public call for nominations.

The case studies are listed below and will be referred to by number throughout this paper.

1 Energy Cost Savings in 5-star office building
2 Clever Planks at Sports Stadium
3 Port of Brisbane Motorway Alliance
4 Fire Engineering at National Gallery of Victoria (NGV)
5 Fibre-Reinforced Polymer Bridge Deck
6 Ground Penetrating Radar and Defective Bridge Beams
7 Managing Stormwater with Storage Gutters and Infiltration
8 Saving On-Site Remediation Costs
9 Post-tensioned Steel Trusses for Long Span Roofs
10 Twin-Coil Air Conditioning at the Art Gallery of South Australia
11 Better Project Outcomes with Relationship Management and 3D CAD
12 Using Recycled Tyres to Construct an Access Road over Saturated Terrain

The 12 case studies comprised three sporting stadiums, two bridges, two art galleries, two commercial buildings, two very different roads – a motorway and an access track, and one case of contaminated land. The projects ranged in value from $13,000 to $112m, while in all cases the benefits achieved were significant. Further details regarding the case studies will be available in upcoming journal publications.

4. CONCEPTUAL BACKGROUND

In its simplest terms, innovation can be thought of as shown in Chart 1. Box A shows that at a broad level, innovation is often split into two main classes, being driven either by technical or organisational changes (Edquist 1997, OECD/Eurostat 2005). Traditionally, the construction industry has relied on technological changes, often underpinned by the research and development (R&D) programs of manufacturers (Arditi et al 1997). However, increasingly, non-technical, organisational changes in business or marketing methods by consultants and contractors fuel business growth and improved project performance (Manley 2005). Such organisational innovation is often associated with the steady refinement of established methods, involving the roles of people, the organisation of work and response to market opportunities (OECD/Eurostat 2005). Whether technological or organisational, Box B notes that innovation may simply be an improvement of current arrangements, or a completely new, world-first idea.

Chart 1 Defining innovation

Innovation				
Box A Involves technological or organisational change	**Box B** By improving existing arrangements or developing new arrangements	**Box C** In products, processes, or methods	**Box D** Being an incremental or radical departure from existing arrangements	**Box E** In either case, driving business growth

The international body that has driven the collection of innovation data over the past 20 years, the Organisation of Economic Cooperation and Development (OECD/Eurostat 2005), defines innovation in more detail, as shown in Box C, as the implementation of significantly improved or new:

- **products** (good or services) with respect to characteristics or intended uses (e.g. changing technical specifications, incorporated software, user friendliness, components, or materials)
- **processes** with respect to production and delivery methods (e.g. changing techniques, equipment or software)
- **business methods** with respect to business practices, workplace organisation or external relations (eg. providing employee incentives for time saving ideas)
- **marketing methods** with respect to design, packaging, placement, promotion or pricing (eg. accessing government programs to enter overseas markets).

Another level of defining innovation is shown in Box D, where innovation is categorised along a continuum ranging from incremental to radical change (Ettlie et al 1984). Even innovation that leads to incremental change may have a significant impact on industry practice and business growth (Slaughter 1998). To be innovative, it is not necessary to launch an untried idea or even to invest in R&D, although more radical innovations may require such strategies. An individual business only needs to implement an idea that is new to itself to reap benefits. Although innovations that are new to the world may pay greater rewards, the risk profile of such innovations makes them unsuitable for many construction businesses. The main point is highlighted in Box E – innovation leads to improved competitive advantage (Porter 1990). The following discussion examines methods businesses might employ to increase their innovation levels and thus reap such advantage.

5. RESULTS, DISCUSSION AND RECOMMENDATIONS

This paper draws on data provided by the survey and case studies to examine the drivers of, and obstacles to, technological and organisational innovation, including both incremental adjustments to existing practice and more radical, completely new arrangements.

Innovation Drivers

The survey results show that Australian repeat public-sector clients can play a significant role in promoting innovation. Sixty percent of the 383 survey respondents nominated repeat public-sector clients as 'encouragers' of innovation in the industry. The survey also found that, compared to other industry groups, such clients had the highest rate of investment in research and development, the highest rate of adoption of advanced practices and technologies, the best return on innovation, and played a key role in providing ideas for innovation. Hence, it may be that an effective innovation program for construction businesses should focus, where possible, on cultivating deeper and broader relationships with repeat public-sector clients.

It would seem that the clients covered by the survey are 'leading-edge' clients. Leading-edge clients are those with high levels of technical competence, with challenging needs and with extensive experience (Morrison et al. 2004). They are also more likely to use value-based tender selection than other clients. The innovation opportunities of a business are influenced by the level of sophistication of the clients for which it works — the more demanding, technically competent and experienced the client, the more likely it is to stimulate innovation in projects, by demanding outcomes that exceed business-as-usual.

The BRITE case studies identified specific roles played by leading-edge public and private-sector clients in driving industry innovation, as shown in Chart 2.

Chart 2 Drivers of innovation on case study projects

Study 1	**Study 2**	**Study 3**	**Study 4**	**Study 5**	**Study 6**
Client wanted to minimise whole-of-life costs	Client's contract provided innovation incentives	Client wanted improved time/cost/ quality	During the project, time and cost started to blow out and needed containment	Client attracted by the weight and corrosion benefits of a new material	During bridge repair faults were found in new concrete beams
Study 7	**Study 8**	**Study 9**	**Study 10**	**Study 11**	**Study 12**
Client (local council) wanted to educate community re water saving technologies	During site remediation highly toxic materials were unexpectedly found	Client had tight time-line; needed to keep stadium operating during construction	Client needed to gain better control of fluctuating humidity and temperature levels	Client had tight time-line; wanted better than usual time/cost/ quality outcomes	Client constrained by restrictive community and environmental requirements and needed new ideas

The clients in these case studies promoted innovation by: setting challenging energy targets; designing new forms of contract; undertaking research and development; networking with specialist experts; and organising demonstrator projects. In the three cases above (4, 6, 8) where client behaviour was not driving innovation, crises during projects were responsible. The case studies revealed that the innovation arising from crises was possible because a cooperative team approach was adopted, leading to a clear focus on finding solutions. The blame-shifting that is often characteristic of the traditional adversarial approach was avoided and more creative 'best-for-project' responses were generated. For businesses wishing to improve their innovation performance, this suggests the value of maintaining robust industry relationships and the flexibility to respond to changing project circumstances.

In summary, this research shows that innovation in the construction industry is typically either sponsored by client needs — in which case businesses can proactively suggest innovations — or it is driven by crises during projects — in which case creativity in the context of harmonious project relations is required for effective reactive innovation.

Obstacles to innovation

The innovation drivers discussed in the previous section operate in complex project and business environments that throw up significant challenges to successful innovation (Dubois and Gadde 2002). Based on the survey, Chart 3 shows the key obstacles to construction innovation.

Chart 3 Obstacles to innovation identified by % survey respondents, Australian construction industry, 2004

Obstacle	%
Prohibitive cost	32%
Insufficient time	30%
Lack of skilled staff	10%
Conservative stakeholders/clients	9%
Insufficient benefits	7%
Inadequate government programs to support innovation	5%
Low volume of available work	1%

Fifty-eight percent of industry participants reported either prohibitive cost or insufficient time as the main obstacles to innovation, pointing to the need to prioritise current efforts aimed at improving industry profitability. In the short term, businesses may need to look at joint approaches to innovation in order to spread the potential risks. This highlights the value of developing robust relationships with key organisations to advance innovation.

Chart 4 Main obstacle encountered during innovation on case study projects

Study 1	Study 2	Study 3	Study 4	Study 5	Study 6
Controlling up-front costs, managing client risk aversion	Managing product testing within the time available	Ensuring a supportive culture across a large client organisation	Addressing lingering safety concerns of the client	Managing tensions between parties in the research group	Managing the risk of a highly novel approach
Study 7	**Study 8**	**Study 9**	**Study 10**	**Study 11**	**Study 12**
Adjusting technical specifications to match building requirements	Managing bureaucratic approval processes to ensure timeliness	Ensuring the precision of technical elements on-site	Managing relationships across many stakeholders	Adjustment of team to a more cooperative way of working	Optimising organisation of site-work to reap maximum efficiency

Only cases 7, 9 and 12 encountered a key obstacle that was technical in nature. In all other cases, the key obstacle encountered during innovation on the projects was non-technical, involving cost, time, risk, conservative attitudes, culture and relationships.

The non-technical nature of typical innovation obstacles highlights the importance for businesses of appropriate training for managers and employees, particularly in the areas of value-management, planning and social skills.

6. CONCLUSIONS

Innovation has been found to be driven by the actions of clients and the challenges thrown up by emergent crises on projects. For businesses wishing to improve their innovation performance in response to these drivers, the study indicates that the single most important strategy is to focus on relationship-building. The learning required for effective innovation is maximised via enhanced relationships and shared understandings, which give rise to a knowledge multiplier effect and the development of collaborative advantage. Enhancing relationships involves thinking about the businesses, industry associations, government departments, research centres and industries that are likely to have knowledge that would complement the in-house knowledge base. Then decisions can be made about the most appropriate level, mode and frequency of contact. Resulting relationships may be informal, or they may evolve into specialised arrangements involving for example, facilitated workshops, working groups, reference groups, memorandums of understanding, partnerships, alliances, joint ventures, joint R&D, joint publications, joint presentations or joint patenting.

Three priorities for business planning are suggested by this study. Firstly, relationships are required with leading-edge clients in order for a business to be exposed to the pressure to perform beyond business-as-usual. Secondly, relationships are required with related businesses to successfully engineer joint approaches to innovation as a means of managing the risks involved. Finally, positive relationships with employees are needed to maximise the impact of training programs aimed at enhancing managerial and social skills to address non-technical obstacles to innovation.

For government policy makers, the results about time and cost constraints to innovation are important. The continuing low levels of profitability in many parts of the industry both cause and exacerbate these resource constraints, warranting greater efforts to increase the rate of adoption of value-based tendering by public-sector clients, as a means of improving profitability levels, and hence the sustainability of the industry.

Planned journal articles will explore the drivers and obstacles raised here in more detail. Further research will involve international comparisons of the innovation performance of the Australian construction industry, together with intersectoral comparisons within Australia (bearing in mind the arguments for, and against, the construction industry as a ‘special case’ in contrast to other industries, such as manufacturing).

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WORK EMPOWERMENT AS AN ANTECEDENT OF ORGANIZATIONAL COMMITMENT IN THE HONG KONG QUANTITY SURVEYING PROFESSION

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ABSTRACT

There is a widespread belief that empowerment of members of the workforce is a universal desirable. The rationale relates to problems of 'command and control' within larger and diverse organisations as well as the expectation that empowerment leads to greater commitment by employees to the organisation and, thereby, results in enhanced performance. This paper reports a pilot study of the relationship between empowerment and organisational commitment amongst quantity surveyors in four different types of construction industry organisations in Hong Kong. Organisational commitment comprises dimensions of affectiveness and continuance. Although analyses demonstrate that perceived empowerment does correlate with organisational commitment, further, more detailed study on affective and continuance commitment is recommended.

Keywords: empowerment; organisational commitment; quantity surveyors

1. INTRODUCTION

In this era of rapid change, organisations keep readjusting/adapting to the environment in order to maintain their effectiveness and competitiveness. It is believed that motivating and empowering employees can enhance their productivity and performance **(**e.g., Schein, 1980; Vroom 1964**).** The motivational aspect of empowerment (Liu and Fang, 2006) and the effects of individuals' commitment on performance in construction projects are investigated by Liu and Walker (1998), Dainty, Bryman, Price, Greasley, Soetanto and King (2005), Leung, Chong, Ng and Cheung (2004) and Peansupap and Walker (2006).

The Classical School, such as Taylor or Fayol (see Walker, 2002), believes that rules and procedures are essential for mechanistic control in an organization. For an effective organization, top-down management is vital. However, as firms grow in size and complexity, together with technological advancements, executives no longer solely manage operational issues, but begin to delegate their scope of control and setting of performance targets for subordinates. In a project organization, construction professionals work in a socio-technical system. People are an important factor and the Human Relations School, such as McGregor or Barnard (see Walker, 2002), shifts emphasis to training and co-operation where organisations are social/cooperative systems and upward communication is encouraged.

Research in motivated behaviours illustrates the importance of human resource planning and work empowerment is a resultant concept developed from these perspectives (e.g. Umiker, 1992; Wellins, Byham and Wilson, 1991). It is postulated that individuals who are motivated would be more committed to their tasks and, hence, perform better. Committed individuals are also less likely to leave their organisations. This study focuses on the individuals' perceptions (quantity surveyors in this sample of study) of the extent of work empowerment and their organisational commitment. The objectives are to investigate:

1) the perception of work empowerment of quantity surveyors;
2) if perceived work empowerment is an antecedent of commitment by quantity surveyors

2. MOTIVATION AND EMPOWERMENT

To understand how people behave/operate in organisations, it is necessary to understand organisation structures. The most prominent thought is that structure empowers what it designates (Child, 1984; Sewell, 1998). First of all, structures can be seen as rules, which are "generalisable procedures applied in the reproduction of social life" (Giddens, 1984:21), yet they are operating at different levels of depth. Also, structures can be regarded as resources, which are things that can serve as a source of power in social interactions. Structures, at the same time, constrain and empower the agents acting within them. The latter aspect of empowerment is the focus of this study.

Position power is determined by organisational structure and how that structure is made active by delegation. The delegation process, therefore, involves empowerment through considerations of what is delegated and the associated responsibility. An organisation's operations may be categorized as decisions and routines. If decision-making is delegated, then so is position power; if authority to follow routines is delegated, the position power of the agent and of the target remain unaltered (Barnes, 1986). Kanter (1983) argues that the more productive forms of organisational power increase with the persons' sharing of power and responsibilities with subordinates. In processes like the realization of construction projects, power structuring is dynamic and so, the shifting multi-goal coalition which results reflects the changing power structure of the main actors (Walker and Newcombe 2000).

Contrary to the Machiavellian approach which encourages a leader to increase and sustain a strong power base, modern management literature suggests the idea of power sharing – the practice of empowerment (e.g. Kanter 1983). Empowerment is the act of strengthening an individual's beliefs in his/her sense of effectiveness – a process of changing the internal beliefs of people (Conger and Kanungo 1988) or self efficacy (see Bandura 1986 on social cognitive theory for self efficacy) which may lead to increased motivation, productivity and effectiveness (Umiker 1992, Pfeiffer and Dunlap 1990, Conger and Kanungo 1988). Whetton and Cameron (1984) regard empowerment as the process of motivation through enhancement of self efficacy, the power to produce effects. Therefore, people who have power are more likely to achieve effectiveness.

Bureaucratic environments are known to create conditions of powerlessness (Block 1987). Authoritarian management styles can strip away subordinates' discretion and, in turn, a sense of power (Conger 1989), i.e., rendering subordinates a sense of powerlessness. The sense of powerlessness maximises feelings of inadequacy and lower self-confidence which, then, lessen motivation and effectiveness (Conger 1989).

3. WORK EMPOWERMENT AND COMMITMENT

Conger and Kanungo (1988) examine work empowerment as a relational construct and as a motivational construct. As a relational construct, work empowerment concerns influences of managerial practices on employee participation. Empowerment occurs when power of the superior is relinquished to subordinates, and with it authority and responsibility. The subordinates experience a sense of ownership and control over their jobs (Wellins et al, 1991). Sullivan (1994) suggests that a working environment encouraging participation, mentoring and training has to be created for joint decision making. In essence, empowerment is similar to the concept of delegation; however, empowerment gives continuous authority in contrast to temporary authority.

When reviewing work empowerment as a motivational construct, it refers to the perception of employees on their power, autonomy and control. Employees feel energized (Thomas and Velthouse, 1990) and a sense of control of their career (Ripley and Ripley, 1992) if they are empowered. In such sense, power sustains self-determination (Deci, Connell and Ryan, 1989), self-worth (Nielson, 1986) and a belief in self-efficacy (Bandura, 1997).

Thomas and Velthouse (1990) suggested that, as well as self-efficacy, a sense of impact, meaningfulness and choice are feelings enhanced on successful implementation of empowerment. Vogt and Murrell (1990) maintain that self-efficacy must be realised and internalised by the employees, otherwise efforts by the management to empower employees will not be of use. Work empowerment is, therefore, multi-dimensional in nature, involving delegation of power by managers and how individuals perceive and internalise such power. Menon (1995) defines empowerment as 'a cognitive state of perceived control, perceived competence and goal internationalisation' (1995 pp.30).

In this research, a multi-dimensional approach towards work empowerment is taken, following Kanter's framework (1977). Under the four dimensional (Access to Opportunity, Information, Resources and Support) framework of Kanter (1977), the practice of work empowerment has been put forward in different terms by other researchers. Ripley and Ripley's (1992) suggestions on the activities to be undertaken in an organisation are almost identical to what have been put forward by Conger and Kanungo (1988) for providing self-efficacy. The dimensions include providing leadership, training, recognition, resources allocation, customer focus and teamwork; to achieve goal internationalisation of the employees. Vogt and Murrell (1990) provide six dimensions of empowerment, including education, leading, mentoring, providing, structuring, and a matrix of all; Kirkman and Rosen's (1999) study of team empowerment dimensions comprise external team leader behaviour, production/

service responsibilities, team-based human resources policies and social structure (as described by Spreitzer, 1996).

Empowered individuals have control over opportunities, information, support and resources and will improve organisational effectiveness by being motivated and by empowering others in sharing the source of power. McClelland (1975) identifies three needs for an individual, namely achievement, power and affiliation. Schein (1980) believes the most important factor in determining an individual's motivation is the psychological contract, defined as the set of expectations between an employee and some implicit components of an organisation, i.e. pay, dignity, opportunities. In return, the organisation demands loyalty and commitment.

Kanter (1968) and Sheldon (1971) claim that organisational commitment concerns an individual's affective emotion to the group, as well as their involvement (Mowday, Porter and Steers, 1982). Some researchers look into the concept of commitment from a cost perspective and regard it as a side bet (Becker 1960), i.e. investment of something that is valuable to the employees such as time, effort and money. To Kanter (1968), commitment to an organisation also relates to the profit from participating, and the cost of leaving the organisation, such as loss of prestige and stability of a working environment. On the other hand, Marsh and Mannari (1977) focus on the moral responsibility one attaches to the organisation as a result of commitment.

Meyer and Allen (1991) categorise organisational commitment into three components: affective, continuance, and normative but normative commitment is not well supported as a form of organisational commitment (Morrow, 1993). Affective commitment involves the employee's emotional attachment, identification with and involvement in the organisation, similar to Mowday et al's (1982) definition of attitudinal commitment. Continuance commitment involves the employee's costs associated with leaving the organisation, similar to behavioural commitment. Normative commitment is associated with the employee's feelings of obligation to stay in the organisation. Employees who experience affective commitment stay in the organisation because they want to stay; those influenced by continuance commitment stay because they need to stay and those influenced by normative commitment feel they ought to stay.

Mowday et al (1982) believe that there is a cyclical relationship between affective and continuance commitment, with one reinforcing the other. However, others believe that they are independent factors, such that employees who are bound to an organisation may not be highly committed to the organisation attitudinally, and vice versa. Organisational commitment also depends on the perception of employees (Eisenberger, Huntington, Hutchison and Sowa, 1986). Steers (1997) shows that if the employee finds the organisation to be more supportive, a higher level of organisational commitment will result.

Allen and Meyer (1990) examine the antecedents of different types of commitment, establishing positive relationships with: job challenge, role clarity, goal clarity, goal difficulty, management receptiveness, peer cohesion, organisation dependability, equity, personal importance, feedback, participation, skills, education, relocate, self-investment, pension, community, alternatives, and commitment norm. These 19 variables fall into the labels of work empowerment; opportunity, information, support and resources.

Commitment reflects the relative strength of an individual's identification with and involvement in that organisation (Steers, 1997). Many studies show that high commitment is beneficial to the organisation, although low commitment can be a source of individual creativity and innovation that may be beneficial for the organisation. High commitment facilitates loyalty so a stable workforce can be sustained despite external environment changes. However, high commitment may limit opportunities for mobility, suppressing creativity and innovation (Suliman and Iles, 1999). Generally, previous findings have shown that organisations benefit from a committed workforce because committed employees tend to be absent less often, to make positive contributions and to stay with the organisation (e.g. DeCotiis and Summers, 1987).

Hence, it is postulated that the individual's perceived extent of work empowerment may increase/decrease the sense of organisational commitment and positively/ negatively affect organisational effectiveness.

4. RESEARCH DESIGN

This paper reports a study of perceived work empowerment and organisational commitment of quantity surveyors (QS) employed in different types of organisations. The case study approach is adopted where four organisations are selected from QS consultancy firms, construction firms, government departments and real estate developers --- these being the major types of organization employing QS in Hong Kong (Rowlinson and Walker 1994). The number of QS employed in the four organisations are 110 in a QS consultancy, 60 in a construction company, 110 in a government department, and 70 in a real estate developer; giving a total of 350 respondents in the sample.

Two sets of questionnaires, based on previous literature, are used. The first set is used to collect information on the perception of the respondents on their job-related empowerment. The second set is used to obtain information on their perception of organisational commitment. The questionnaire is structured into three sections, (1) demographic information, (2) work empowerment, (3) organizational commitment.

Demographic Information
Certain demographic variables are included: age, tenure/work experience, education level, gender, nationality, and professional qualification status.

Conditions of Work Environment Questionnaire (CWEQ)
This questionnaire was first developed by Chandler (1986) to measure the work empowerment of the nursing profession in Canada. Further improvements on the constructs have been made by the Western Ontario University Research Programme. An acceptable reliability has been established ranging from 0.66 to 0.92 across different studies (Laschinger and Shamian, 1994; Wilson and Laschinger, 1994). A five-point Likert scale is used ranging from 1 to 5. The higher the perception of work empowerment, the higher the score is. Some items are added to the questionnaire

according to Spreitzer's (1995) measurement of information as a dimension of empowerment. The new questionnaire has a total of 33 items under four guiding questions: How much of each kind of opportunity do you have in your present job? How much access to information do you have in your present job? How much access to support do you have in your present job? How much access to resources do you have in your present job? The alpha coefficients for the four groups of guiding questions range from 0.79 to 0.93.

Organisational Commitment Questionnaire (OCQ)
This questionnaire originated from Allen and Meyer's (1990) scale of measurement of organisational commitment – which is regarded as a multi-dimensional construct. After gradual development and improvement after various tests for statistical significance (Meyer and Allen, 1991), the questionnaire adopted for this research is the latest version of Allen and Meyer (2000).The 5-point scale is labelled from Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4) to Strongly Agree (5).

5. RESULTS

There are 152 returned questionnaires from a total of 350 in the sample of four selected organisations, giving a response rate of 43.4%. Valid number of questionnaires is 136. The score for perceived work empowerment is obtained by adding up the subscales of the four dimensions (opportunity, information, resource, support), with a possible range from 4 to 20 and then dividing by 4. The higher the score, the higher is the perception of job-related empowerment. The descriptive statistics results are shown in Table 1.

Table 1 Descriptive statistics results

Aspects of work empowerment	F	Sig.	A	B	C	D
Access to opportunity	5.090	0.002	3.053	3.517	2.810	2.800
Access to information	2.125	0.100	2.920	3.131	3.031	3.375
Access to resource	2.680	0.050	3.000	3.212	2.871	2.860
Access to support	1.278	0.285	2.750	2.851	2.577	2.686
Perceived work empowerment (average score)	2.989	0.033	2.931	3.136	2.820	2.930
N = 136			64	43	24	5

A=QS consultancy; B=contractor; C=government department; D=developer

The contractor organisation has the highest score in all the four work empowerment dimensions in Table 1, giving an average score of 3.13. Organisations A and D, (the QS consultancy and the developer) obtain the same score of 2.93. The government department (Organisation C) obtains the lowest average score of 2.82 in the sample. It seems that the QS in private organizations generally perceive a higher level of work empowerment in comparison with the government department. However, it is difficult to judge subjectively whether the scores in this sample are high as comparables in the construction industry are not available. The mean scores of the nursing profession in Canada are relatively higher. For example, in the research by Laschinger and Shamian (1994), the results of the sample in a group of staff nurses for opportunity, information, support and resources are 2.97, 2.98, 2.77 and 2.96.

ANOVA result shows that the F-ratios of all the five items in Table 1 are larger than 1, i.e., the sample means vary more than expected if the null hypothesis is true. Hence, the first step to reject the null hypothesis is established. From the significance of the F-value, it is evident that the contractor's QS (Organisation B) feel more empowered because of access to opportunity and resources than their counterparts in other organisations. The lowest F ratio is 1.278 (Access to Resources) and the highest is 5.09 (Access to Opportunity). Perceived work empowerment is significantly different (sig. 0.033) for the four organisations. However, only two dimensions out of four (Access to Opportunities, and Access to Support) in the work empowerment construct are significantly different at 5% level of significance.

The results of the regression analysis is summarised in Table 2. To eliminate the problem of multicollinearity, the variables of age, rank and education are dropped in the multiple regression model in order to give a more statistically significant result.

Table 2 Regression Results on Organisational Commitment

Predictors	Organizational commitment			
	β	t	ΔR^2	*p*
			.121	
Work empowerment	.267	3.052		.003*
Tenure	-.066	-.633		.528
Professional qualification dummy	.141	1.237		.218
Gender dummy	-.019	-.218		.828
Nationality dummy	.028	.295		.768
QS Consultancy dummy	-.303	-2.1		.036*
Contractor dummy	-.041	-.277		.782
Developer dummy	.005	.045		.964

The value of the adjusted R-squared is 12.1%, which means that organisational commitment can be partially explained by the antecedents included. As an antecedent, work empowerment is attributable to organisational commitment with the coefficient of 0.267 and the t-statistic is large (3.052) and significant ($p<0.05$), i.e., when the perception of work empowerment increases, organisational commitment increases accordingly.

The only statistically significant variable at $p<0.05$ is the consultancy dummy with a negative coefficient of -0.303. That means the QS consultancy firm has a lower organisational commitment as compared to other organisations in the study. The rest of the demographic variables are found to be statistically insignificant as antecedents of organisational commitment for the Quantity Surveyors. *Tenure* and *Gender* are negatively related to organisational commitment, which supports the findings of Mathieu and Sajac (1990) and Cohen (1993) but such findings are not statistically significant at 5%. Furthermore, *Professional Qualification* and *Nationality* are positively, but not significantly, related to organisational commitment.

The adjusted R^2 of 12 % means that work empowerment is, but not a very strong, predictor of commitment. There are two possible reasons identified: firstly, the model constructed is not comprehensive enough to incorporate all possible antecedents of commitment, where the major focus of the authors is on the impact of work empowerment on organisational commitment. Secondly, this study is exploratory and the sample is not large enough.

Though the perceptions of individuals vary in different situations, the adjusted R^2 of the study give similar results compared to some previous studies. For example, in the study of Taormina (1999) on the effects of socialisation and demographics, the adjusted R^2 figures range from 4% to 38%. In Tao et al. (1998)'s study of the effects of demographic variables and organisational climates on organisational commitment, less satisfactory results on affective commitment with R^2 (result of adjusted R^2 not available) of 18.3% and on continuance commitment with of R^2 of 3.2% are obtained.

6. CONCLUSION

Commitment reflects the relative strength of a person's identification with and involvement in that organisation. Work empowerment enhances self efficacy and, through motivation and commitment, leads to increased performance and effectiveness. In this study, it is found that when the perception of work empowerment increases, organisational commitment increases accordingly.

However, organizational commitment has two dimensions, affective commitment and continuance commitment. Further analyses have to be performed to examine the relationship of work empowerment with continuance commitment and affective commitment respectively. Although organisational commitment (overall) is related to work empowerment, there is a possibility that only one dimension of organisational commitment, say affective commitment, is significantly related to work empowerment.

It is suggested that a detailed conceptual model of work empowerment – motivation – commitment – effectiveness be tested by means of structural equations modelling based on larger scale data collection. The present regression analysis provides a basis to support the relationship of commitment and work empowerment, but further model development is required to take account of other possible antecedents of effectiveness.

7. ACKNOWLEDGMENT

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IMPACT OF ORGANISATIONAL CULTURAL FACTORS ON KNOWLEDGE MANAGEMENT IN CONSTRUCTION

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ABSTRACT

Knowledge Management (KM) is a process that focuses on knowledge-related activities to facilitate knowledge creation, capture, transformation and use, with the ultimate aim of leveraging organisations' intellectual capital to achieve organisational objectives. Organisational culture and climate have been identified as major catalysts to knowledge creation and sharing, and hence are considered important dimensions of KM research. The fragmented and hierarchical nature of the construction industry illustrates its difficulties to operate in a co-ordinated and homogeneous way when dealing with knowledge-related issues such as research and development, training and innovation. The culture and climate of organisations operating within the construction industry are profoundly shaped by the long-established characteristics of the industry, whilst also being influenced by the changes within the sector. Meanwhile, the special project-based structure of construction organisations constitutes additional challenges in facing knowledge production. The study this paper reports on addresses the impact of organisational culture and climate on the intensity of KM activities within construction organisations, with specific focus on the managerial activities that help to manage these challenges and to facilitate KM. A series of semi-structured interviews were undertaken to investigate the KM activities of the contractors operating in Hong Kong. The analysis on the qualitative data revealed that leadership on KM, innovation management, communication management and IT development were key factors that impact positively on the KM activities within the organisations under investigation.

Keywords: Contractors, Hong Kong, Knowledge management, Organisation culture

1. INTRODUCTION

Knowledge Management (KM) is a process that focuses on knowledge-related activities to facilitate knowledge creation, capture, transformation and use, with the ultimate aim of leveraging organisations' intellectual capital to achieve organisational objectives (Sveiby, 1997). As with any business process, KM is perceived as a process that receives input from its context, and produces output (in this case knowledge) to serve the purpose of achieving organisational objectives (Mouritsen, 2004). It has been proposed that within a project-based environment, some factors of organisational culture and climate such as structure, strategy, policy, and motivation have direct impact on people, process and technology that carry out KM activities and ultimately influence an organisation's knowledge content (Egbu, 2004).

Despite recent efforts in conceptual model proposition and exploratory studies, a deeper understanding of how organisational culture and climate affect KM activities within construction organisations is limited (Egbu et al., 2003a). The research this paper reports on addresses this research need by investigating the impact of key cultural factors on the intensity of KM activities within construction organisations. First, the paper briefly explains the concept of organisational culture and climate, their influence on KM and the managerial actions that help to create an internal cultural environment that fosters KM activities within the construction organisations. Second, it presents findings from 15 interviews undertaken with managerial staff members employed by 12 contractors operating in Hong Kong. These interviews aimed to elucidate how organisational culture and climate affected the extent to which KM activities were implemented within a range of contractors with diverse internal cultural environments. Third, it discusses the results of the interviews and proposes some suitable actions to develop and reinforce a culture within construction organisations that motivate KM.

2. THEORETICAL BACKGROUND

Organisational Culture and Climate

Functioning within the background of an organisation, culture is the collection of overt and covert rules, values, and principles that ensure and guide organisational behaviour (Burke and Litwin, 1992). Whereas more in the foreground of organisation, climate is held to be a summary of perception of how an organisation deals with its members and environment (Ostroff and Schmitt, 1993). Therefore, the capacity of organisational culture to enable changes to internal structures and systems is further recognised as critical success factors for effective exploitation of organisational knowledge resource (Sutton, 2001).

Cultural Factors' Impact on KM within Construction Organisations

The construction industry is characterised as being a highly turbulent, rapidly changing, very complex, and extremely competitive business environment (Price and Newson, 2003). Within this environment, emerging issues attributed to changes resulting from technology and market advances increasingly demand collaborative practice across traditional professional boundaries, leading to the emergence of knowledge-based tasks as a central focus of organisational operations (Chan et al., 2001). Nevertheless, the fragmented and hierarchical nature of the construction industry illustrates its difficulties to operate in a co-ordinated and homogeneous way when dealing with knowledge-related issues such as research and development, training and innovation (Barthorpe et al., 2000). To overcome this problem, the construction industry has moved the focus towards more innovative and effective procurement methods, supply chain management and collaborative approaches such as partnering (Phua and Rowlinson, 2003).

It can be expected that the culture and climate of organisations operating within the construction industry are profoundly shaped by the long-established characteristics of the industry, whilst also being influenced by changes within the sector (Egbu et al., 2003a). It has been empirically revealed that factors such as 'a climate of openness in organisation'; 'a shared vision in building knowledge'; and 'committed leadership to learning' were actively performed by contractors to sustain a culture of double-loop learning (Kululanga et al., 2002). A recent exploratory research (Egbu et al., 2003a) also identified three major cultural promoters for knowledge productions within construction organisations, i.e.: ‘an environment which encourages innovation to deliver better value’; ‘willingness to embrace technological development including IT’; and ‘awareness of the importance of KM including the provision of leadership’. Conversely, ‘time pressure’, ‘inward looking silo mentality’, ‘reluctance to change or to embrace new ideas and development in the sector’ were the three (3) frequently-cited obstacles. Additionally, recent studies (Egbu et al., 2003b, Stewart et al., 2004) suggest that adoption of IT to support knowledge sharing could bring about a cultural change within organisations; meanwhile, organisational culture factors also impact upon IT implementation. Cultural barriers to IT implementation were identified as: lack of organisational strategic planning; conservative business practices; resistance to change; and reluctance to invest in innovation.

Managerial Actions to Motivate KM Activities

In view of the above, the key organisational culture and climate factors that encourage KM activities within construction organisations can be summarised into four major perspectives, i.e.: ‘leadership on KM’; ‘innovation management’; ‘communication management’; and ‘IT development’. The corresponding managerial actions identified by previous studies (Bossink, 2004, Egbu et al., 2003a, Egbu et al., 2003b, Kululanga and McCaffer, 2001, Moffett et al., 2003, Stewart et al., 2004) found to have fostered a KM-friendly internal cultural environment under each perspective are summarised as following:

Leadership on KM

- Have shared vision for managing organisational knowledge;
- Have committed leadership to manage organisational knowledge;
- Problems/ errors are discussed openly.

Innovation management

- Innovations are rewarded;
- Innovations to deliver better cost-effectiveness are encouraged;
- Divisions, departments, construction sites often work jointly on innovations;
- Interdisciplinary team work is encouraged;
- Formal and informal innovation activities are integrated.

Communication management

- Teams look to see how they can contribute more to the company;
- Lateral communication structure between construction sites is adopted;
- Lateral communication structure between construction sites and functional departments is adopted.

IT development

- Senior management support IT development;
- IT and its applications are developed based on a strategic plan;
- IT and its applications are developed with a clear vision of business needs;
- IT is adopted with a view to change traditional business processes;
- IT is designed to aid efficient decision-making;
- IT applications are designed to share information across the whole organisation;
- Employees are trained to use IT.

3. RESEARCH METHODOLOGY

This study is qualitative in nature, and aims to provide enhanced understanding on organisational cultural factors' impact on KM activities within construction organisations. The semi-structured interview format was chosen as the main data collection method. The interview questions were designed to elicit opinions about the different kinds of KM activities executed by the interviewed firms, and the perceived internal environment factors that affect the implementation of these KM activities.

To select sample interviewee candidates, two (2) trade directories were referred to, i.e. the *"List of Approved Contractors for Public Works"* (ETWB, 2005) published through the website of the Environment, Transport and Works Bureau of the Government of the Hong Kong Special Administrative Region; and the "Members List" (HKCA, 2005) of the Hong Kong Construction Association, whose members represent local and overseas contractors operating in Hong Kong. Large- and medium-sized contractors within Hong Kong represent the research target, because they provide a relatively better environment for KM compared with small contractors (Ng, 2003). The firm interviewed were selected based on 1) the scope, indicated by contract values the firms were qualified for public works; 2) nature of work, general or specialised contractors; 3) nationality back ground of the firms, i.e. international, local or Chinese state owned (Hung et al., 2002, ETWB, 2005).

A total of 15 semi-structured interviews were undertaken with top management staff members, department managers and project managers employed by 12 contractors operating in Hong Kong. The interviewees include one chairman, one managing director, six directors, two regional branch managers, three project managers, and two department managers. The 12 contractors include six overseas companies; five Hong Kong local companies; and one subsidiary company of a leading contractor from China. Of these, seven were Group C contractors qualified for public works with contract values exceeding $50 million (ETWB, 2005); five were Group B contractors qualified for public works with contract values of up to $50 million; whilst six (6) of them were general contractors and the rest are specialist contractors. These sample contractors engaged in active operations in the Hong Kong market, and were the leading companies in their targeted market segments. Therefore, it was considered that the 15 interviews (that lasted between 40 minutes to 3 hours), provided specific cases, events and actions that helped to clarify and deepen understanding of the KM process within the context of the research target. Secondary qualitative data sources such as local news and corporate websites, annual reports, news magazines and other publications of the interviewed companies were also consulted, concurrently with the interviews.

4. STUDY FINDINGS

During the interviews, interviewees were asked to describe their organisations' KM activities and KM-related systems, as well as the policies and approaches they had adopted to promote KM activities. The interviews revealed the variation in organisational culture and climate between contractors. The reasons for such variations are many, and include (but are not limited to) the impact of management principles developed on the basis of different national cultures of contractors' home-countries; the nature of their marketing strategies and established market positions; the length of operation history within the local market; and the extent of localisation. The study found that the intensity of KM activities varies due to such variations within the internal cultural environment.

Leadership on KM

All interviewees acknowledged the importance of KM to their business. Even though few interviewed firms had formal programs or schemes under the title of KM, KM activities such as knowledge creation, acquisition, dissemination and application had been the integral parts of their operational procedures and long established management approaches. The interviewees also indicated that "strategic guidance to KM was critical to the implementation of KM activities." Committed leadership, (particularly top management leadership) was advised as being paramount to the promotion of KM and the conveyance of KM-related vision to various organisational levels.

For example, during the economic downturn period of 2001-04, a local specialist contractor chose 'Innovation' as their core business strategy for maintaining market share. Under the leadership of the firm's top management, an innovation task force was formed by department heads and key managerial project staff to actively implement the strategy. Through innovation, this contractor was able to achieve higher productivity, as well as cost reduction in the business of constructing deep foundations. In this process, both knowledge acquisition and knowledge application became more intense, through the increased demand for effective knowledge dissemination activities to ensure efficient implementation and continual refinement of the proposed construction technique.

In coping with the same challenges, many contractors appear to have adopted a business strategy wherein they temporarily withdrew from the local market, shifting their focus to more profitable regional markets. In doing so, their business operations were reduced to fewer but more financially justifiable projects; meanwhile, their local marketing and business development activities were less active, and some key staff were re-located to other regional office/s. As a consequence, knowledge acquisition and knowledge application activities through active marketing and intense project operations have substantially decreased, which in turn lowered the capacity of knowledge dissemination. As an interviewee commented: "At the beginning of the past financial year, a business review forum was instigated to cover the KM related areas on a three-monthly schedule. Unfortunately after the second such forum, the practice was not continued due to staff changes and a new management approach / direction." Another interviewee succinctly stated: "With no sustainable support from large profitable projects, our proposed IT-based solutions to disseminate project knowledge were significantly hindered".

Innovation Management

Remarking on the role of innovation in construction operations, an interviewee indicated: "Construction, in principle, is a creative industry, because each of our projects is unique. Therefore, innovation is naturally an essential part of operations. All the company needs to do is to encourage the innovative practices". It was revealed that innovation was adopted as a major approach by leading contractors within the Hong Kong market to increase productivity, to control cost, to gain technological advantage through creative design, and to apply new technology. The innovative practices ranged from new construction methods invented on site; alternative designs helping to tender; to creative utilisation of information technology. Some contractors' news magazines and websites reported that innovations were rewarded through both monetary and non-monetary terms.

During interviews, it was noted, that interdisciplinary team work represented a characteristics of construction work within the project-based environment. The tendering process was suggested as a very good example. The tendering team is generally formed jointly by functional departments responsible for tendering and cost control, and project teams with experience in works of similar nature required by the tender documents. Innovation was said to be a strategic approach, particularly for bidding for large-scale projects where low profit margin and high technical requirement mean alternative designs are essential for success. This interdisciplinary team work enabled the transfer of knowledge acquired from previous project operations into new innovative designs and construction methods. In the case of joint-venture tendering teams, knowledge could be acquired and transferred mutually between venture partners, and was reflected in the creative designs and methods.

Another example also reflects the cultural factor's facilitation to innovation; a local firm had a cost-effective project information management system developed through several projects as an innovation product of joint efforts made by several project teams, including joint-venture projects. The innovation process was initiated from frontline production units – site offices under the leadership of project management teams, and evolved to meet specific needs of various construction projects, with very little supervision or interruption from head office. The roles performed by the IT team at head office were to co-operate with project teams during the innovation process, to promote the innovative system to other projects, and to build a company-wide system on the basis of innovation. This case clearly showed that leadership and support from various levels of management, effective innovation policy, and flexible and efficient inter-site and inter-department communications had enabled a long period of innovation process that combined a wide range of KM activities.

Communication Management

The field of strategic management acknowledges the importance of tacit knowledge in the protection of an organisation's core capabilities from competitors' covetousness (Baumard, 1999: 220). This was reflected by most interviewees who addressed the tacit nature of project knowledge and the importance of managing tacit knowledge effectively. They revealed that gaining competence on site works, for example, is a typical process of "learning by doing", and tacit knowledge such as skills, experience, knowledge about certain market segments and personal network takes a long time to acquire, and is difficult to externalised. This explains the traditional focus of contractors on tacit knowledge retention and dissemination.

The intention of retaining tacit knowledge is reflected in comments such as "experienced and skilled employees are key organisational assets"; and "people-oriented management create synergy that is essential to business particularly during difficult time." In order to keep the core tacit knowledge asset within the organisations during the economic downturn, most of the local contractors endeavoured to retain their key professional and managerial staff members. Meanwhile, "empowering policies" were used to motivate project teams, particularly those of large work scale and of joint-venture structure, to look beyond the scope of their own projects, and to assist other teams in operations and innovations. These "people-related" policies appear to play key roles in encouraging effective communication (through both vertical and bilateral structures, as well as formal and informal channels), that facilitate externalisation and dissemination of knowledge. This is particularly so for tacit knowledge; as an interviewee pointed out: "Effectiveness of KM activities depends on the organisation's internal system of communication and encouraging knowledge sharing is the key to improve the process efficiency."

Mentoring, brainstorming, regular meetings within or across projects and departments, appear to be frequently utilised tacit knowledge dissemination approaches. The routine project and corporate meetings (e.g. regular project team meetings, monthly project progress review meetings, and innovation task force meetings) were commonly used for sharing experience, to review internal process design, and to discuss process re-engineering for the purpose of reducing handling time, and to improve efficiency. With large-sized contractors, sharing knowledge between regional offices through regular professional seminars, workshops, project meetings and Intranet were also said to be common practices.

The interviews also found that contractors with stronger focus on the local market normally have a very stable team of core managerial and professional staff who had been working with the companies for a relatively long period. Although high context culture characterised by hierarchical relationships, ascribed status and a tendency towards a well-structured formal line of communication were observed (Rowlinson, 2001) in these organisations, mutual respect, trust and friendship between managerial and professional staff established through a long period of co-operation made the communication and decision making styles much more flexible than they superficially appeared. Apart from formal communication structures, informal communication channels of local characteristics such as lunch and dinner meetings were also common. These channels appear to play a paramount role in complementing the formal structures in enabling knowledge sharing.

IT Development

In terms of explicit knowledge management, establishing and maintaining IT systems was frequently addressed during interviews. The systems for managing specific internal processes, such as project management systems, ISO document systems, cost and financial control systems, technical information archives or method statement data banks, though varied in degrees of technological sophistication, had already been widely adopted by most contractors to facilitate dissemination and utilisation of explicit knowledge in internal processes. The large contractors with comparatively larger market share and longer operational history within the local market had been in the process of building or deploying an Internet-based corporate wide computer system, which is flexible enough to bring together programme and cost information; to present value analysis-type information to project managers; to enable e-trading in procurement and supply chain management; to offer access to clients for open book framework contracting (Kumaraswamy et al., 2006). In other words, these contractors were endeavouring to use information technology to facilitate more efficient and effective explicit knowledge utilisation and sharing between stakeholders in the supply chain of their business.

Although the high cost of IT systems was said to be a concern for most of the interviewed leading contractors (particularly during the economic down-turn), the IT system integration process had been an ongoing project, even though their scopes and approaches varied. Larger companies with better financial resources appear to have clearer vision and a more sophisticated strategic plan for the system development, and projects were normally handled by a combined team of personnel from the contractor and a software provider. It seems that medium-sized contractors adopted in-house development as the primary approach, focused on consolidating the project control system, and depended on larger projects for resources as well as the trailing and testing of the IT system. In order for both approaches to be successful, top management support and collaboration across the boundaries of various professions were said to be the key. The most difficult task was said not to produce IT technical solutions, but to motivate the different functional units such as finance management, procurement and supply chain management, and project management to work together to generate new procedures and interfaces to enable previously isolated systems to communicate with each other, and particularly in taking a more radical approach to creating a new system. Risk-averse attitudes and particularly the boundaries between overseas headquarters and Hong Kong branches, between the functional departments, between head office and construction sites, and those between different professions were said to be the primary barriers to both system development and implementation. Therefore, under the circumstances where strong top management leadership and clear strategic plans were presented, the system development was smooth; where these were absent, the project was idled whenever cultural barriers were strong. Nevertheless, the interviewees also indicated that the deployment of sophisticated IT systems allowed more efficient information transfer and sharing within the organisation, which enabled a more effective and transparent decision-making process. This in turn helped to increase confidence in the adoption the new IT system and to overcome culture barriers such as conservative business practices and resistance to change.

5. CONCLUDING REMARKS

The study provided insights into the influence of organisational cultural and climate on the KM activities within the contractors. The project-based environment and the uniqueness of construction projects bring the contractors' challenges in KM implementation, as was indicated by the literature review. In managing these challenges, the contractors have incorporated managerial approaches such as interdisciplinary team work; collaboration across organisational boundaries, innovation, vertical and lateral communication structures; formal and informal communication channels and IT system development into their organisational climate to facilitate knowledge acquisition, creation, dissemination and application. However, for these approaches to be effective, certain policies need to be in place to ensure the presence of beliefs and values of the organisational culture that enable KM behaviours and actions.

Firstly, strategic guidance and top management leadership are essential for implementation of KM. KM implementation will be much more effective if KM related tactics such as innovation, joint-venture, and new technology utilisation are formulated as core components of corporate strategy; thereby ensuring accessibility of management support and resource allocation to enable the implementation process. Secondly, reward and incentive systems should be used to motivate tacit knowledge externalisation (Nonaka and Takeuchi, 1995), which is the key to knowledge asset building in the construction process. Innovative ideas, methods, and designs are a natural product of operations. Without proper motivational policies, it is difficult to externalise and share this knowledge due to tight time schedules and risk-averse attitudes, thus it is also difficult to form into the knowledge synergy of the company, and it can easily be lost in dynamic project delivery circles and team structures. Thirdly, empowering policies to promote autonomous work and task identity are important to increasing the sense of responsibility, and hence the willingness to produce new knowledge through activities such as invention and innovation. Fourthly, large and technologically-intensive projects are the contractors' resource and profit centres, and a major base for knowledge creation and application. In addition to empowering project teams to innovate, it is also paramount that the company motivates these projects to take the lead in sharing the created knowledge with other production units. Finally, IT systems integration and development should be undertaken under the guidance of clear vision and strategic plans, and supported by the top management team.

This study was undertaken with only one type of construction organisations within a specific region, and employed the semi-structured interview as the major component of the research design. Future research would benefit from diverse research methods such as in-depth case studies, and empirical study, as well as greater sample diversity in terms of size and category of organisations, and also cultural context.

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AN OVERVIEW OF SUSTAINABILITY IN SAUDI ARABIA

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ABSTRACT

The present demand for economically viable construction projects in the Saudi Public Sector is coupled with the need to maximise the efficient use of Saudi Arabian natural resources. The aim of this paper is to investigate sustainability in Saudi Arabia in terms of strategies, policies, barriers and enablers associated with its implementation and as perceived by key decision makers. It also endeavours to define sustainable construction principles as currently being applied in the country. The data used in this study were obtained through a review of related literature, reinforced with information distilled from interviews conducted with people working in or possessing significant experience of the Saudi Public Sector. The findings show that the Saudi government has made significant efforts towards protecting the environment by enacting a number of regulations and policies and by joining a number of global conventions over the past few years. However, the lack of consideration paid to sustainable construction principles during the conceptual phase of design has resulted undesirable consumption rates of materials, water and energy during the construction, operating and maintenance phases of projects. Moreover, there currently appears to be are lack of awareness, regulation, policies, information and leaderships with regard to implementation of sustainable construction. Several relevant principles for sustainable construction in terms of environmental, economic and social have been elaborated upon; and enablers that could accelerate its understanding and implementation in the country have been highlighted.

Keywords: environment, national strategies, Saudi Arabia, sustainability, sustainable construction

1. INTRODUCTION

There has recently been considerable concern regarding the degradation of the environment caused by depletion of natural resources, air pollution, global warming and the lack of consideration paid to the earth's ecosystem. The principles of sustainable construction have thus been widely adopted in a number of countries throughout the world. Sustainability issues are frequently categorized into three major types: economic, environmental and social. Sustainable development was defined by United Nations Word Commission on Environment and Development as "development which meets the needs of the present generations without compromising the ability of the future generations to meet their own needs" (Brundtland, 1987). This definition is about realizing a balance between: economic growth and progress; and natural resource conservation and social equality promotion. Sustainable development is thus about minimising the negative impacts whilst improving the environment to ensure a better quality of life for the current and future generations. It implies using renewable natural resources in a way which does not eradicate or degrade them. It also implies using non-renewable natural resources at a rate slow enough to ensure an orderly societal transition to new alternatives (Langston and Mackley, 1998). Over recent years, Saudi Arabia has experienced considerable economic growth due to strong oil prices and ongoing reforms in the country. This has been also spurred by major government construction activities and development of infrastructure and building projects including; schools, hospitals, accommodation, private construction, as well as rapidly expanding tourism sectors.

The present demand for economic buildings in the Saudi Public Sector needs to be coupled with the need to use the Saudi Arabian natural resources in an efficient manner. In addition, extreme economic development in the countries of the Arabian Peninsula has caused a significant imbalance of water resources and demand. Between 1980 and 1990, demand increased from 9.95m^3 billion to 22.6m^3 billion of water. If the current situation continues, water demand could reach 35.4m^3 billion by 2010 (Abdulrazzak 1995). Moreover, the Saudi Government energy plan calls for the installation of 50,500 MW of additional generating capacity which requires an investment of $117 billion in the next 20 years (Asharq Alawsat, 2003). Statistics relating to the Saudi population illustrate that 60 per cent of the population are under 25, which means there will be increasing demand for dwellings and infrastructure (Asharq Alawsat, 2003). It is inferred from these statistics that resources are being, and will be continued to be, used at an exceptionally high rate. If this situation continues, future generations may well run out of sufficient natural resources. Moreover, sustainable construction appears not to have been sufficiently considered in Saudi Arabia and there is a lack of awareness and knowledge amongst key decision makers in the Saudi Public Sector (Al-Yami and Price, 2006). In the light of the above, greater consideration needs to be given to sustainability by the Saudi Arabian construction industry whilst at the same time supporting the immediate economic, social and environmental needs of the country. The aim of this paper is to investigate sustainability in Saudi Arabia in terms of strategies, policies, barriers and enablers associated with its implementation and as perceived by key decision makers. It also endeavours to define sustainable construction principles as currently being applied in the country.

2. LITERATURE REVIEW IN SAUDI ARABIA

There is scarcity of literature addressing sustainable development in general and sustainable construction implementation in particular in Saudi Arabia. A few publications highlight environmental policies and their history in the country. Al-Gilani and Filor (1997) reviewed the Saudi government's attempts through policy documents which include the administrative structure and decision making process with regard to environment protection. In a later paper, they also propose improving the current national framework for environmental policies in Saudi Arabia (Al-Gilani and Filor, 1999). The suggested framework comprises four areas: political culture and the public role; environmental decision-making procedures; environmental policies and laws; and new institutional structure (ibid).

Thereafter, Alshuwaikhat and Aina (2004) suggested a framework for achieving sustainability principles in Saudi Arabia at the municipal level. They also proposed developing Strategic Environment Assessment (SEA) to start from the level of the

Ministerial Committee on the Environment (MCE) and the Preparatory Committee for the Ministerial Committee on the Environment (PCMCE). The second level of the framework covers the most important ministries, such as the Ministry of Economy and Planning (MoEP) and Ministry of Municipal and Rural Affairs (MoMRA). The framework at the ministry level should be sectoral except at MoEP and MoMRA where have a mandate for region planning. The final level is the municipal level and the Presidency of Meteorology and Environment (PME) which needs to be more equipped to conduct Environment Impact Assessments (EIA) at the project level in compliance with the SAE process.

Alshuwaikhat and Aina (2005) subsequently appraised the incorporation of environmental assessment into the municipal planning process and planning documents. The study findings were that: the implementation of environmental assessment at the municipal level was minimal; there was lack of experience in the sustainability assessment of planning documents; and sustainability principles have yet to be entirely integrated into the planning process. Al-Yami and Price (2005) explored the conceptual linkages between Value Management and sustainable construction, concluding that Value Management could be an effective vehicle for implementing sustainable construction principles in the country.

3. CURRENT STATUS IN SAUDI ARABIA

Sustainability Agencies in Saudi Arabia

During the last decade, the Saudi government has given significant consideration to protecting the environment, conserving biodiversity and natural resources and providing a better quality of life. It has contributed significantly to sustainable development, through the initiation of a number of regulations, polices and reports by relevant agencies that are playing major roles in achieving sustainability principles in the country. These agencies and their roles are shown in Table 1(MoEP, 2006).

Table 1: Agencies associated with sustainable development in Saudi Arabia

No	*Agency*	*Responsibilities*
1.	The Presidency of Meteorology and Environment (PME)	Protecting environment at the national level. The PME and other relevant agencies are jointly accountable for implementing and monitoring sustainable development.
2.	The National Commission for Wildlife Conservation and Development (NCWCD)	Preserving both terrestrial and marine wildlife, along with maintaining ecological balance and bio-diversity in addition to conservation of environmental and natural resources
3.	the Ministry of Agriculture (MoA)	Maintaining pasture, forestry, animal resources and fisheries, as well as the establishment of national parks.
4.	The Ministry of Water and Electricity (MoWE),	Managing and sustaining water resources, the sewage system and the generation of power.
5.	the Ministry of Petroleum and Mineral Resources (MoPMR)	Managing and sustaining mineral and oil industries.
6.	The Ministry of Municipal and Rural Affairs (MoMRA)	Providing urban services with respect to environmental health, waste management, cleaning of cities and landscaping.

7.	The Ministry of Health (MoH)	Managing and eliminating medical waste
8.	the Ministry of Interior (MoI)	Checking and inspecting periodically vehicles which enforce measures with respect to air pollution as a result of vehicles exhaust fumes.
9.	The Ministry of Culture and Information (MoCI)	Raising environmental awareness by conducting campaign.
10.	The Saudi Arabian Standards Organization (SASO)	Setting standards and specifications as to environment protection and elimination of pollution
11.	The Royal Commission for Jubail and Yanbu (RCJY)	Sharing some specific environmental concerns with other agencies.
12.	King Abdulaziz City for Science and Technology (KACST)	
13.	Saudi Aramco	
14.	Saudi Arabian Basic Industry Company (SABIC)	

Achievements of Saudi Government in Sustainable Developmen*t*

The Saudi Government has taken an active role in initiating sustainable development during the Seventh Five-Year Development Plan (2000-2004). Agenda 21 issued at the 1992 Earth Summit in Rio as the international blueprint for sustainable development, was approved by the Saudi Government in December 1994. A number of environmental targets were accomplished such as reducing the level of pollution, controlling desertification, creating environmental information network, adopting coastal management plan and conserving national wildlife.

The General Environmental Regulations were enacted in October 2001 and the executive by-law was enacted in September 2003, which led to the appointment of the Presidency of Meteorology and Environment; the main agency responsible for the enforcement of the environmental regulations in coordination with other appropriate agencies. Moreover, Saudi Arabia joined the following international environment conventions during the Seventh Five-Year Development Plan: the United Nations Framework Convention on Climate Change (UNFCCC); the supplement of Kyoto Protocol which was approved on January 2005; the United Nations Bio-Diversity Convention; and United Nation Desertification Control. The PME coordinates with related agencies which embark on the implementation and follow up of a number of environment conventions associated with their duties. These include: the Basel Convention on the Control of Transboundary Movement of Hazardous Waste; the Vienna Ozone Layer Protection Convention; and the Montreal Protocol on substances that deplete the ozone layer Agreement (Ministry of Economy and Planning, 2006).

The Saudi Government is preparing outline of the National Strategy for Health and Environment, the National Environment Strategy, the National and Action Programme for Desertification Control, the National Strategy for Biodiversity, the National Forestry Strategy and the National Plan for Management of Coastal Regions in terms of the national environment strategies and developing related regulations. The Saudi Government has also enacted: water resource conservation and consumption rationalization; and sewage water recycling regulations. In the meantime, the Ministry of Water and Electricity has been updating its water resources studies as part of formulating the National Water Plan (MoEP, 2006).

The Ministry of Municipal and Rural Affairs has issued a circular in terms of water resources conservation to all its branches and consultants. It informs them that it is mandatory for all new construction and area planning to be designed to use conservative plumbing equipment in line with the new Technical Saudi Standards and Codes, to maximise water-efficient use. Licenses for starting construction will not be issued and all services such as water supply and electricity will not will not be connected for these projects and areas until the relevant standards and requirements have been met (MoMRA, 2006).

Sustainable Development National Strategy of Saudi Arabia

The Eighth Five-Year Development Plan (2005-2009) has been drawn up, with a broad strategic vision of the economy and development that is geared to accomplishing sustainable development. The main objective is to satisfy the material, cultural and spiritual needs of people in addition to health and quality of life. The objectives of the development strategy are to achieve sustainable development and eliminate any negative impacts on natural resources, the quality of life and public health while protecting the environment against harmful activities and practices. This section highlights the objectives, policies and targets of environmental operations during the Eighth Five-Year Development Plan (MoEP, 2006).

Objectives

- Protecting the environment against pollution.
- Improving the quality of life and public health.
- Achieving sustainable development through a closer harmony between human activities and the protection of natural resources; the conservation of non-renewal natural resources in addition to searching for alternative resources.
- Developing and protecting wildlife to ensure their sustainability.

Policies

- Enhancing the efficiency of protective mechanisms to protect the environment and conserve natural resources.
- Reassessing and updating environmental standards.
- Enhancing databases of the weather, climate and the environment.
- Enhancing the role of the private sector in the protection of the environment, natural resources and wildlife conservation, and especially the adoption of "green" materials and environmentally friendly processes in industry.
- Developing the institutional capacities of the environmental agencies.
- Introducing sustainability awareness issues into the school curricula and the media.

Targets

- Conducting studies on the environmental effects of new factories as part of licensing requirements.
- Updating air, soil, groundwater databases as well as surface and coastal water pollution standards.
- Spreading environmental awareness programmes.
- Stimulate the formation of environmental protection societies in all regions of the country.

- Strengthening inspection of the environmental status of existing industrial establishments to ensure compliance of new industries with environment protection requirements.
- Broadening the meteorological monitoring network to cover the entire Saudi territories.
- Reassessing and modifying the school curricula to cover environmental and awareness issues starting from primary schools.
- Co-ordinating with the ministry of culture and information for preparing shows, programmes and TV serials that focus on environment issues, as well as providing coverage to regional and international environment news and issues.

4. INTERVIEWS ON SUSTAINBLE CONSTRUCTION

Qualitative research is a systematic, empirical strategy for eliciting responses from people in a special social context (Locke, 2000). Qualitative research is often referred to as 'idealistic' and is concerned with information about things that are less easily understood by calculation. It seeks to understand how people see and interact with 'the world' (Fellows and Liu, 2003). This study intends to: explore; explain; and describe the sustainable construction situation, as well as defining sustainable construction principles in Saudi Arabia.

Conduct of interviews

The data for this research were obtained through semi-structured interviews with twelve experts working in or possessing significant experience of the Saudi Public Sector. The experience in the Saudi Arabian construction industry was on average 14 years. The qualifications of interviewees were: five of them held a PhD; four held an MSc; and three held a BSc. The interviews lasted between 55 minutes and 2:32 hrs. These semi-structured expert interviews were conducted to investigate in-depth sustainable construction in Saudi Arabia as illustrated in below sections.

Interview results

Rationale behind sustainable construction implementation in Saudi Arabia

The implementation of sustainable construction is undoubtedly crucial all over the world, however, each country has its own needs, agenda and circumstances. This section is to identify the reasons behind the consideration of sustainable construction principles in construction projects by asking the interviewees "*Why are sustainable construction principles important to be implemented in the Saudi construction projects?*" Table 2 illustrates important factors that justify the implementation of sustainable construction principles in the country.

Table 2: Reasons behind sustainable construction implementation in Saudi Arabia

	Rationale behind sustainable construction implementation	*n*
1	Elimination of green area; deterioration of environment and scarcity of resources;	3
2	Seventy per cent of energy goes to buildings;	1
3	Sick buildings that includes harmful paints, furniture, ducts, IT, air and materials;	1
4	Forty five per cent of overall waste comes from construction;	1
5	Landfills are quickly filled by waste	3
6	Sea and ground water are being polluted;	3
7	Shortages of dwellings especially in big cities such as Riyadh, Jeddah, Eastern province;	3

8	Shortage of water and energy in addition to high demand;	4
9	Dwellings and land price have dramatically increased over the few past years;	3
10	Demolition of buildings result in negative impacts to environment;	2
11	Distortion of large areas where materials are taken for construction; and	1
12	Neighbours' relationships have increasingly abated.	2

n= Number of interviewees mentioned a reason

Defining sustainable construction dimensions

Sustainable construction issues were identified in Saudi Arabia by asking the interviewees the following question, "*What are the sustainable construction principles that are important to be taken into account in the Saudi building projects?* Table 3 shows the principles of sustainable construction in Saudi Arabia according to the perception of interviewees.

Table3: Sustainable construction dimensions in Saudi Arabia

	Sustainable construction principles	*n*
1	Environmental	
	- Recycle and reuse water and materials.	6
	- Maximise efficient use of land.	4
	- Minimise water and energy consumption.	7
	- Maximise efficient use of non-renewable resources.	2
	- Encourage renewable resources use (solar energy).	4
	- Reduce material waste in construction and use.	4
	- Stop desertification.	2
	- Deplete ozone.	1
	- Conserve and develop costal regains.	1
	- Stop pollution to sea and groundwater, air and land.	4
	- Protect biodiversity, and flora and fauna.	1
	- Satisfy good indoor and outdoor environment.	5
	- Minimize CO2 emission.	1
2	Social	n
	- Provide evacuation area.	1
	- Prevent crime.	2
	- Consider neighbourhood relationships in design.	3
	- Stop smoking inside building and general places.	1
	- Consider earthquake, geotechnical and weather aspects in design.	2
	- Eliminate toxicity and sick buildings.	2
	- Respect culture of people.	4
	- Involve society in decision making.	2
	- Satisfy user's needs and requirements.	5
	- Respect disabled and satisfy their requirements and needs.	2
	- Provide public amenities.	3
	- Satisfy privacy.	4
3	Economic	n
	- Apply whole life cost .	5
	- Deliver affordability.	3
	- Ensure durability.	2
	- Enable adaptability.	3
	- Ensure quality.	4
	- Satisfy equity.	5
	- Create jobs.	3

n = Number of interviewees mentioned a factor

Barriers to sustainable construction in Saudi Arabia

This section is to identify the barriers that could hinder the implementation of sustainable construction by asking "*What are the barriers that could impede the implementation of sustainable construction in the Saudi construction industry?* Table 4 illustrates these challenges to implementing sustainable construction in the country.

Table 4: Barriers to sustainable construction implementation in Saudi Arabia

	The barriers	**n**
1	Lack of information;	4
2	Lack of awareness;	10
3	Lack of government support;	3
4	Lack of regulations and policies in terms of sustainable construction implementation;	5
5	Lack of guidance for sustainable construction to clients, designers and contractors;	3
6	Lack of penalties and inspection to violation works;	2
7	Lack of collaboration and coordination between governmental agencies	2
8	Shortage of sustainable materials, equipment and appliances in the Saudi market;	3
9	Shortages of practitioners, expertise, and knowledge of sustainable construction;	4
10	Misperception of high initial cost to implement sustainable design; and	2
11	Complexity of agencies' legislation, rules and bureaucracy.	1

n= Number of interviewees mentioned a barrier

Overcoming the barriers to sustainable construction

The interviewees were asked two questions regarding how to overcome existing barriers and implement sustainable construction principles in Saudi construction projects. The first question was, *"What are the enablers and incentives that can/do encourage sustainable construction implementation in Saudi Arabia?"* The second question was, *"What steps should the government or Saudi agencies take to establish or improve sustainable construction performance in Saudi Arabia?"* Table 5 illustrates the enablers that could provide a catalyst for improving the implementation of sustainable construction in the Saudi construction industry.

Table 5: Enablers to sustainable construction implementation in Saudi Arabia

	Enablers to implementation	**n**
1	**Demonstration**	
	- Achieve sustainable construction principles in governmental projects and demonstrate a good example.	5
	- The Government should strongly advocate sustainable construction implementation to be a leader as major customer and sponsor of the industry.	3
2	**Regulations/policies**	
	- Enact regulations and policies for sustainable construction implementation.	7
	- Establish guidance of sustainable design, construction, operations and maintenance to clients, contractors and designers.	2 2
	- Establish Saudi Council of Engineers System.	3
	- Mandate Saudi Building Code and sustainable construction principle implementation in new projects.	1
	- Establish ranking of consultants and designers in Saudi Arabia.	2

		- Certify people who work in sustainable construction.	
3	**Incentives**		
		- Establish monetary incentives and awards for designers, consultants and contractors who implement sustainable construction principles and give them a priority to obtain new projects.	5
4	**Technology**		
		- Provide sustainable materials, environmentally friendly, suitable appliances and equipment to conserve energy and water in the Saudi market at an affordable price.	2
5	**Awareness**		
		- Bring key stakeholders together in one place and introduce them the principles of sustainable construction and its benefits and drivers at early stages of a project.	3
		- Teach people benefits and drivers of sustainable construction and involve them in decision taking.	4
		- Start teaching sustainability principles at schools and institutions.	3
		- Train engineers, architects and labours and raise awareness of top management and affected stakeholders.	4
		- Find sponsor to adopt sustainable construction by introducing its benefits to the society.	2
6	**Process**		
		- Make competitions of sustainable design for designers & consultants;	2
		- Evaluate performance of sustainable construction during design, construction stage and after completion; and	1
		- Work together with relevant agencies (MOMRA, PEM, MWE, MPM , NCWCD) to establish regulations and policies, and assign duties and tasks for each one.	4

n= Number of interviewees mentioned an enabler

5. CONCLUSIONS AND RECOMMENDATIONS

The Saudi government has made significant efforts towards protecting the environment by introducing a number of regulations and policies and by participating in a number of global conventions over the past few years: general environmental regulations and its rules for implementation have been issued and approved; climatic research and reports have been produced; meteorological, environmental and air pollution measurements are being conducted; and the implementation of sustainable development is handled by collaboration between a number of ministries and agencies in the public and private sector. The Saudi government has also signed a number of international environmental protection conventions. Although the Saudi Government has enacted and approved a number of regulations and joined a number of global conventions relating to sustainable development, there is unawareness among the agencies and people regarding sustainable principle implementation, both in the public and private sector in the country.

This study has established sustainable construction issues in Saudi Arabia and explored the most important reasons behind its implementation. Furthermore, it has identified the barriers that could hinder sustainable construction application and introduced enablers that could overcome these obstacles. The identified enablers could help accelerate the understanding and implementation of sustainable construction dimensions in the Saudi Arabian construction industry. On the basis of the findings of the study and related literature, it is clear that the lack of awareness for sustainable construction principles within the Saudi Arabian construction industry would appear to be a problem across the country. Moreover, most governmental agencies in the Saudi Arabia have a long way to go, before they can effectively implement sustainable construction principles. The result of this study indicate that the most important issues of sustainability were energy and resources conservation as well as land use regulation and urban planning policies which are justified by that fact that energy and resource are of increased concern in Saudi Arabia.

Developing solutions to the aforementioned problems from the perspectives of the interviewees requires further research, which could involve developing two legislative frameworks in initiating the process of entrenching sustainable construction in the Saudi construction industry. These frameworks can be classified into two broad categories connected to general and specific – sustainable construction - framework. They would need to focus on reducing conflict of interests that could happen between the Saudi governmental agencies in addition to determine authorities and duties for each agency. The general framework should focus on sustainable urban development, education and training programmes development. The sustainable construction framework should comprise all sustainable construction principles.

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RISK MANAGEMENT IN JOINT VENTURE PROJECTS: AN APPROACH FOR CONTRACTORS IN MALAYSIA.

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ABSTRACT

Construction joint ventures have attracted a lot of research interest over the last two decades. Joint venturing can allow participating companies to rapidly change the scale or scope of their businesses. However, joint ventures are often regarded as a risky business. The construction industry is associated with high degrees of risk in the nature of its business activities, operational environment and organization. The success of a construction project depends on the results it is supposed to achieve. But achieving results depends upon how well companies manage the risks that confront their projects.

This paper aims to identify the risk factors associated with joint venture projects in the Malaysian construction industry at the project-specific, internal and external levels. The main factors crucial to joint venture success were identified from a literature review and through a questionnaire survey administered to both local and foreign construction organisations in Malaysia. The identification of these factors will assist the successful application of joint venture arrangements in construction projects in Malaysia.

Keywords: Risk management, construction, joint ventures

1. INTRODUCTION

A joint venture is a procedure used to respond to specific business phenomena such as access to new markets, specific government policy, business capacity, technology transfer or economies of scale. An international joint venture is a separate legal organisational entity representing the partial holdings of two or more parent firms, in which the headquarters of at least one is located outside the country of operation of the joint venture. The feasibility and the desirability of a joint venture must be assembled by careful analysis of the economic, political, social and cultural environment within which the venture will be implemented and managed. A planned approach necessitates a thorough and careful evaluation of these aspects by both partners to ensure successful implementation.

Research into risk management in joint venture projects is increasing but is mostly concerned with the manufacturing industries. However, the lack of empirical evidence in risk management in the joint venture construction projects motivates this research. Joint venturing had been labeled as the most risky form of business because of the rate of failure shown by previous performance but this had largely been in the manufacturing sector. Construction risk generally has not been well research and much remains to be discovered. In particular, risk in construction in joint ventures is poorly understood and very little research has been directed at Malaysian construction joint ventures. Currently there is no single organization in Malaysia providing or keeping data pertaining to the joint venturing companies. Risk management techniques are not so well developed in the construction industry and there is a need to develop proven techniques, rather than rely on intuitive methods.

2. PROBLEM STATEMENT

In Malaysia, there are a number of different combinations of Malaysian contractors and local partners and also Malaysian contractors with foreign partners. Also, these projects vary in type, scale and complexity. There is need, firstly to map out the range of variables then to select a suitable set of comparable JVs for further in deep limitations.

3. OBJECTIVE OF THE RESEARCH

The main objective of this research was to determine the most critical risk factors which support the successful application of joint venture arrangements in construction projects in Malaysia. The result of this study are expected to provide useful guidelines for forming and operating effective and efficient joint ventures both in Malaysia in other similar economies.

4. OVERVIEW OF RISK MANAGEMENT IN THE CONSTRUCTION INDUSTRY

Risk in the occurrence of an event that has consequences for impacts on the performance of a projects. A broader definition indicates that it is not just a question of something negative happening, but also that something positive does not happen. Uncertainty can be regarded as the chance of occurrence of some events or events where the probability distribution is genuinely not known. Risk exists when a decision is expressed in terms of a range of possible outcomes and when known probabilities can be attached to the outcomes.

Risk management has been developed mainly in the USA to enable organizations to combat an ever-increasing exposure to risk. Risk management can be used to denote methods that aim to develop a comprehensive understanding and awareness of the risk associated with particular variables of interest in strategic decision-making, or with the successful accomplishment of the projects success criteria. These are variables such as project costs, project schedule and performance, net present value or return on investment.

Risk management applied to the construction industry refers to the assessment and reaction to the risk and uncertainty that will inevitably be associated with a project. To manage a project, a system to control cost, quality of time and safety are normally employed in order to meet the objectives and expectations of a company. Risk management is the systematic process of identifying, analyzing, mitigating or responding to potential project risk. It includes maximizing the probability and impact of positive events and minimizing the probability and consequences of events adverse to project objectives. Because of the complex nature of construction business activity processes, environment, and organization, the participants are actively exposed to a high degree of risk. Construction involves unforeseen and predictable risks (Smith, 1992). Predictable risks are events or conditions that the contractor can foresee before construction begins.

5. CONSTRUCTION JOINT VENTURE PROJECTS IN MALAYSIA

Joint ventures are established to take advantage of the economic, political and social conditions prevailing in a particular economy. In Malaysia’s case, international firms came to its shores mainly because of its political stability, economic growth and a relatively low cost of labour and other resources. Construction joint ventures in Malaysian are becoming increasingly popular both in multinational construction firms and local government in order to achieve their individual objectives. There are already established joint ventures between two or more local indigenous contractors and also between indigenous local and foreign contractors.

Malaysia’s booming economy over the last ten years has spawned massive developments thus creating an investment environment. Over the years, Malaysia has managed to attract a good many well-known multinational companies from Japan, Taiwan, Korea, United States, United Kingdom, France, Australia, Germany and others. These projects have included work for public and private clients comprising infrastructure, civil engineering works, residential and non-residential building work. Foreign firms are often required to bid with local partners on large infrastructure projects and a JV bid must normally have at least 30% bumiputera (indigenous Malay) participation. The total value of the projects awarded to foreign contractors from 2000-2003 was Ringgit Malaysia 17.5 billion with a total of 121 projects. The total value of contract works as in year 2003 of Ringgit Malaysia RM 39.4 billion with 4,162 projects.

6. RESEARCH METHODOLOGY

The research methodology was divided into three major sections consisting of a literature review. questionnaire survey and in-depth interviews. The questionnaire survey was distributed to 550 Grade G7 and G6 registered contractors under the Construction Industry Development Board Malaysia (CIDB). The purposed of the questionnaire was to discover which companies had experience of JV projects, the extent of that experience and their views of risk factors associated with joint ventures.

The 2nd part of the research involved a case study whereby an in-depth interview conducted with the General Manager of one of the Grade G7 contractors to provide detailed information on his company structure, management and experience of one of his major projects undertaken in Malaysia. It was found from the search for appropriate cases of JVs that those in this category were restricted. The search for cases such as JVs was made in the various company directories particularly in construction organisations such as the CIDB Malaysia, Master Builders Association Malaysia, Malaysia 2000 Construction Equipment and Builders' Directory and Pusat Khidmat Kontraktor Malaysia.

7. RESULTS AND ANALYSES GENERAL CHARACTERISTICS

There were fifty (50) local contractors and five (5) foreign contractors which responded to the questionnaire. This was about 10% of the total number of the 550 companies. Only 5 foreign companies returned the questionnaire out of 250 and only one was willing to be interviewed. This was disappointing but it was thought that it could be the lack of JV experience which could be the reason. It could be that there were many that had not been received, or it could be that those not responding had bad experiences in JVs, or they were reluctant to share their experience.

<u>The questionnaire was divided into three parts.</u>

- Part One: General information about the JVs - company status, nature of business, involvement's in JVs project numbers and operation structure.
- Part Two: Risk factors that might be involved in JV projects. These factors were divided into three groups, namely internal, project -specific and external risks (Groups 1,2 and 3).
- Part Three: For companies with no experience of joint venturing but which were willing to participate in the future.

A Likert Scale of 1-5 was used in the questionnaire. The respondents were required to indicate the relative criticality/ effectiveness of each of the risk factors and management measures.

Most of the respondents were involved in the civil engineering works, which consisted of highways, roads and bridges, tunneling, road pavements and resurfacing. This could be seen by the jobs completed by them from 1995 until 2001. About 50% of them were involved in commercial, industrial and residential building. Many projects had been completed but some were still in progress. There were others involved in specialist works, piping, petrochemical and oil refinery and airport facilities.

From the questionnaire on the priority to be achieved from the JV projects was the new market opportunities where 19 respondents out of 40 agreed on the statement, which makes 51% from the overall population. Meanwhile, increasing project scale then profit were at 2nd and 3rd ranked which are 23% and a slight decrease in percentage to 22% of the respondent's priorities. This was followed by time of completion, cooperation and quality of works, which took the 4th and 5th places.

Yates, 1993 identified that JVs, with other project-specific limitations of partnering and termination schedules, were concerned to be the most viable means of entering foreign markets. Since the construction markets in the developing countries are unfamiliar to most of the companies in developed countries. It is always difficult for them to get into the markets at the beginning. Joint venturing is one of the most common ways to overcome the barriers to these markets. By forming the JVs, foreign companies improved access to local human resources including managers and labour, and specific resources possessed by local partners. This capability is, therefore, improved in terms of size and scope of work undertaken.

From the research, the respondents ranked first business expansion and new economies of scale. The financial status for a company was at the 2nd rank. It could be seen that the skill and experience, competitive advantages and market share were at the 3rd rank. 13 respondents also shared their opinion of having technology, knowledge and information and sharing of risk. The new market opportunity and coordination of work were in the 5th place and sharing of resources was in the 6th place.

From the research survey, the writers concentrated on the risk factors that were involved in JV projects based upon the respective contractors' experience. The analysis assessed the 29 respondents that responded to the question on risk factors.

Risk Group 1: Internal Risk Factors

Among the nine factors, the highest mean of 3.89 was the problem from both the partner's parent companies. Another risk factor related to a partner is its lack of management competence and resourcefulness, which is ranked 2nd. Thus the credit worthiness of a prospective JV party's parent company should be scrutinized and its current management competence and resources must be ascertained. (Li Bing,Tiong,1999).

Policy changes received the 3rd highest rank, which was at 3.29 and 3.25, which is very critical among the internal risk factors for a JV project. The parent companies play an important role in the JV process as they can influence a JV's performance. Most of the researchers on JVs have concluded that a good JV agreement is an essential success factor and can avoid a great deal of trouble and conflict in future JV operations.

Employment from the parent company and work allocation received 5th and 6th rankings; as trust among JV staff from different partners is also a critical risk factor in JV projects. Another critical risk factor is the disagreement on accounting of profit and loss. It received the 7th ranking; followed by the technology transfer and disagreement on allocation of staff positions in JV which received less critical scores, ranking 8th and 9th, respectively. Disputes over works allocation often happen when designs are changed and the changes are unfavourable to one of the partners. Technology transfer received the least critical ranking in this group.

Table 1 : Internal Risk Factors

No	Risk Factors	Mean
1.	Financial Problems	3.89
2.	Management	3.44
3.	Policy	3.29
4.	Over inteference	3.25
5.	Employment	2.97
6.	Allocation of work	2.96
7.	Accounting	2.88
8.	Technology Transfer	2.77

9.	Allocation of staff positions	2.61

Risk Group 2: Project- Specific Factors

The risk caused by the project characteristics must be considered when dealing with JVs risk. Many JVs are formed for a specific project, and the project's characteristics could strongly influence the JV's performance. A Client's cash problem is regarded as the most critical risk factors to a JV. It received 4.19 and is ranked first in this group among all risk factors considered in this research. Thus, it could be seen that the financial risk to the JV contractor includes whether the owner has sufficient funds to complete the project or has the availability of funds for progress payments. The most critical factor is a poor project relationship. It received a critical value at 3.54 and 2nd in the project-specific risk group. Strained relationships will occur when someone goes directly to the Client without informing his counterpart, particularly when the matter concerns contractor-client reimbursement.

Currently, in the construction industries, the general contractors are subcontracting many project activities. It is rated as the 3rd critical risk factor in the group. Compared with other risks, disagreement over some conditions in the contract is considered to be less critical value at 2.89. Contractual risks usually are caused by disagreement arising from flawed contract documents, inappropriate types of contract, improper tendering procedures, contractual clauses and/or incomplete contract documentation.

Table 2 : Project Specific Factors

No	Risk Factors	Mean
1	Cash Flow Problems	4.19
2	Poor Project	3.54
3	Incompetence of suppliers	3.08
4.	Conditions of Contract	2.89
5.	Demands & Variation By Client	2.88

Risk Group 3: External Risk Factors

The major risk factors for overseas construction projects at the national or regional level are those related to economic, political, social and environmental risks. Economic fluctuation and inflation score the highest means at 3.80 and 3.49. These were followed by policies, fund repatriations and exchange rate, which stand at the 3rd, 4th and 5th ranking, respectively. Economic slowdown causes the construction market to shrink. Foreign exchange risks exist when the JV formally enters a contractual agreement as a contractor with the owner. Inconsistency in policies, regulation restrictions on fund repatriation and import restrictions were ranked at 6th, 7th and 8th respectively.

The environment has a certain critical influence on JV projects. It received a critical value at 2.26 and is ranked 9th in this group. The participants considered the pollution effect on a JV least critical. The surveys showed that the social environment problems are not critical and they are ranked at 10th and 11th,respectively. The lack of complimentarity is caused by a failure to understand how cultural assumptions influence the development of the JV.

Table 3 : External Risk Factors

No	Risk Factors	Mean
1.	Economies Fluctuation	3.80
2.	Inflation	3.48
3.	Policies, laws and regulations	3.39
4.	Exchange rate	3.21
5.	Fund Repatriation	3.14
6.	Import restrictions	2.55
7.	Force Majeure & Social	2.50
8.	Security Problems	2.45
9.	Pollution	2.26
10.	Language Barrier	2.21
11.	Different social, culture & religion	2.10

8. CONCLUSIONS

The questionnaire survey on the JV projects between Malaysia local and foreign contractors working in Malaysia showed that both perceived risk in construction as the likelihood of the potential completion of the project i.e. terms of cost, time and quality of performance. To minimize the chances of failure or underperformance of a JV, risk management techniques must be introduced into the construction industry. In order to manage them effectively, a comprehensive method for managing risk techniques must be introduced into the construction industry. Also in order to manage them effectively, a comprehensive method for managing risk during the construction process, particularly in the pre- contracting and contracting stages, should be applied. The major risks factors were found to be the agreement of the contract, partner selection, control/equity, sub-contractors, renegotiations and training.

9. RECOMMENDATIONS FOR FURTHER RESEARCH

These findings may have implications for the curriculum in Construction management education, particularly at the Degree and Masters Courses in various disciplines at Faculties of Architecture, Planning and Surveying or Built Environment where the implementation of project risk analysis management, in view of the implications for construction business profitability, may demand education and training of the construction project managers and professionals in risk management techniques to bridge the gap between theory and practice. There is already a risk management module in the existing M.Sc taught programme at UiTM.

Informal education and training could be in form of CPD programmes organized by academic establishments or interest groups within professional bodies such as CIDB Institution Surveyors Malaysia, Institute of Engineers Malaysia, MBAM and others. It may not be expected that this will be an immediate panacea, but would be a move in the right direction to improve JV performance in the industry.

The nature of construction JVs and international JVs compared with other types of procurement may be different due to the fundamental intent of co-operation in the participants where large differences in cultural, political and social backgrounds exist.

The findings of the research will hopefully support the more successful implementation of joint venture projects in other similar economies.

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A HYBRID FRAMEWORK FOR COLLABORATION IN DESIGN CURRICULA

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ABSTRACT

One of the most important aspects of construction is the reliance on effective and strong collaboration between professionals. Today, with the opportunities provided by the computers, most of the collaborative tasks can be handled digitally. In order to be prepared for the demands and procedure of professional life, it is required to embellish current higher education students with adequate collaborational skills. In previous works, young generation of students were studied, as the future professionals, in order to analyze their tendencies in choosing digitized versus traditional media in design collaboration. Given the strong background of this generation of students in using and being familiar with computers, one would quickly presume that they would prefer Internet based collaboration. Yet, the findings indicated a different direction. The students strongly suggested that they would like to collaborate in a hybrid manner, that is to say both traditionally (face to face) and over the Internet (web-based). With this paper, work was extended by analysing a new student group's preferences, appreciations and problems in terms of establishing a healthy collaborative environment. Notably, the findings with this new group of students not only confirm the previous findings, but further analysis provide clues as to in what aspects web-based collaboration needs to be improved. Within this framework, a hybrid framework for collaboration in design curricula is proposed.

Keywords: Communication, Collaboration**,** Design education, Hybrid course, Web-based collaboration.

1. INTRODUCTION

The recent developments of the Information and Communication Technologies (ICT) have demonstrated the value of capturing, storing, distributing, searching, and generating information in higher education. Use of ICT in higher education provides a chance to broaden the horizons of the educational methods, incorporating new educational techniques, such as hybrid courses.

Hybrid courses are courses in which a significant portion of the learning activities take place online. Hybrid courses reduce, but do not totally eliminate, the time spent in the classroom. According to Garnham and Kaleta (2002), the goal of hybrid courses is to join the best features of in-class teaching with the best features of online learning to promote active independent learning and reduce class seat time. Accessibility to course content, effectiveness of large lecture instruction, and level of connectivity between students and instructor are advantages of hybrid courses over the traditional face-to-face communication (Poltrock & Engelbeck, 1999; Cheng & Kvan, 2000; Johnson, 2002).

One of the areas where such hybrid structure, integrating face-to-face and online communication, is utilized currently is the design studio. In the design studio, students develop designs mainly based on interactions with their instructors and fellow students. In the recent years, not only the hybrid structure but also online collaboration have become indispensible parts of most design studios. In line with this, Seitamaa, Lahti and Hakkarainen (2005) propose a progressive inquiry model of collaborative designing. In this model, collaboration should occur in all phases, from design context to feedback, and it is also important to integrate instructors and experts (distributed expertise) with students.

Hansley (2005) on the other hand, explores the steps taken in creating a hybrid course at Appalachian State University. A hybrid course model was proposed for a fifty-student course. Student interaction was provided online using a database. Results of this study demonstrate that a few students had difficulty using the technology; also the instructor spent much more time in hybrid class on individual communication compared to a regular class.

Parallel to those studies, this study analyses the impact and the evaluation of the two components of a hybrid communication structure; face-to-face and web based, in a design studio setting. The study was conducted in two consecutive steps involving two different student groups. The aim was to infer design students' communication preferences in the project lifecycle and to propose a hybrid framework for collaboration in a design curriculum based on findings.

2. CASE STUDIES

The students enrolled in an elective design course in two different semesters have participated in the studies. The students were asked to collaborate on a design project handling design communication through both techniques; face-to-face and web-based. At the end of each semester the students were asked to fill in questionnaire forms assesing their satisfaction and inquiring about the strong and weak aspects of both techniques.

First Study

In the first study, a group of 13 students were studied. Students formed groups of 3-4 to work on the given project. Total duration of the project was 6 weeks. Students had a 3-hour course each week. One preview with a design jury (comprising 3 design instructors) was held during the project period, and students had the chance to receive face-to-face and web-based critiques consecutively while developing the project. In this study, web-based critiques were mostly given by e-mails (Şenyapılı & Karakaya, 2005).

Second Study

In the second study, 16 design students were enrolled in the same elective design course. Design students constituted 4 groups, each group composing of 4 students.

This time web based critiques were given through the virtual communication platform developed by Bilkent University.

3. FINDINGS

The findings are grouped in three main categories composing of:

. students' background in using computers,
. students' assesment of face-to-face and web-based communication separately,
. students' evaluation of the both communication techniques comparatively.

Students' Background in using Computers
All students had previous computer experience. Second group of students were more experienced with computers. In the first study, the student with the least computer experience had 3 years of experince (mean= 7,46), whereas in the second study the least was 6 years (mean = 9,18). Students indicated that they use computer for mostly *writing*, *drawing*, and/or *connecting to the Internet.*

Especially regarding the Internet use, the mean of years of using the Internet for first group of students was 5,41, and 6,18 for the second group of students (Figure 1).

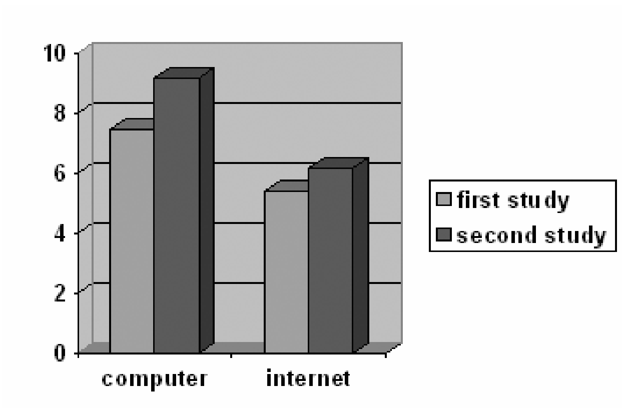

Figure 1. Students' background in terms of years in using computer and Internet

Both student groups were familiar with computers, used to navigating in the Internet as well. Therefore, students were not expected to have difficulties in terms of handling web-based communication.

Assesment of Communication Techniques Separately
In the questionnaires, students were asked which type of communication they found useful the most. Major part of the students said that both techniques were useful, while a few favored face-to-face communication alone. Students were asked to evaluate both types of communications on a 1 to 5 scale, 5 being 'very helpful', and 1 corresponding to 'not helpful at all'. In both studies, face-to-face communication were favored more than web-based communication (for the first study the mean for face-to-face was 4,69 and and for web-based 3,53) (for the second study the mean for face-to-face 4,62 and for web-based was 3,87) (Figure 2).

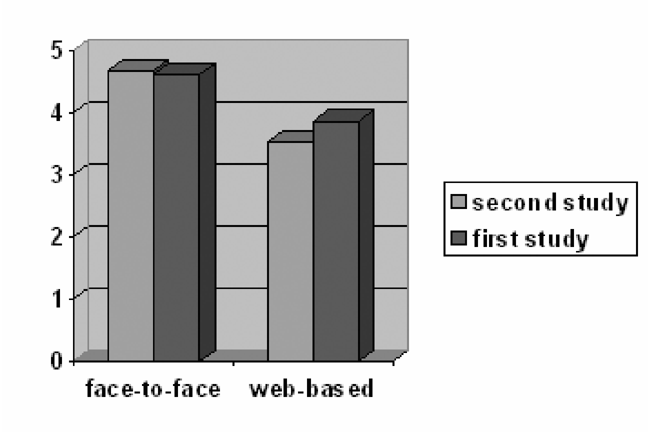

Figure 2. Favored communication technique on a 1-5 scale

Both communication techniques were tested in terms of a given set of criteria, each item being evaluated on a 5-point scale, the criteria being:

- Understanding the critiques
- Preparation load for presentaion
- Quality of presentation
- Changes on the design after the critique
- Collaboration with the instructor
- Collaboration with the friends

For face-to-face communication the highest mean ($m_{\text{first study}}$ = 4,76, $m_{\text{second study}}$ = 4,37) was received in terms of *understanding the critiques* in both studies. This result indicates that understanding the critiques via face-to-face communication was evaluated as being *easy* by the students. For face-to-face communication, the least mean was equally received for both *preparation load for presentaion* and *quality of presentation* ($m_{\text{first study}}$ = 3,76). In the second study, the least mean was received for *quality of presentation* (m= 3,28) and similar to the first study, preparation load for presentation received the second lowest mean (m= 3, 76). These results showed that for face-to-face critiques students thought that the *preparation load for presentations* was *dense* and they were not satisfied with the *quality of the presentations.*

For web-based communication, in the first study the highest mean was received for understanding the critiques (m= 4,30), in the second study for *collaboration with friends* (m= 4,03). The least means for web-based communication was received for *changes on the design after the ciritique* in the first study (m=3,30), and for *presentation quality* in the second study (m=3,40) (Figure 3)(Table 1).

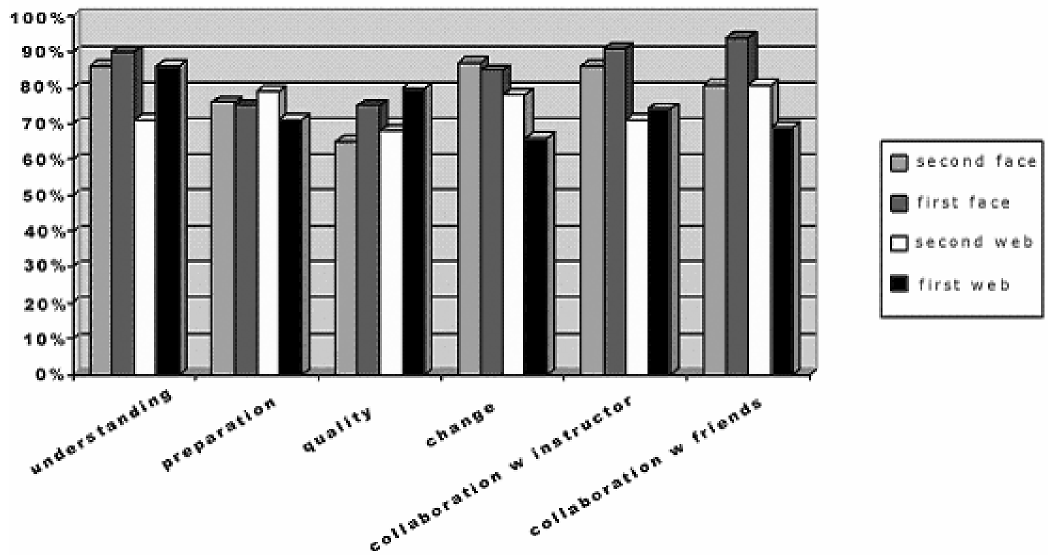

Figure 3. Assesment of face to face and web-based communication with regard to the given criteria.

Table 1. Assesment of communication types (face to face 'f-t-f' and web-based 'wb') in the first and second studies

	understanding	preparation	quality	change	coll w/inst.	coll w/friends
f-t-f 1	4,76	3,76	3,76	4,26	4,56	4,71
f-t-f 2	4,37	3, 76	3,28	4,37	4,37	4,08
w b 1	4,30	3,55	4,00	3,30	3,70	3,45
w b 2	3,52	3,09	3,40	3,91	3,61	4,03

The superimposition of the most preferrable aspect of face-to-face communication in both studies on *understanding the critiques*, showed that although not written in document and not offering the chance of repeated reference, students still value the advantages of face-to-face communication; such as, facial expressions, instant response, complimentary figures of speech, and gestures. Interestingly, in the second study, web-based communication received the highest mean for *understanding the critiques*, with a slight difference in the mean. This provides grounds to argue that students acknowledge the positive assets of the web-based communication as well, which helped them in comprehending the critiques on their designs; such as, clear and direct critique text, chance of repeated references, chance of discussing with others over the critique text.

It seems to be no coincidence that both face-to-face and web-based communication have at some point received the least means for the *quality of presentation* since students tended to blame presentation's inadequencies for the shortcomings of their design.

Comparative Assesment of Web-based and Face-to-face Techniques
A set of 5 point scale was used to obtain an overall evaluation of both types of communication, in terms of *easiness, interaction, quickness, stimulation capacity,* and *clearness.*

In the first study, face-to-face communication received highest mean for *easiness* (mean= 4,46) and least (mean= 3,84) for *being stimulative.* Web-based critiques, similarly, received highest mean for *easiness* (mean= 4,53) and least (mean= 3,69) for *being stimulative.* This result is very interesting as it shows that there is a comparatively students indicate no difference between the two techniques.

In the second study, the highest mean for face-to-face communication was received for *clearness* (mean= 4,27) and the least for *quickness* (mean= 3,57), whereas web-based communication received the highest mean for *quickness* (mean= 4,50) and the least (mean= 3,62) for *interaction*. Again, the findings rightfully in acknowledge the time consuming nature of face to face communication, while giving credit to web-based communication in that aspect, but the differences are not major (Figure 4) (Table 2).

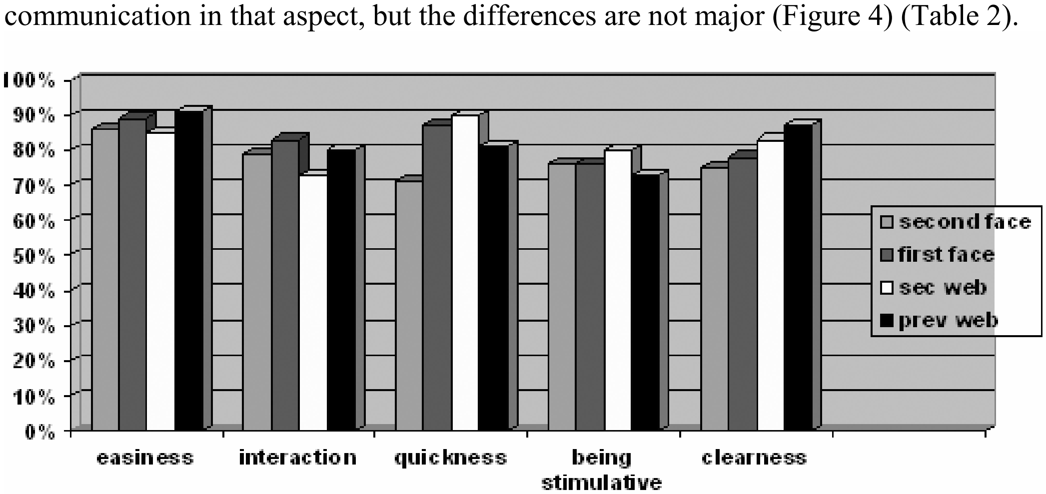

Figure 4. Comparative assessment of face to face and web-based communication in the design studio

Table 2. Comperative assesment of communication types (face to face 'f-t-f' and web-based 'wb') in the first and second studies

	easiness	interaction	quickness	being stimulative	clearness
f-t-f 1	4,46	4,15	4,35	3,84	3,92
f-t-f 2	3,93	3,81	3,57	3,73	4,27
w b 1	4,53	4,00	4,20	3,69	4,38
w b 2	4,25	3,62	4,50	4,00	4,12

4. DISCUSSIONS AND HYBRID FRAMEWORK

The findings provided grounds to assert two major arguments:

1. The students have a strong background in computer use, and they are familiar with way finding in virtual environments. With a quick presumption, one would expect them to favor web-based communication in a collaborative environment. However, they hold on to the positive assets of traditional face-to-face communication and do not welcome web-based communication without reservations.

2. Although students seem to favor face-to-face communication while separately evaluating the communication techniques, when it comes to comparative evaluation they do not seem to distinguish majorly between the two. In other words, they do not favor one communication alone. Figure 4 shows how close their evaluations for both communication techniques are. Therefore it may be asserted that in collaboration students will appreciate a hybrid communication framework instead of utilizing one communication technique alone.

One of the essential characteristics of the design process is a designer's way of using a variety of visual representations, written notes, and graphical models for representing, developing, and storing emerging ideas (Goel, 1995; McGown et al., 1998). Students communicate these ideas in a design studio. In a traditional communication framework, the students are organized into different groups and can collaborate each other by face-to-face communication. The face-to-face communication between the groups disappears in a web-based learning environment since students are distributed. Students cannot see eachother unless they use video conferancing (Zhao and Akahori, 2001).

Utilizing the positive aspects of both communication techniques, a hybrid framework for a collaborative design course can be introduced. The framework model demonstrates the face-to-face and web-based communications in a hybrid setting. The framework may be broken down into 3 different sub-structures according to the stage of the design process. In a fourteen week semester course the initial phase may correspond to the first-fourth weeks, the development phase to fourth to tenth weeks, and the final phase tenth to fourteenth weeks. Although not in a one-to-one relationship, the assesment criteria of the collaborative work used in thesestudies may be correlated with the design phases as shown in Figure 5.

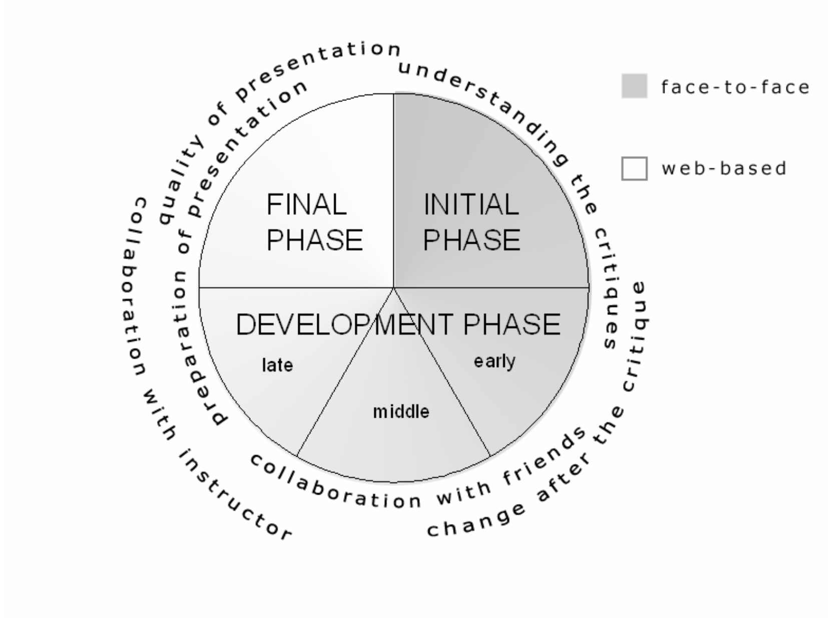

Figure 5. Phases of design process in relation to theassesment criteria.

As the design process requires different means and densities of communication at different stages, the framework may be adapted according to the design phase. For the initial design phase the density of communication evolves around face-to-face (Figure 6).

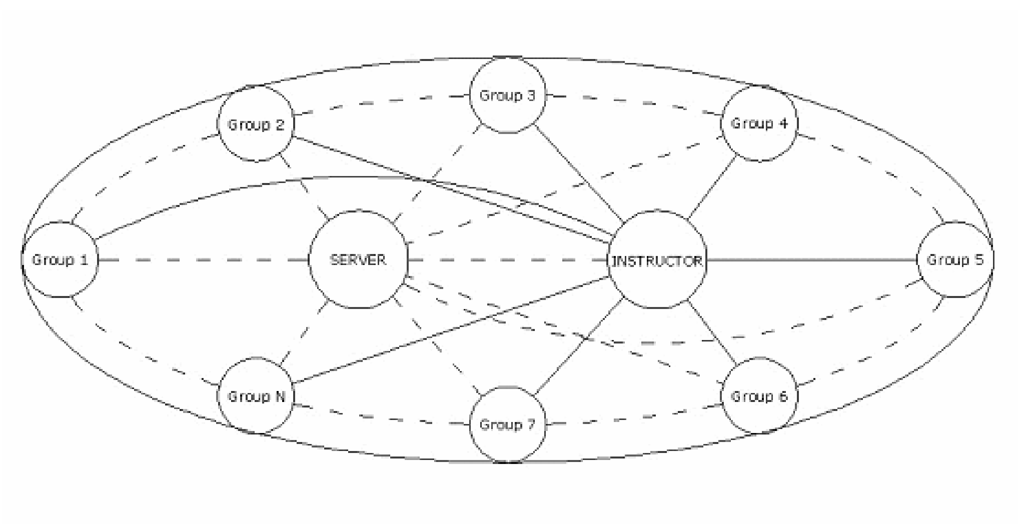

Figure 6. The hybrid framework of communication for the initial design phase

The continuous lines indicate primary communication; while the dashed lines represent secondary communication. In line with this, the hybrid framework may be adapted to the development and final phases of design process as in Figure 7 and Figure 8.

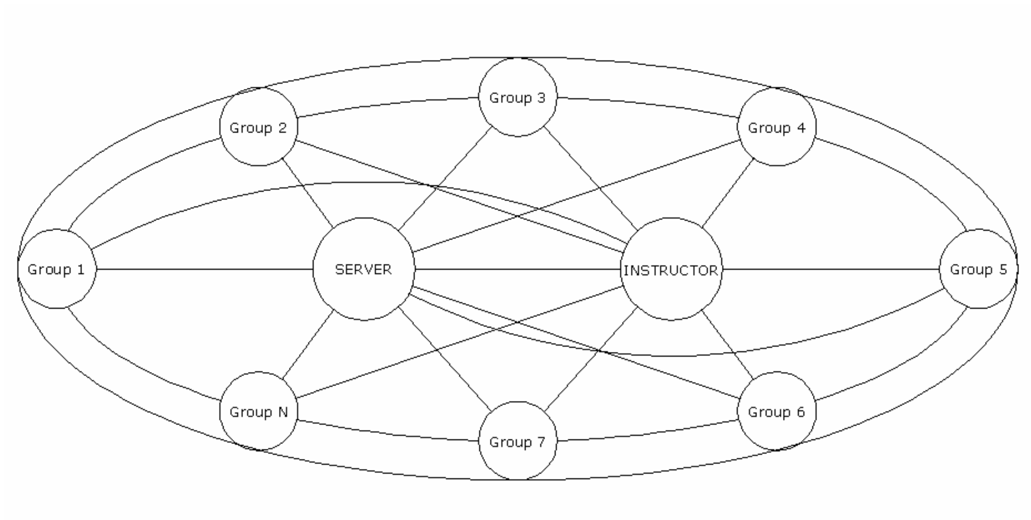

Figure 7. The hybrid framework of communication for the development phase

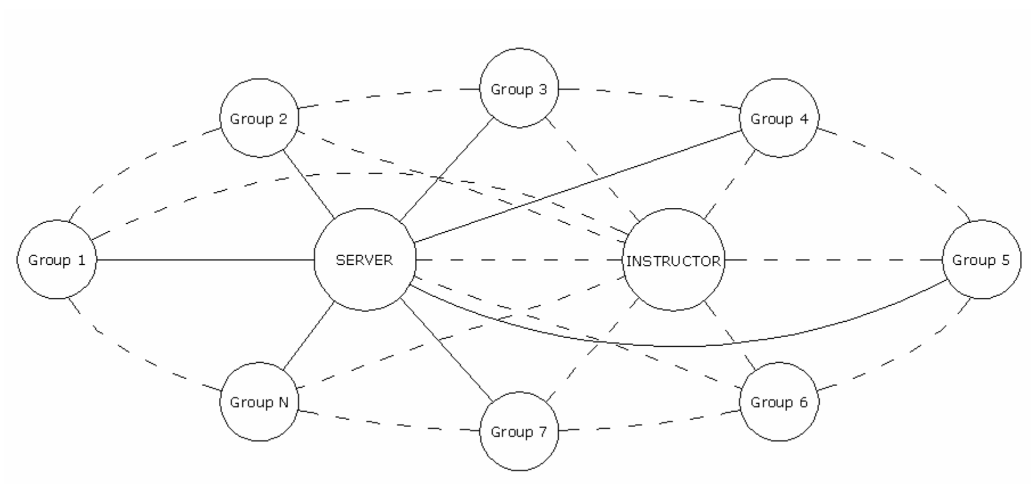

Figure 8. The hybrid framework of communication for the final design phase

5. CONCLUSION

Unlike the opinion that the future design studio will shift from traditional communication technique to a fully virtual one, we believe that the future design education should be based on such an integrated design communication where oral and written skills, hand and computer drawings, face-to-face and virtual encounters will all be presented to the student (Şenyapılı & Karakaya, 2005). Fowler (1996) states "the web allows the ability to more efficiently share the process of education or information with greater numbers of persons. This allows for the ability to celebrate the educational process and make more of an event surrounding 'real life issues' that students should be exposed to and discuss in the academic setting" (p. 6).

A hybrid framework of communication was intruduced in a collaborative environment in a design curriculum. The communication preferences of two separate groups of design students were studied. The students' assesments on the preferences of face-to-face and web-based communication techniques indicated the assests of both techniques. In order to make this framework more efficient it needs to be implemented in different groups in different design curricula. Introducing hybrid framework in education would be beneficial for preparing students to the professional collaboration.

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CULTURE AS A CATEGORY OF RISK IN CONSTRUCTION

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ABSTRACT

Culture has long been expressed as a reason for project and organisational performance being different from what is desired and predicted. Given increasing globalization of construction activities, the potential for culture to impact on construction is ever greater. Although culture is a construct which is acknowledged to impact on performance, it remains one which is not understood well. Hence, culture constitutes an important factor of risk/uncertainty at all levels of industry analysis. As culture is multi-layered, it operates differently on projects, within firms and across nations. Further, culture is multi-faceted and extends into all behavioural manifestations of human beliefs and values. To recognise culture as an important risk factor is to move towards understanding its existence, manifestations and impacts on performance with a view to aiding management of projects and organisations – that is not to fall under the delusion of culture as a tool of control but to foster appreciation of the processes and appropriate responses to cultural manifestations and mixes and, thereby, aid performance improvement. Thus, this paper adopts a risk management perspective of culture and its manifestations to endeavour to help raise awareness of culture's presence and impacts and so, indicate more appropriate approaches to the management of the cultural mixes inevitably encountered in construction.

Keywords: Behaviour, Culture, Performance, Risk Management, Values.

1. INTRODUCTION

Given the increasing incidence of internationalisation / globalisation, it is ever more evident that construction projects are realised and used within a mix of national and organisational cultures. The realisation processes involve joint venturing (JV) – which is invariably informal but, sometimes, formal as well which, on major projects, often involves strategic alliances and significant foreign direct investment (FDI).

Notoriously, performance realisations of construction projects are significantly below expectations. That may be due to poor forecasts, poor performance realisations, or both. A significant concern is that the participants have different criteria, constructs and measures of performance because their cultural fundamentals comprise differing beliefs and values. Thus, culture and its manifestations are important components of risk for construction projects. Only through appreciation of such contextual factors, sensitivity to them, and appropriate accommodation of their overt requirements and important nuances, can their impacts on performance be rendered positive.

It is important to appreciate that it is unlikely that culture can be used as a management 'tool' to help control performance. Rather, the nature of culture positions it as a contextual construct which impacts negatively on performance unless accommodated appropriately in processes and procedures.

Frequently, it is postulated that globalisation is fostering pursuit of the convergence hypothesis. However, globalisation 'gurus', such as Ohmae (1999), emphasise the importance of 'glocalisation' – a global generic but employing local particularisations. Thus, Boyer (1996) asserts that there is as much evidence supporting the divergence hypothesis as there is to support convergence.

2. CULTURE, VALUES, AND BEHAVIOUR

Culture is, "…the collective programming of the mind which distinguishes one category of people from another" (Hofstede, 1994a). Thus, culture is learned, rather than being innate or inherited genetically; it is learned and practised through replicating and responding to the behaviour of others. Culture is a collective construct and so, categorisation of people may be by ethnic origin, political nation, organisation.

Culture is manifested through behaviour. Behaviour, whether determined via conscious thought and evaluation or instinctive, is dependent upon values and beliefs. Instinctive, genetically-driven human behaviour is quite consistent amongst people whilst, in cognitive-driven behaviour, cultural influences are strong and so, behaviour varies. That prompts models of culture with physiological instincts and beliefs at the core (survival imperatives; religion, morality), values as the intermediate layer (the hierarchical ordering of aspects of beliefs, perhaps with visions of trade-offs), and behaviour at the outer layer (language, symbols, heroes, practices, artefacts).

The observable, outer layer must be employed to secure measurements indicative of culture through identifying and defining suitable dimensions. For national cultures, Hofstede (1980) determined four dimensions: Power Distance, Individualism / Collectivism, Masculinity / Femininity, and Uncertainty Avoidance. A fifth dimension of Long-Termism / Short-Termism was added later (Hofstede, 1994b) following studies in Asia which found important impacts of 'Confucian Dynamism' (The Chinese Culture Connection, 1987).

People in collectivist cultures tend to favour people within their group but discriminate against outsiders (Gomez, Kirkman and Shapiro, 2000). Chen, Meindl and Hunt (1997) identify vertical and horizontal components of Collectivism and juxtapose them to Hofstede's (1980) concept of Individualism as, "…individualism (low concern for collectivity and low concern for in-group others) at one end of the spectrum with vertical collectivism (high concern for the collectivity) and horizontal collectivity (high concern for in-group others) at the other end". They find that, "Because the vertical scale items refer to work situations and the horizontal scale items primarily refer to non-work situations, one may speculate that the Chinese are becoming 'organizational individualists' even though they are still cultural collectivists in other domains…". That finding which, it is postulated, could be extended to the 'Asian Tiger economies', may well be consequential upon the rapidly rising levels of industrialisation and wealth (e.g. Triandis, 1990; Hofstede, 1983, 1994b:75), thereby demonstrating an important manifestation of evolutionary dynamism of national cultures. Hofstede (1983) notes the correlation between wealth and individualism in various countries and that "…Collectivist countries always show large Power Distances but Individualist countries do not always show small Power Distance". Thus, collectivist countries tend to have rigidly structured societies.

Hofstede (1994b) employs six dimensions of organisational cultures: Process – Results Orientation, Job – Employee Orientation, Professional – Parochial, Open – Closed System, Tight – Loose Control, and Pragmatic – Normative. Cameron and Quinn (1999) use a 'competing values' model – 'flexibility and discretion' are juxtaposed to 'stability and control' on one dimension; the other dimension juxtaposes 'internal focus and integration' and 'external focus and differentiation'. The resultant model yields four quadrants, each one denoting a type of organisational culture: Clan, Adhocracy, Market, Hierarchy.

Cultures and cultural changes impact on performance, including what aspects of performance are regarded as important! Importation of alien methods and values commonly generates rapid rejection – whether overt (e.g. refusal to comply) or implicit (e.g. low levels of performance). However, the situation is not straight forward as many sub-cultures co-exist; Cameron and Quinn (1999) suggest that organisations may not exhibit a single, unitary culture and that measures used for strengths of cultures are subject to significant question. However, Schneider (2000) asserts that every successful organisation has a core culture (control; collaboration; competence; cultivation) which is central to its functioning. Oliver (1997) confirms that organisational cultures are strongly influenced by both national cultures and other aspects of the institutional environments (social norms, law, codes of conduct); she stresses that the values of firms' resources are often context and time dependent.

Changes in organisational cultures are gradual and evolutionary in path-dependent directions; often punctuated by rapid, step-type changes, and by periods of stability. "The evolution of culture is shaped by agency and power, but cannot be created by fiat" (Weeks and Gulunic, 2003). In the context of change, most people prefer the familiar and so, tend to resist change; if change does occur, a strong tendency to revert to prior norms is common so, even behavioural modification is quite difficult.

Encounters between differing cultures may generate clashes; in organisational 'mergers', "Usually the corporate culture of the most powerful economically successful company dominates." (Furnham, 1997). Hence, 'merger' really means 'take-over' so, in JVs, whether formal or informal, one participant will dominate; if only temporarily, as in the shifting, multi-goal, power-based coalitions of construction project temporary multi-organisations (TMOs) (Cherns and Bryant, 1984).

3. RISK AND TRUST

Commonly, the terms 'risk' and 'uncertainty' are used interchangeably. However, in risk management, the terms have distinct meanings – risk "is where the outcome can be predicted on the basis of statistical probability" (Fellows, 1996), whereas uncertainties are future outcomes to which probabilities can be attached only subjectively, if at all. Thus, both risks and uncertainties are future outcomes which are products of 'hazard' events (performance variables) and their likelihoods. Risk may be viewed as analogous to systematic error for which detection and control measures may be put in place; uncertainty is akin to unsystematic (random) error with, consequently, enhanced managerial difficulties. Differentiation between risks and uncertainties is germane to the second, third and fourth stages of risk management – identification, quantification, allocation, response; notably for response (avoid, reduce, transfer, insure/hedge, accept), the risk aversion profile of the decision maker couples with the confidence in the risk assessment to determine the response.

Risks / uncertainties operate bi-directionally and so, performance may be better than the prediction, not just worse (performance 'worse' than that predicted is commonly called 'downside risk' and is frequently the focus of management activities intended to control performance). Further, the probability density functions (distributions) of hazard events, individually and in combination, may not be uniform.

The literature concerning risks on construction projects is replete with technical and economic investigations of risks (e.g., Perry and Hayes, 1985; Chapman and Ward, 1997). Culture, as a component of risk, has received only 'passing' attention in construction research (identified only); unlike in the field of strategic alliances.

Elmuti and Kathawala (2001) categorise risks/problems commonly faced by strategic alliances as clashes of cultures/personalities, lack of trust, lack of clear goals/objectives, lack of coordination (between management teams), differences in operating procedures and attitudes, relational risks, performance risks, and that the alliance, itself, may constitute a further, future competitor. Das and Teng (1999) suggest a typology of risks in strategic alliances as relational risks and performance risks. Relational risk concerns unsatisfactory interfirm cooperation and comprises lack of commitment by partner firms and their possible opportunistic behaviour; performance risks are all other risks (environmental, market, and internal).

Having identified risks, the focus moves to overcoming them through control; differing frameworks are adopted, notably including transactions costs and FDI. Equity-based control is suggested to be effective through alignment of objectives of formal alliances; however, for informal alliances, contractual and managerial controls must be used. For inter-organisational relationships, the issue of risk may be transmuted into cheating and forbearance (see, e.g., Buckley and Casson, 1995). Cooperation is "coordination effected through mutual forbearance" (ibid:127). Forbearance is refraining from cheating. Hence, trust may be adequate confidence (on the part of the subject actor/participant) that the other participant(s) will not cheat.

Risk, cheating, forbearance, and trust are culturally-bound behaviour and encompass ethics. The moral underpinnings and their manifestations in rules and practices vary between societies and it is all too easy for ethnocentrism to operate (unwittingly) in setting the value system against which behaviour, particularly of others, is judged. Double standards may result for judging self and in-group members, and for judging out-group actors. That cultural differences may be neither recognised nor taken into account exacerbates the likely problems. Peoples' values, objectives, behaviour, and tolerances are not consistent. In pragmatic terms, notions of what is cheating vary, as do initial, trend-setting ploys in forming relationships (trusting or wary).

Trust is always a vital element in the decision to engage in any (business) relationship, whether the source of trust is founded in legal/contractual mechanisms, in institutions (Hagen and Choe, 1998; Bachmann, 2001), or in individuals (singly or in combination). In simple, individual transactions within a competitive market, the duality of trust and control are employed in determining the other party with whom to transact – to secure performance and its assurance from the outset and/or to secure redress for any material deficiencies. In construction, standard procedures have evolved (with authority) to help ensure that the performance required (specified) is secured – tendering procedures, contract forms etc., reflecting particulars of generic legal requirements. Recently, attention has reverted to 'teamwork', 'partnering', 'relational contracting' as an apparent, overt endeavour to foster trust, somewhat independent of legal-based controls. In that context, impressions of cultures with more collective and longer-term orientations have been material, especially Japan.

However, Womack, Jones and Roos (1990:155) note that "The relationship…in Japan is *not* built primarily on trust, but on the mutual interdependence enshrined in the agreed-upon rules of the game" (emphasis added). That is extended by Hagen and Choe (1998) who state that "…the institutionalized industry practices that we call 'institutional sanctions' in the context of societal sanctions, are key determinants of interfirm cooperation", manifested as the deterrent-based trust in Japanese industry.

Yamagishi and Yamagishi (1994) distinguish trust and (performance) assurance. If an actor trusts another due to some 'guarantee' that the other has an incentive to cooperate, then that situation is one of assurance; trust exists when an actor believes that the other has an incentive to cheat but does not do so – perhaps because of goodwill. That echoes Hagen and Choe (1998) who note that, "…a trust relationship in business involves an expectation of cooperation but not an expectation of altruism".

4. PERFORMANCE

Many factors affect performance on construction projects – both project performance (the completed project in use) and project management performance (the project realisation processes; usually measured in terms of quality, time and cost). To date, the majority of research has, at best, only identified 'culture' as a construct which impacts on performance, and so, constitutes an element of performance 'risk'.

Popularly, the focus of performance has concerned measures of project management, especially regarding choice of procurement approach and methods for selection of participants. Often, performance variables and parameters have been confused with, and supplanted by, performance targets. Literature concerning (strategic) procurement (e.g., Kelly, MacPherson, and Male, 1992; Atkin, and Flanagan, 1995) asserts the importance of analysis of the commissioning client and their requirements for project performance, usually adopting a value management approach. However, that orientation not only ignores other participants but, usually, deflects to project management performance and comparisons of realizations with targets.

Thus, a cultural fundamental of the industry seems to be a strong focus on project management performance, as that is the business environment of participants. Amongst primary designers (architects, engineers, surveyors), much of their input relates to realization/delivery mechanisms. Although architects and engineers do focus on the project as product – and so, relate to project performance – they also consider realization processes in executing design as those requirements are often strongly expressed as the major, immediate targets. That is reinforced by surveyors (cost engineers) having a 'traditional' focus on the client's budget/cost limit for obtaining the project; the gradual move towards 'life cycle costing' should be a mitigating factor as, more notably, should be the use of 'value management'.

That final aspect inevitably raises the questions of whose values should be used, how to identify them, and how to ensure that they operate as the focal criteria for both project performance and project management performance. Hence, the imperative of understanding culture, especially in the context of construction project TMOs.

An enduring criticism of the construction industry is fragmentation which, in alternative guises, is division of labour, or specialisation. Lawrence and Lorsch (1967) investigate the dichotomy of differentiation and integration within organisational processes and determine that appropriate degrees of both are required for effectiveness and efficiency – analogous to clan organisational culture.

Commonly, the realisation of construction projects is discussed in terms of 'the team' (see, e.g., Latham, 1994), which, according to systems theory, comprises various 'sub-teams'. The essential element distinguishing a team is that the participants in the share a common (set of) goal(s) – i.e., goal congruence (common project – management – performance criteria). Nicolini (2002) notes five categorical factors which are critical to success and superior performance of cross-functional teams – task design, group composition, organisational context, internal processes, and group psychosocial traits. Those factors are important contributors to 'project chemistry', which is a range of antecedent variables necessary for project management success. Dainty, Bryman, Price, Greasley, Soetanto and King (2005) assert that project affinity, emotional attachments to the project (objectives/purpose) outcome, enhances how people work, especially their organisational citizenship behaviour, thereby fostering performance. Both constructs are culturally-bound and, to their degrees of presence, enhance performance via team formation and commitment of personnel.

5. DISCUSSION

"A transaction is the exchange of *values* between two parties." (Kotler, 1972). Cox (1999) asserts that, "Essentially, business is about appropriating value for oneself…only by having the ability to appropriate value from relationships with others…can business be sustained….must…be conflicts of interest between vertical participants in supply chains, just as there are between those competing horizontally…In Western (as opposed to Japanese) culture most suppliers are basically opportunistic rather than deferential". Those perspectives emphasise participants' values, what 'value' represents, the differences likely to be encountered and so, indicate an important source of potential conflict and performance risk.

Dunning and Bansal (1997) examine operating approaches and determine that individualistic cultures have advantages in technological assets whilst collectivist cultures have advantages in organisation of the workforce and establishment of relationships between participants. However, Li, Lam and Qian (2001) note that "…the effects of societal culture seem to be moderated by the technological resources of the investors." and that there is "…a significant impact of technology on productivity…". That widespread perception underpins the common desire by developing countries to participate in formal JVs with firms from developed countries – to foster technological advancement and training through 'technology transfers'.

Wilkins and Ouchi (1983) examine three modes for governing transaction – markets, bureaucracies and clans. Clans (quasi extended families) socialise self-interested actors to identify congruence in the objectives of the transaction(s), thereby reducing (even removing) the requirement for close monitoring and so, fostering efficiency in governance despite high transactional uncertainty and complexity. The 'loosely coupled' but, *necessarily*, goal congruent clan is suited to overcoming short term difficulties due to its long term perspective – as in construction project participants repeatedly encountering each other. That construct appears to be congruent with the clan category of organisational culture (Cameron and Quinn, 1999).

A number of studies have concerned business relationships across national, and, hence, assumed, cultural borders. Often, the studies have used measures of cultural distance, investment risk, and market potential to explain the modes of entry to new locations – how the firms respond to the externalities which they perceive in the target location. Hence, Agarwal (1994) notes that "..firms choose a higher control form in response to conditions of high external (market and political) uncertainty ..[and].. in countries that have greater market potential..". But "..firms..need to get established early in emerging markets..[and so,]..regardless of the market potential and/or country risk, firms resort to sharing of risks and managerial resources" often, because they are required to do so by the law of the target country in order to obtain a presence there (as was the case in mainland China until entry to WTO) – indicating that the perceived gains from early entry outweigh the perceived risks (costs).

Brouthers and Brouthers (2001) investigate the relationship between cultural distance and entry mode and find that investment risk moderates that relationship, "Firms entering culturally distant markets low in investment risk tended to prefer cooperative modes of entry. Conversely, firms entering culturally distant markets high in investment risk tended to prefer wholly owned modes of entry.". This finding appears to contrast with Agarwal (1994) but the contrast may be due to the influences of the intervening variables – desire for early market entry; perceptions of investment risk.

Shenkar (2001) discusses the impact of the theory of familiarity in that firms are less likely to invest in markets which they perceive to be culturally distant. Hence, in predicting entry mode, transaction cost theory (e.g., Williamson, 1985) associates greater cultural distance with higher risks and, therefore, higher entry costs; greater perceived cultural distance is positively correlated with hierarchical structural forms of entry (Dunning, 1988). That approach may be reflected temporally also in that during initial stages of engagement in 'foreign' markets, firms show stronger preferences for similar cultures than in later stages, when they seem to be less 'culturally sensitive' (Davidson, 1980). Kogut and Singh (1988) note that both the cultural distance from the home country and the score for uncertainty avoidance is correlated with preference for JV form of entry to a new country market.

Clearly, measurement of cultural distance is, itself, an issue. Normally, cultural distance has been measured through use of indices – by addition of scores on Hofstede's dimensions of national cultures (as in Kogut and Singh, 1988). Such an approach to measuring cultural distance involves assumptions which may be problematic (Shenkar, 2001). Cultural distance is not symmetric – home country culture is embedded in the firm, host country culture is embedded in local partner(s) and in the local, operating environment. Cultures are dynamic temporally and vary within national borders. Not all cultural facets are of equal importance nor do they, necessarily, operate in the same direction. Intra-cultural variations (national and organisational) may exceed inter-cultural variations (Au, 2000). Hofstede (1989) asserts that differences (gaps) between cultures vary in significance and that differences in Uncertainty Avoidance are, potentially, the most problematic for international JVs, and, by extension, for all construction projects.

6. CONCLUSIONS

Culture is a major component of risk on construction projects; as a contextual construct, it is not a 'tool' for managerial control but must be accommodated through suitable processes/procedures. National cultures vary significantly internally. Organisational cultures often exhibit hierarchical combinations of types. Hence, it is likely to be (simplistically) misleading to employ an index measure for cultural distance; rather, important factors should be determined case-by-case and measurements made accordingly. Cultural distance between participants is perceived as high risk and so, requires greater management inputs or equity-based relationships.

Evaluation of performance is value-determined and so, is culturally-based. Values of major participants generate the criteria for both project and project management performance – those criteria must be determined rigorously, early, and with cultural sensitivity as an accepted amalgam of requirements of *all* participants in the JV to foster goal congruence and, then, maintained intact as the basis for subsequent evaluations. Only agreed amendments should be incorporated.

Goal congruence fosters trust and so, promotes reduction of control requirements; that promotes efficiency through reduction of transaction costs, independent of the market-firm dichotomy. Environments promoting deterrent-based trust via social institutions have similar consequences. Trust promotes effectiveness also, especially if coupled with implementation of the appropriate value/performance determination, as above.

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A CRITICAL LOOK AT THE FACADES OF CONTEMPORARY APARTMENT BLOCKS: THE CASE OF EVER-CONSTRUCTION IN ANKARA

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ABSTRACT

Highly populated cities of Turkey are ever under-construction due to the never ending market demand for especially apartment blocks. In the case of Ankara, capital city of Turkey, being one of the planned cities of the modern era, a construction haze trying to keep up with this market demand is evident, somehow threatening the control over the city plan. The haze in constructing the apartment blocks leads to the fast generation of buildings, the speed of which the environment cannot keep up with. Hence, the buildings become detached from both their immediate surroundings, and similarly from the urban setting. This paper, looks at the built environment not from the point of view of users, but it rather regards the apartment blocks as an indispensable part of the urban fabric and discusses the quality of physical environment in terms of the facades of these apartmet blocks. One of the most effective and important faces/representatives that reflect the tastes of a period are the facades. The facades of contemporary apartment blocks in Ankara display tastes ranging from pure modern to high kitsch. This may be regarded as an asset in terms of creating a rich and polyphonic architectural scenery, yet the problem arises when the number of kitschy examples becomes overwhelming in this scenery. This paper asserts that the kitsch traced on the facades may be explained by the wish to become distinguished within the so-called pile of apartment blocks. The element of distinction is often formed by twisting some cultural references, inspired by traditional motives or by scenographic ornamentation. Such facades attempt to mark/distinguish the ostensible status of the owner and announce it to the passerby. Within this framework, this paper indicates the cultural twists turning into architectural bodies, and traces their roots to the desire of becoming part of the whole with a unique pompous identity. Parallel to this, the paper argues that in the case of Ankara, the phenomenon of ever-construction generates sustainability, yet unfortunately of cultural twists. However, the situation cannot be simplified to a cause-and-effect relationship. It should be noted that the relationship between the phenomenon of ever-construction and cultural change is reciprocal. This paper indicates that when either one goes haywire due to an uncontrollable speed, then it drags the other one along and both end up deformed.

Keywords: Ankara, Apartment blocks, Construction haze, Culture, Façade

1. INTRODUCTION

After its proclamation as the capital city of the young Turkish Republic, Ankara has developed fast as a 'modern' city within the confines of a series of 'modern' plans. Currently, after more than 80 years, in spite of having a 'modern' face and a highly developed, widely spread built environment, the need for further expansion and the demand for new built areas do not seem to have ceased in Ankara. In line with the profile of Turkey as a developing country, Ankara is perhaps the most forthcoming city to reflect that profile. Considering the vast historical heritage of Istanbul, which gives the city a unique quality as well as a unique status in terms of construction criteria, Ankara displays a more flexible situation as it may grow along a series of contemporary city plans, allowing new residential areas to be formed where the necessity arises. Therefore Ankara becomes a place where the overall development speed and enthusiasm of Turkey is translated into an ever growing and never stopping development in construction.

Within this construction portfolio, due to the fast increase in the demographics (born and migrated) and the dynamics of market demand in line with the profile of a developing country, the supply of especially high-mid class and high class apartment housing is at a peak point. With the increasing economical share and understanding of contemporary living styles and trends, more people come to demand such standard of housing.

The resulting increase in construction is without a doubt, a positive asset, providing extensive areas of employment and giving way to high technologies to be applied in the constructional sites. However, the increasing demand and the quick and uninterrupted return of the invested capital render construction a popular field, and result in a ‘construction haze’: Build as much and as quick as possible! (Figure 1) Within this haze, it is often the case that the environment cannot keep up with the speed of the building construction. The result is high quality apartment blocks standing alone in unbuilt sites, without properly built roads, organized environments, adequately provided service facilities. The construction of apartment blocks may even jump ahead of the city growth, and become detached from the emerging urban tissue.

Figure 1. The ongoing construction activity in Ankara

Without the support of a properly developed surrounding environment (Figure 2) and/or the attachment to a physically explicit urban tissue, the apartment blocks may fall short of having an adequate means of expression, in terms of distinguishing them from the rest of the pile of blocks. A distinguishing property, a means of expressing its unique identity becomes so desirable that especially the facades of the blocks turn into available surfaces/faces to speak out for identification.

In some cases the identification goes in line with the 'modern' aura, parallel to the technological edge(s) of the construction, putting forth contemporary and innovative features. Yet, in some others, self-identification on the facades may be reduced to the utilization of eclectic folkloric motifs, applied mostly 2 dimensional, often at a blown up scale. Such applications justify Elkadi's argument that while economical forces dress up the cities in the global manner, cultural forces tend to protect the more conventional/traditional look (Elkadi, 2005).

Figure 2. Luxurious apartment blocks popping up within unbuilt vicinities

In our case, the prevalent traditional look on the faces of the apartment blocks addresses the taste of the "simple folk", as Salgueiro (2006) names it, desiring a simple and extensive adherence. Freschi studies a specific case in architectural history from a façade-based point of view, and based on his observation that "expression of urban consciousness and desire to articulate capitalist cosmopolitanism in the vocabulary of modernism" he asserts that "form follows façade" (Freschi, 2004). In the case of Ankara, the facades with eclectic motifs neither drag form along nor affect the interior.

In light of the above discussions, this paper problematizes the tendency of the facades in representing a bad taste within all the attractiveness of the ongoing constructional innovations. The architectural criticism in Turkey tends to focus its attention too much on some famous architects and their works, and displays an insufficient interest in the unknown architects' dispersed works. Whereas the urban environment is not formed by the landmarks, but by these anonymous majority of apartment blocks. Here, the problem is that when these apartment blocks are critically assessed, it is often done through the social, cultural, economical aspects, but rarely through aesthetical and innovational aspects. Academia, on the other hand, does not recognize the apartment block as a prominent design problem to be studied in the design studio. What this paper aims is to encourage development of a critical look at the apartment blocks, since they play a fundemental role in the shaping of the urban environment. With the initiation of such a critical look, consequently there may open up a route for arriving at possible legislational and planning solutions.

2. MEANING OF THE FAÇADE AS THE 'FACE' OF THE SOCIAL IDENTITY

Culture is a term that refers to a variety of meanings and concepts (Hall, 1959). In this respect, it is very important to clarify the viewpoint before using the term. According to Amos Rapoport, culture may be understood as a system of symbols, meanings, and cognitive schemata transmitted through symbolic codes. Parallel with this understanding, we assume that façades, the representative elements which transmit certain meanings through symbolic codes, should be considered as the powerful constituents of the complex web of cultural expression (Rapoport, 1984). Famous theoretician and architect Rob Krier states that "the façade is still the most essential architectural element capable of communicating the function and significance of a building" and "a façade (also) tells us about the inhabitant of a building, gives them a collective identity as a community and ultimately is the representation of the latter in public"(Krier, 1992).

Cities cannot be explained through single theories (Teymur, 1996). However, urban environments find their expression through the facades to a great extent, and we will frame our view-point based on the analysis of the facades. The architectural experience within an urban environment is largely formed by the facades. Besides many other features, the architectural culture of a society can be read through the facades as well. Thus, the architect *re*shapes the spirit of the city in a sense, while determining the 'face' (façade deriving from *faccia* meaning *face* as stated in the Merriam Webster online dictionary) of his/her building.

Colquhoun argues that building is composed of complimentary elements, which are motivated with potential meaning (1986). In this sense, facades do not simply envelope function(s), rather they give expression to the architectural idea, they transmit meaning through symbols and they present 'readings' of the intended and unintended messages. Facades may also be considered as the essential visual signs of the cultural contours of the present time as well as displaying the artistic choices of the architect. In this dichotomy if the cultural contours come to dictate over architect's innovation the situation becomes problematic. This problematic is further complexified when it occurs in a growing city where the cultural contours are dynamic due to migration, such as in Ankara.

3. ANKARA

Prior to proclamation as the capital city, Ankara was a small Anatolian town located north of the İstanbul-Anatolia railway connecting the town to the national system. The settlement area covered about 140 hectars and the 1902 population was 33.768 organized in small, dense neighborhoods around a modest town center and the spread of loose settlements in farms and orchards in the northern section of the city (Altaban, 1987). With the proclamation of the city as the capital, a national administrative staff arrived from İstanbul to create a new town representing the sovereignity of the new Republic, through an international planning competition opened in 1928 for a comprehensive development plan. The Jansen plan, winner of the competition, was put to effect in 1932 and had a pronounced impact on the development of the city. The construction process proceeding rapidly according to the plan and adoption of capital city functions created a lively employment market drawing waves of migration from surrounding provinces.

Population of the city increased rapidly especially due to incoming migration and by the year 1955 the target population of the Jansen plan (300.000) was largely exceeded. A new international planning competition was therefore organized in 1955 and a plan based on target population of 750.000 in the year 2000 prepared by Turkish planners was approved in 1957. The target population of the plan was reached in the mid-1960's (Altaban, 1987). Today in 2006, Ankara accomodates a population of almost 4 million. This paper concentrates majorly on the areas where the high-middle income residences are gathered and especially the migrant and rich are settled (Güvenç, 1990). Two sample neighbourhoods; 100. Yıl and Yıldız are selected to illustrate the arguments of this paper.

4. CASES: TWISTING CULTURAL SYMBOLS IN THE NAME OF INNOVATION

In Ankara, expansion, change and variety in the citizen profile/composition, resulted in a complex urban fabric. Ankara is still growing and this growth is reciprocal with the on-going construction. In other words, it is growing with the construction and it is constructed parallel to where it grows. This situation not only speeds up construction but expands it as well, leading it to become almost a haze. No doubt, this construction haze embraces pure forms and modern monuments of dwelling, speaking of the contemporary architectural language, some with a compotent grammer, some with distorted syntax.

Unconscious and deformed quotations from the historical repertoire of architectural elements and folkloric motifs on the facades seem to succeed in creating a popular accomplishment (Figure 3). Devoid of intellectual recognition/thrust, but fully armed to seduce the (intended) public, the provocative facades of the new housing blocks reinterpret the capital city. Those facades which involve symbols, ornamentation and applied decoration, ostensibly fullfil the desire of being distinguished. Ankara's typology of earlier apartment blocks, conservative and serious, are taken over by the kitschy monumentality of new residential blocks.

Figure 3. A collection of folkloric and decorative figures applied on the facades

Starving for recognition both socially and architecturally in the multiplicity of residential blocks, some display two dimensional folkloric motives on the facades, mostly on the front, and not on the sides.

These motives may at times become less folkloric and more figurative, or they may totally transform into scenographic/theatrical arrangements (Figure 4), yet the most accurate depictions of the cultural references are illustrated by the folkloric ones.

Figure 4. Chaotic use of architectonic elements (left) and theatrical reproduction of the stone age (right), resulting in 'kitsch'

The transfer of folkloric patterns (often utilized on carpets, upholstery, pottery, traditional clothing) into the facades often indicate an oscillating social profile between being urbanized and being attached to aesthetics of the rural. Moreover, if this transfer lacks skillful architectural interpretation, it becomes pure cut-and-paste; twisting cultural references by dislocating them and stripping them off their original context (Figure 5). As such, a great opportunity that could produce innovative works is wasted, replaced by easy populism.

Figure 5. Reproduction of traditional Turkish house feautures on the apartment blocks

5. CONCLUSION

For the construction community, from architects to engineers, from city planners to landscape architects, it seems to be an opportunity to have an ongoing construction activity. Due to the tremendous increase of population, the need for more dwelling occupies the agenda of urban issues. This situation, at the same time, creates occasion to introduce innovations both in design ideas and construction techniques. Furthermore, the sustainability of construction activities is identified as a prerequisite for social development by the Ministry of Public Works and Settlement of Turkey (Erbakan, 2006). However, when the construction activity turns into a construction haze, there occurs the potential danger of creating an uncontrolled environment.

The case of Ankara contains the lesson that within such a haze some populist images may easily be absorbed as innovation, besides the real innovatory attempts. Similarly, some cliché symbols and kitschy fragments may be celebrated as the reflections of cultural expression, besides the outstanding products of post-modern architectural thought.

The advantage of the aesthetic and innovative approach to the facades lies in its potential for raising the quality of urban environment in general and triggering technological novelty. Practicing architecture within a construction haze should not prevent us from remembering that creating a built environment is an irreversible process. Physical expression of cultural relations no doubt can be subject of creative design yet, tatooing buildings with reproduction of traditional features or with unsophisticated images inevitably reduces this expression and its cultural associations into easy decoration.

Uncritical acceptance of the environment built in a haze seems to be a gaffe. When preoccupation with tatoo-like ornamentation does not meet with careful judgement by the architectural authorities, such trivial formulae constitute the new architectural identity! The phenomenon of ever-construction generates sustainability, yet unfortunately of cultural twists embodied in façade ornamentation. This situation cannot simply be explained by a cause-and-effect relationship. The relationship between the phenomenon of ever-construction and cultural change is reciprocal: When either one goes haywire due to an uncontrollable speed, then it drags the other one along and both end up deformed.

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CULTURAL RISK ASSESSMENT IN CONSTRUCTION PROJECTS

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ABSTRACT

Construction projects are subject to diverse risk factors which may influence project participants' performance and eventually quality of the constructed projects. One of the significant risk factors is cultural risk that stems from the characteristics of a multi-cultural project environment. Therefore, it is essential to analyze causes and consequences of cultural risk when a construction organization decides to perform projects where different cultures of project parties may cause conflicts in the working environment. The aim of this study is to define cultural risk, identify its sources and build a model for the assessment of cultural risk related to construction projects performed in multi-cultural environments. Based on the opinions of construction professionals, an Analytic Network Process (ANP) model, which may be used as a decision support tool for cultural risk assessment will be developed. With the help of ANP interdependence relationships between factors can be modeled. The findings of the prioritization process conducted by ANP will be discussed to identify the most significant contributors of cultural risk.

Keywords: Analytic Network Process, Cultural Risk, International Construction, Multi-Cultural Environment.

1. INTRODUCTION

Construction projects are subject to an assortment of risk factors which are the outcomes of the involvement of diverse parties in different stages throughout their life cycle. Moreover, since the trend towards international construction is increased due to the new opportunities offered by developing countries which are in need for infrastructure and buildings, new sources of risk emerge together with the original causes (Gunhan and Arditi, 2005). One of the significant risk factors is cultural risk that stems from the characteristics of a multi-cultural project environment. Although both local and international construction projects may have multi-cultural environments, nonetheless, the risk of working with different cultures increases in global markets.

Construction organizations are enthusiastic to explore new opportunities abroad. Globalization of construction markets now allows local construction companies to compete internationally (Han and Diekmann, 2001). Mahalingam and Levitt (2005) argue that as globalization proceeds at an ever-increasing rate, the amount of international or cross-national construction activity is increasing dramatically. Large domestic and multinational companies are setting up overseas subsidiaries. Simultaneously many governments, particularly in developing countries, are soliciting international aid in terms of financing, technology and know-how, in order to speed up their development. However, it is essential to analyze causes and consequences of cultural risk when a construction organization decides to perform projects where different cultures of project parties may cause conflicts in the working environment. Moreover, to analyze risk from a project point of view, it is essential to identify how the project is likely to be impacted by the country factors and the specific market conditions (Hastak and Shaked, 2000).

Because of the significance of the risks associated with working in international markets, several studies were conducted to analyze risk related to international construction. There exist three different approaches for assessing country risks which are: (1) the political risk assessment approach; (2) the macro- sociopolitical approach; and (3) the exchange instability approach (Hastak and Shaked, 2000). The political risk assessment models mainly consider economic, financial, political, legal, and social condition in addition to policy and foreign exchange systems of the host country (Hastak and Shaked, 2000). Moreover, most of the studies focus on the political risk assessment on the expense of the cultural risk coupled with working in a multi-cultural environment. The available studies in literature usually handled cultural risk in two ways. The first approach considers the overall effect of social, cultural, and religious differences as part of the country risk; while the other takes into account the effect of cultural difference on the working environment (business and project specific conflicts). Yet, there is no integrated study which combines both approaches together and conducts a detailed assessment of cultural risk factors. On the other hand, there are some attempts to provide comprehensive models for assessing international construction risk. One of the comprehensive models is ICRAM-1 (International Construction Risk Assessment Model-1) which was developed by Hastak and Shaked (2000). The model analyzes risk of working in international markets in three levels: (1) Macro (country) level, (2) Market level, and (3) Project level. Although the model may be considered as a comprehensive model, Analytic Hierarchy Process (AHP) is used to calculate the risk impacts, thus the interrelations between the risk factors at the same level are ignored. Moreover, the overall impact of cultural differences may not be assessed reliably. Another study was conducted by Dikmen and Birgonul (2006) which aimed at the assessment of risks and opportunities in international construction projects. The study also uses AHP and considers cultural differences as a risk factor without elaborating the sources of cultural differences. There are some studies which analyzed cultural conflicts in some detail, an example of which is Baba (1996). In his study, he categorized cultural difference into: traditional organization structure; managerial differences; and differences in fundamental concept and philosophy. Moreover, Baba considered cross cultural differences from risk management perspective; he recognized that the risk factors associated with international construction can be classified into: political situation; economic and financial situation; and social environment, where he proposed that social environment risks are mostly expected to be the outcome of cultural differences. Further, he stated that these risk factors are beyond the control of the construction organizations, yet they can be managed, and are relatively predictable and measurable by adequate statistics.

The major shortcoming of the existing research studies is related to the absence of detailed assessment of the foremost sources of cultural risk. A crucial research question is "What are the sources of cultural risk?" Measuring the level of cultural risk in a project is the next step. There may be strong dependencies between the sources of cultural risk. Thus, another research question is “How can the level of cultural risk be measured by considering the complex relations between the risk sources?” Major shortcoming of the existing models that use AHP is the assumption of independence among the identified factors. Moreover, the conducted studies mainly analyze cultural risk at the country level and do not consider the impact of cultural risk on either market or project level indicators (Hastak and Shaked, 2000). Therefore, the aim of this study is to develop a comprehensive model for the assessment of cultural risk related to construction projects which are performed in multi-cultural environments. For this purpose, initially, cultural risk will be defined and sources of cultural risk will be identified. Further, a model will be developed using Analytic Network Process (ANP).

2. DEFINITION OF CULTURE AND CULTURAL RISK

According to the definition of Edward B. Taylor "Culture, taken in its wide ethnographic sense, is that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society" . The United Nations agency UNESCO defines culture as the "set of distinctive spiritual, material, intellectual and emotional features of society or a social group, and that it encompasses, in addition to art and literature, lifestyle, ways of living together, value systems, traditions and beliefs". Kroeber and Kluckhohn (1952) compiled a list of more than 200 different definitions of culture in their book.

In this study, the term “culture” is used to reflect the beliefs, customs, habits and the ways of conducting business in a society that will have an impact on how a construction project is conducted and managed. Risk is defined as any event or factor that involves either uncertainty or vagueness that may have an impact on project objectives. It is assumed that some problems may be encountered in a multi-cultural project environment due to cultural difference between the project participants and these problems may have an adverse effect on the predetermined project success criteria such as cost, time and quality. The reasons of these problems associated with cultural differences are defined as cultural risk factors.

3. METHODOLOGY

The study was carried out through the following main steps: (1) Risk identification: Identification of cultural risk factors associated with international construction through literature review and experience; (2) Development of the conceptual model: Developing a network structure that includes the risk factors and interrelations between them (3) Utilization of ANP: Conducting brainstorming sessions and using ANP to calculate the contribution of each risk factor to the overall cultural risk. The detailed discussions for the above mentioned steps are given below.

Step 1: Identification of Cultural Risk Factors
While identifying the risk factors, it is of vital importance to avoid inconsistency of defining risk. Risk may be seen as source, consequence or probability of occurrence of a negative event. Inconsistency results from mixing the different perspectives of risk (Dikmen and Birgonul, 2006). For this research, as mentioned earlier, all of the factors

that may have an impact on project success criteria and resulted from cultural differences are defined as cultural risk factors; thus, risk is considered as a source rather than a consequence. However, the consequences of each defined source will be discussed briefly.

The literature related to international construction was reviewed to identify the potential sources of cultural risk. Individual sources of cultural risk cited in different research studies (e.g. Pheng and Yuquan, 2002; Han and Diekmann, 2001; Baba, 1996; Hastak and Shaked, 2000) were tried to be integrated into a comprehensive model. The experience of the authors of this paper was also utilized to improve the model with additional sources. Identified risk factors were grouped into two main categories where the first category included the risk factors associated with host country and the other one with the project environment.

Step 2: Development of the Conceptual Model
In this step, a conceptual model is developed in the form of a network. For this purpose, criteria, sub-criteria and interrelations between them have been defined. The model is depicted in Figure 1.

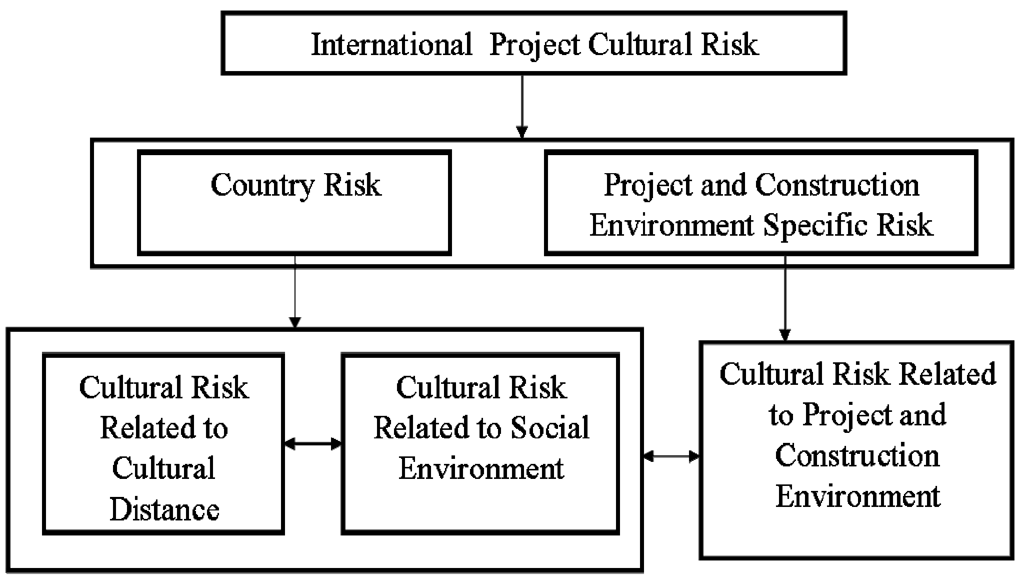

Fig. 1 International Project Cultural Risk

The study identified a total of 13 cultural risk factors, which include both country and project specific factors. Table 1 describes these factors in detail.

Table 1. Cultural Risk Factors

Criteria	Sub-Criteria	Risk Factors	Description
Country Risk	Cultural Risk Related to Cultural Distance	Individualism	Opposite to collectivism which is the degree to which individuals are integrated into groups. It is about the degree the society reinforces individual or collective achievement and interpersonal relationships.
		Power Distance	The nature of human relationships in term of hierarchy. It is about the degree of equality, or inequality, between people in the country's society.
		Long Term Orientation	It focuses on the degree the society embraces, or does not embrace long-term devotion to traditional, forward thinking values.
		Uncertainty Avoidance	It is concerned with how cultures adopts to changes and cope with uncertainty. It is about the level of tolerance for uncertainty and ambiguity within the society.
		Masculinity	It considered the extent that society stresses achievement or nurture. It is about the degree the society reinforces, or does not reinforce, the traditional masculine work role model of male achievement, control, and power.
	Cultural Risk Related to Socio Environmental factors	Traditions	Tradition is a mode of thought or behavior followed by a people continuously from generation to generation. This factor considers the risk of working where different traditions may exist.
		Language	Language barrier is the risk related to the language(s) of the host country and the degree of familiarity of the contractor and his employees to these language(s).
		Legislation	This factor is related to the risk associated with the traditional methods used for solving disputes and the ruling law in case of conflicts.
		Religion	Risks due to religious differences between the contractor and the host country.
Project and construction environment specific risk	Cultural Risk Related to Project and Construction Environment	Collaboration and Communication	Barriers to collaboration and communication due to working in multi-cultural environment. When the parties of projects coming from different cultures, high communication barriers may be faced and poor communication and collaboration within project environment could jeopardize the success of project.
		Contract Language	In international projects, the contract is usually written in more than one language, therefore, the ruling language for the execution of the contract and in case of dispute represents a source of risk for contractors.
		Construction Methods and Resources	Culture plays an important role in the determination of the methods and approaches used for construction and the utilized technologies. Working in different cultures may lead to inability to make use of the previous experience of the contractor which is risk related to construction methods and resources.
		Requirements	Unclear safety and quality requirements are sources of risk which may cause accidents and poor quality work. This may be due to the adoption of different standards or unclear regulations.

The term “Cultural Distance” that is mentioned in Table 1, adopts the national cultural framework proposed by Hofstede who specifically examined the role of national culture in work-related values and information system design. Hofstede constructed his framework on a review of sociological and anthropological theories and work (Harvey and Francis, 1997). The initial four dimensions of national culture which are considered in the framework are:

- **Uncertainty avoidance**: the extent to which future possibilities are defended against or accepted. This dimension focuses on how cultures adapt to changes and cope with uncertainty. Emphasis is on the extent to which a culture feels threatened or is anxious about ambiguity.
- **Power distance**: the degree of inequality of power between a person at a higher level and a person at a lower level, this dimension focuses on the nature of human relationship in terms of hierarchy.
- **Individualism**: the relative importance of individual goals compared with group or collective goals, this dimension focuses on relationship between the individual and the group.
- **Masculinity**: the extent to which the goals of men dominate those of women, this dimension focuses on how extent to which a society stress achievement or nurture.

Later, a fifth dimension was added by Hofstede after conducting an additional international study with a survey instrument developed with Chinese employees and managers. This dimension is “Long Term Orientation” which focuses on the degree the society embraces a long term devotion to traditional forward thinking values or not. Cultural distance was considered due to the role that those factors play on the stabilization of the working environment. The influence they have on the potential project specific risk factors is also included in the model. According to Hofstede, countries with high uncertainty avoidance tend to minimize risk which leads to resistance to change. In an effort to minimize or reduce this level of uncertainty; strict rules, laws, policies, and regulations are adopted and implemented. Hofstede argues that the ultimate goal of these populations is to control everything in order to eliminate or avoid the unexpected. As a result of this high “uncertainty avoidance” characteristic, the society does not readily accept change and is very risk adverse. Moreover, when a country have both high “uncertainty avoidance” and “power distance” this would create society that is highly rule-oriented with laws, rules, regulations, and controls to reduce the amount of uncertainty, while inequalities of power and wealth have been allowed to grow within the society. Further, such culture is more likely to follow a caste system that does not allow significant upward mobility of its citizens (http://www.geert-hofstede.com).

Socio Environmental Factors

These are the factors related to the social environment of the country. Four factors where considered under this category: (1) Difference in Traditions; (2) Language Barriers; (3) Legislations; and (4) Religious Inconsistency. Detailed description of these factors is listed in Table 1. The factors considered are the potential sources of risk associated with the differences that are due to different social practices between two countries. Language(s) of the host country are usually decided to be the ruling language in case of disputes; therefore the familiarity of the language(s) used in the host country become an essential advantage for the contractor while poor knowledge of the language(s) may lead to misinterpretation of contract clauses or requirements which may end up to conflicts within the project environment. Moreover, these factors are highly related with the cultural distance factors discussed earlier. It is assumed that there are bi-directional relations between these factors.

Cultural Risk Related to Project and Construction Environment

These are risk factors related specifically to the project in a specific country (Hastak and Shaked, 2000). The influence of the country risk (both Cultural Distance and Social Environment) on the identified project risk factors is also included in the model.

The conceptual model that consists of 3 levels is shown in Figure 1. In the network, “an influence” is represented by an external two directional arrow between the two risk categories (country, and project specific) whereas a “relation” is represented by a two directional arrow within country risk sub-criteria. Boxes surrounding each sub-criterion represent the internal relations among elements of sub-criteria.

Step 3: ANP model

It is anticipated that systematic cultural risk assessment may help managers to estimate the level of cultural risk quantitatively, develop effective response strategies to minimize its impacts and determine reliable risk premiums while conducting construction projects in a multi-cultural environment. Thus, in this study, based on the conceptual model, an ANP model is developed as a decision support tool for cultural risk assessment. As defined by Saaty (2005), ANP is a general theory of relative measurement used to derive composite priority ratio scales from individual ratio scales that represent relative measurements of the influence of elements that interact with respect to control criteria. This step aims to perform pair-wise comparisons among the risk factors. In ANP, pair-wise comparisons of the elements in each level are conducted with respect to their relative importance towards their control criterion. Saaty (2005) has suggested a scale of 1 to 9 while comparing two components. A score of 1 indicates that the two options have equal importance where a score of 9 indicates overwhelming dominance of the component under consideration (row component) over the comparison component (column component). Once the pair-wise comparisons are completed for the whole network, the vectors corresponding to the maximum eigenvalues of the constructed matrices are computed and a priority vector is obtained. The priority value of the concerned element is found by normalizing this vector. In the assessment process, a problem may occur in the consistency of the pair-wise comparisons. The consistency ratio provides a numerical assessment of how inconsistent these evaluations might be. If the calculated ratio is less than 0.10, consistency is considered to be satisfactory.

In this step of the research, the conceptual model is imported to the ANP software; SuperDecisions (developed by Adams, W. J., and Saaty, R. W.), and the pair-wise comparison matrices have been prepared and solved using this software. The aim of constructing pair-wise matrices is to find out the relative importance weights of the identified risk factors. The importance weight of a risk factor reveals the contribution of that factor to the overall cultural risk in general. Pair-wise comparisons between parameters are performed considering the inter-related ones based on brainstorming sessions of an expert team.

The procedures carried out in this step are outlined below:

i. The conceptual model depicted in Fig. 1 and the factors listed in Table 1 were used to develop the logical groupings of ANP network; the categories in the conceptual model were used as clusters (Aim, Criteria, Sub-criteria) while the elements under each category in Table 1 were created as nodes.

ii. An Expert team which was composed of three experts experienced in international construction has established links between the parent nodes (either influence or influenced by) and all its children nodes in each cluster. The comparison matrices between nodes were created this way.

iii. The comparisons were conducted in three ways: (1) when comparing the sub-criteria with the main criteria the importance of each sub-criterion with respect to the parent criterion was considered; the question asked was "e.g. Given country risk which sub-criterion under country risk is more important (have greater influence on country risk)?"; (2) when comparing sub-criteria under cultural risk related to the project and construction environment with the sub-criteria under country risk the comparison considered the influence of country risk on the project specific risk (e.g. Given sub-criterion under country risk and comparing two sub-criteria under project and construction environment which one is more influenced by the parent criterion?); and (3) when the interrelation between the two sub-criteria clusters under country risk was considered, the comparison was made between the criteria according to the strength of the relation "e.g. Given a parent which of the two elements is more related to the parent?". Finally, feedbacks (inner relations) between elements in all sub-criteria clusters were also examined. An essential assumption was made during the assessment and comparison: the comparison was bicultural that is when assigning the ratings, it was assumed that the contractor is conducting the job abroad and the other multinational contractors were ignored. The total number of comparison matrices evaluated by the experts was 43. The inconsistency indices for all the matrices were below 0.10 therefore the judgments were assumed to be consistent. Table 2 shows an example of comparison matrix.

Table 2. Comparisons with respect to "Country Risk" node in "Sub-Criteria Social Environment Factors" Cluster (Inconsistency index = 0.0887 < 0.1)

	Language	Legislations	Religion
Traditions	1/5	1/7	4
Language		1/2	5
Legislations			8

iv. There are three super-matrices associated with the network: the un-weighted super-matrix, the weighted super-matrix and the limit super-matrix. The un-weighted super-matrix contains the local priorities derived from the pair-wise comparisons throughout the network. The weighted super-matrix is obtained by multiplying all the elements in a component of the un-weighted super-matrix by the corresponding cluster weight (derived from Cluster comparisons). Finally, the limit super-matrix is derived by raising the weighted super-matrix to its powers and multiplication process is discontinued when the numbers become the same for all columns. Super-matrices are constructed for the resolution of the effects of the interdependences that exist between the factors. In this study, all calculations were performed by Super Decisions

Software. “Computations Priorities command” was used to determine the priorities of all the nodes in the network. The final weights (limiting priorities) obtained as a result of these calculations are given in Table 3.

Table 3. Importance Weights of Cultural Risk Factors as obtained from ANP

Risk Factor	Weights
Collaboration and Communication	0.113816
Traditions	0.108597
Legislation	0.087291
Individualism	0.086981
Power Distance	0.078804
Contract Language	0.077077
Requirements	0.075543
Language	0.074367
Masculinity	0.071053
Construction Methods and Resources	0.066898
Religion	0.063079
Uncertainty Avoidance	0.050763
Long-Term Orientation	0.045733

4. DISCUSSION OF FINDINGS

The obtained weights indicate that the most critical risk factors related to cultural differences are: potential barriers to collaboration and communication, traditions, and legislations; while the least significant factors were to be long term orientation, and uncertainty avoidance. The fact that construction projects experience the involvement of dispersed parties with diverse contributions to the successful achievement of predefined project objectives; implementation of an adequate communication and collaboration system within the project is indispensable to provide a solid ground for achieving the success of the project. However, when the contractor conducts project abroad, it entails working in multi-cultural environment where the probability of the existence of collaboration and communications obstacles raises. Traditions and legislations are risk factors related to the behavior of people and legal practices in the host country. The high rating of these factors reflect the significant influence they have on the project. Traditions reflected by the stream of behaviors within people in certain environment have a noteworthy influence on the project and conflicts due to different traditions lead to increasing possibilities of facing other risks within the project environment. Moreover, complexity of construction projects, especially the ones constructed abroad; increases the risk of disputes and methods used to solve disputes represent a major source of risk for international projects. Although importance weights slightly differ between the factors within the range of (0.06-0.09), long term orientation is ranked the last with a very low weight (0.046), followed by uncertainty avoidance (0.051). These results indicate that the factors which are directly related to the working environment are considered more important than the other factors that do not have a direct influence on the project specific environment. Moreover, the social environmental factors have slightly more influence on the working environment than the cultural distance factors.

5. CONCLUSIONS

In this study, a comprehensive conceptual model was developed to identify the cultural risk sources and an application of ANP was demonstrated as a cultural risk assessment tool in international construction projects. According to the subjective assessments of the expert team, the most important risk factors associated with multi-cultural environments were found as barriers to collaboration and communication, traditions and legislations. However, it should be noted that, the obtained weights reflect the subjective judgments of three experts and are subject to change with respect to different expert assessments. Thus, the aim of this paper is not to report universally accepted views on major reasons of cultural risk, but to propose a framework for cultural risk assessment. Using the conceptual model and outlined procedure, companies may develop their own tools by referring to their own judgments on the level of different risk factors. Alternatively, the proposed model can be used by professionals as a decision-support tool, where he/she can utilize the suggested weights for the specified risk factors. For a given project in a given country, by using a subjective scale, he/she can assign a rating to each risk factor. The specific country conditions should be taken into account while assigning ratings to the identified risk factors. Cultural risk rating may be found by multiplying weights with ratings and summing them up. The output is an indicator of magnitude of problems that may be experienced in an international project due to difficulties of working in a multi-cultural project environment in a specific country. Finally, cultural risk rating may help decision-makers to identify appropriate markup while bidding for international projects.

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RISK AND OPPORTUNITY MANAGEMENT IN PROJECTS

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ABSTRACT

Risk analysis and risk management in project management field is often considered as a separate planning and response function. Its principle thrust is to minimize cost and schedule effects due to risky factors. This paper advocates a project management approach, which is based on business strategy. As a key element to this philosophy this paper aims at bringing out the concept of utilizing a life cycle project management approach for risk management. Risk and opportunity management is a way of approaching business and should cover the entire gamut of project activities. In this context it would be beneficial to club risks, uncertainty and opportunity management as a single management exercise. Focusing on key business objectives in light of risks and rewards is a significant aspect to be looked into while formulating project management philosophy. Risk evaluation should not be limited to schedule and cost factors but should be extended to development and operation of a long term business entity capable of realizing the business goals of the stake holders without diluting community expectations. This may require better knowledge management.

Keywords: Risk Management, Project Management, Construction Management, Life Cycle

1. INTRODUCTION

Risk in Project Management has the dimensions of Impact, or exposure to loss/gain, and the Probability of occurrence (PMBOK, 2005). The product of these two numbers, measured on a scale of 0.0 to 1.0, is referred to as the Risk Index (PMBOK, 2005). Events are said to be certain if the probability of their occurrence is 100% or totally uncertain if the probability of occurrence is 0%.

In a project scenario, we can define one or a number of objective functions to represent the project under consideration and then measure the likelihood and probability of achieving certain target values for them. A few examples of objective functions are capital expenditure, completion time and so on. Risk management involves modeling the project's objective functions against project variables, such as cost, quantities of input resources, external factors, etc. Since the project variables are often stochastic in nature and dynamic (i.e. exhibiting varying degrees of uncertainty over time) it is only to be expected that the objective functions will also exhibit uncertainty. Project uncertainty can then be considered to be the probability that the objective function will not reach their planned target value.

As project variables cannot be expected to remain unchanged in their behavior during the course of a project, it is not possible to estimate the risks associated with these variances. Also it is not possible to identify all of the variables at the outset of the project. Many things unique to each project emerge as the project progresses, and this will compound the difficulty of Risk Management.

The problem is that usually there is no single measure to represent project uncertainty. However, one approach is to identify a theme key to the project. For example in a tight scheduled project where stakes on the schedule are very high, the possibility that the project will not come on time could be considered as representative of the entire project uncertainty. Against this all the project variables can then be evaluated for forming the basis of risk analysis throughout the project. This is however not very successful in complex projects where the traditional theory that uncertainty is high during conceptualization stage and typically gets reduced by planning and decision making does not hold good. In such projects, uncertainties crop up in a dynamic fashion, and do not pursue any specific pattern. As such risk management has to be very flexible continuously monitoring the project variables with a view to constantly re-evaluate objective functions and readjust the strategies.

Projects are usually subject to uncertainties due to three principal sources: external factors, shifting business objectives and poorly defined methods for project planning and execution. The latter is not only due to poor knowledge and experience of the project team but also due to project complexity and absence of repetition (most projects are unique undertakings). Examples of external factors include commercial and competitive pressures, collision of social, political and institutional norms and rules with project financial and technical goals, shifting requirements of project stakeholders etc. Developing a knowledge management (KM) system to harvest lessons learned and their contexts through learning histories (Eppler and Sukowski, 2000) would be a vital part of improving access to knowledge of risks and more importantly, their likely causes and impacts. Knowledge about stakeholders and their power to kill or maim projects has been addressed through using visualization tools see for example Bourne and Walker (2005b; 2005a).

Early resolution of project variables is not often possible as the basic information needed to make decisions is not available or it is fuzzy and changes with time. Even when the status of a project variable has been determined it could change over time. This then creates unknown exposure to risks. New risks can be encountered during the currency of the project and seemingly unimportant risks could pose new threats. The combined effects are often so complex that many issues cannot be forecast clearly early on in the life of a project, despite the magnitude of planning and evaluation efforts typically spent on most projects. Uncertainty surrounds many aspects of the project or its parts. Against this background of complexity and uncertainty the challenge is to pursue project objectives earnestly and to look for opportunities to further improve the project's base value.

Thus, project conceptualisation, planning and implementation is a complex, dynamic and evolving process. It should be managed on the basis of a set of strategic objectives, which themselves would be subject to change (in response to the project's shifting environment), on a fully fluid and flexible basis. Further, a holistic and integrative framework is needed in which not only planning and proactive management of technical and financial factors receive attention but equally the social, environmental, political and community aspects are placed at the centre of decision making. The objectives chosen should embrace the project's viability in its broadest sense, over its entire life, and should facilitate management of the process using a continuous risk and uncertainty reduction within a fluid and flexible management framework. Flexibility is very much tied in with a project leader’s sense of security and openness to new ideas to ensure that cross-cultural diversity of teams opens up potential dialogue and knowledge sharing within teams (Walker and Shen, 2002).

2. FRAMEWORK

A framework for conceptualization and implementation of complex projects following a strategy-based decision making philosophy can be developed. It will be argued that risk and uncertainty management should not be seen as a discrete set of activities taking place at the time of conceptualization. Rather, risk and uncertainty management permeates all decisions and should form a component of all evaluations and decisions made during the currency of the project. In particular, management of risks and uncertainties should be a continuous real time operation integrated with other project management operations. This is vital for facilitating the realization of the strategic objectives underlying the project. Properly constituted, risk management processes can provide functional, adaptable, suitable and timely (FAST) knowledge from risk management processes—Cavaleri and Seivert (2005) refer to this as Pragmatic Knowledge. Creating an environment where continuous questioning takes place, reflective experimentation and analysis of causal loops lies at the hard of KM and reduces what is sometimes termed as the ‘stickiness’ of knowledge transfer (Szulanski, 1996). Linking risk management to KM develops the requisite culture.

Project Management and Risk Management

According to the Project Management Body of Knowledge, risk management forms one of the so called nine functions of project management (the other eight being integration, communications, human resources, time, cost, scope, quality and procurement management). The traditional concept is that these functions should form the basis of planning and that each should be the focus of attention in each phase of the project. This approach is fundamentally flawed due to the following reasons:

- It is a disjointed approach as project decisions are evaluated against individual functions using their respective plans.
- It is neither proactive, nor dynamic, as it follows a stepwise (plan-implement-monitor) and somewhat linear approach.
- It focuses on the implementation process and activities, whereas most risks and uncertainties are associated with the project outcome and its viability as a business entity. On many projects risks and uncertainties are particularly high during the pre-implementation stage.

Formulation of Strategic Objectives

Different prospects and strategic business considerations motivate project promoters, including securing a presence in a particular market, entering global competition and maintaining technological supremacy. However, more often than not, the overriding motivator will be the prospect of achieving a target EIRR (Equity Internal Rate of Return). Generally speaking, the promoter's interest on a project can be classified as one or a combination of the following:

- Limiting up-front expenditure on a project prospect (minimizing risk money), while protecting any resultant rights.
- Achieving a target EIRR.
- Limiting or transferring to other parties' risks and liabilities. Risks arise from the likely impacts the proposed project may have on the host community, the surrounding environment, users and other stakeholders. (Risk management will only be plausible when the probability of occurrence and magnitude of impacts can be estimated with a reasonable degree of accuracy.)
- Putting in place a proactive system to reduce project uncertainty continuously.
- Building up a desired corporate profile.

Sometimes, promoters are not investors, and the investors' interests may be different in the sense that many institutional and individual investors are not active participants in the management of the process. Their interests are investment, and receiving dividends and capital gain. Put differently, promoters' objectives are to create a long-term financially viable and balanced business entity of which the project completion is only one part. The ultimate project is a compromise between the promoters' interest and the interests of the community at large. If the objectives are to create a viable business entity then the processes of development and decision-making must also be proactively and deliberately directed to achieving the same.

As seen from the above review, the basis for project development and implementation should be a set of strategic objectives reflecting the worth of the project as a business, and then tying in the project decisions to strategic business decisions. These are referred to as Life Cycle Objective Functions (LCOF's), and classified into the following classes:

- Financial, i.e., those, which relate to the financial state of the project, such as project net worth, EIRR, total life cycle cost, cost/worth ratio and similar functions.
- Customer satisfaction, i.e., those affecting project utility, operability, quality and safety aspects.
- Due diligence, concerns management of statutory, societal, and environmental issues, particularly if the project is located in populated areas or adjacent to sensitive ecological systems.

The aim is to plan the project proactively vis-à-vis its variables, and manage it optimally in respect of its LCOF's. An aspect of this involves real time minimization of project uncertainty. The goal is ensure that projects get conceptualized and implemented based on a set of strategic objectives.

Typical Risk Variables

On large projects the following risk variables are typically encountered: *promotion, market, political, technical, financing, environmental, cost estimate, schedule, operating, organizational, integration and force majeure risks*. In particular, the thrust of management effort tends to be on the individual risk variables and provision of legal protection, should risk variables materialize.

Risk Management Philosophy and Framework

In a conventional project management scenario, Risk Management is considered as a separate activity wherein the managers are alerted to the risks and uncertainties. Very little attention is paid towards quantification of the risks. Simply enumerating a few Risk factors with qualitative categorization as high risk, low risk etc. is not the best way and at times can lead to totally erroneous conclusions. Also, documentation of risk assessment should have cause-and-effect linkages clearly spelled out. This latter point is often overlooked or poorly understood.

The reality is that projects are subject to the shifting forces and constant changes due to the external factors, changing objectives and poor methods for project realization. One important aspect of achieving project success is maintaining a the project vision that aligns with the strategic project objectives (Christensen and Walker, 2004). The vision should be easily understood, inspirational, credible and provide stretch goals to prompt smarter risk management practices (Lynn and Akgün, 2001). So the process of risk and uncertainty management must be continuous, holistic and conducted in real time to be of any value to project managers. This leads us to consider an entirely new approach to risk analysis and management, based on the following general principles:

- Project risk assessment must not be based on a collection of individual assessment of project risk variables, but be based on assessing the likelihood of achieving project's strategic objectives.
- Risk analysis must not be viewed as a stand alone activity; any strategies developed must not be seen as cast in stone commandments. Rather, these should be seen as a component of all decisions made continually to respond to project dynamics.
- Because of the poor understanding of business objectives, scope, method of execution and as well as the shifting influence of the project risk factors on complex projects the project uncertainty tends to be initially high, and difficult to evaluate.
- Even with the best planning and evaluation efforts it will not be possible to gather all the relevant information quickly and craft a viable project, doing so will run the risk of achieving sub-optimal results. As such, the project options should remain open so that uncertainties surrounding the project variables can be resolved optimally at appropriate junctures to minimize their impacts on project objectives.
- Efforts should be made to capture experience not just as a set of bullet points of lessons learned but making explicit likely cause-and-effect impacts.
- Life cycle objective functions must be formulated as the vehicle for analysis and management of risks. The use of LCOF’s permits a holistic analysis of the project risks and within a life cycle framework.

Project options should be kept open and flexible throughout, the concept, planning and implementation stages. Risk mitigation strategies to counter the adverse impacts of known events should be developed. This presupposes that there will be a process whereby knowledge of exposure to such events exists. No amount of technological advance can predict with exactitude as to what lies ahead. The real challenge lies on exposure to unknown events. The Risk Management Philosophy must be able to quickly reevaluate the project options against the unpredicted developments and come out with a re-structuring of the options to adapt to the project objectives.

Occasionally, it is seen that a sub-optimal decision wrongly taken (due to poor reading of the situation) multiplies its effects and forces the project management to take a series of sub-optimal decisions to support the initial sub-optional decision. This could lead to a vicious circle. Also, at times personal ego and focus of a manager to maintain his/her power position at any cost could lead to questionable decisions being taken, and to intransigence. Lack of access to past experience and the context might also exacerbate problems associated with poor risk management.

Such departure from rationality in decision making is a risk that can not be mitigated easily. Strategy based and goal focused approach is the most effective way to counter such irrationality.

Some of the key factors leading to successful project management are (a) recognizing complexities and proactively managing them (b) Strategy based reason decision making (c) Integration of external variables (d) Integration of project phases.

However, it is seen in most cases that project managers (including the successful ones) tend to exercise these factors rather intuitively rather than on any scientific model. Each project manager based on his/her experiences makes up his or her own mental model or project challenges and risks. This model becomes the basis of formulation of project plans, strategies and decision making processes. The whole process is a sort of trial and error effort with the project manager trying to gauge what will work. Success of projects is largely person centric depending on the knowledge, experience and forward thinking capacity of the project manager.

Yet another aspect noted in some project scenarios is that the real decision makers (often called project directors) are different from the project managers who are relegated to the level of mere day to day coordinators and project report generators. The project manager should be put back to don the role of strategy formulator and should make decisions synchronous with the overall objectives.

Life Cycle Project Management

Life cycle project management (LCPM) as a concept acknowledges the above success factors as the basis of project management. This approach attempts to formulated life cycle objective functions to form the basis of evaluation and decision making at all stages of the project.

Life Cycle Project Risk Management

A system for successful life cycle project management will thus have risk and uncertainty management at its core. Risk assessment will be the real time evaluation of the probability at which LCOF’s will fall short of their target values. A high value indicates a high project failure risk.

Some key features of the concept are:

- All project procurement strategies and sales and marketing efforts on strategic deals are based on the LCOF’s and sharing of risks and rewards on these.

- All project decisions are based on all project life cycle information (including both downstream requirements and business objectives). Such information will be generated, integrated, shared and accessed by teams throughout project life cycle. There is a focus on knowledge through action and with reflection this can provide valuable feedback for improved risk assessment in future.
- The LCPM approach employs concurrency as well as pooling of the expertise of project participants within an integrated organization and establishment of a shared design space as well as a facility to integrate and evaluate inputs in real time. Pragmatic knowledge sharing becomes easier to share and there is better opportunity to explore reasons why things happened the way they appear.
- The LCPM approach attempts to integrate decisions on soft variables with decisions on the core technical and financial objectives so that a holistic approach to the management of the project is promoted.
- The evaluation of all project variables and associated uncertainties are based on LCOF's, at any given juncture, so project completion, cost estimate and other implementation risks will be considered as intermediary risks and evaluated only for communication purposes or for meeting intermediary objectives.

Risk Dimensions	**Financial**			**Satisfaction**			**Sustainability**			**Sum**
	P	**I**	**P x I**	**P**	**I**	**P x I**	**P**	**I**	**P x I**	**P x I**
Due Diligence										
Environmental Issues	0.2	0.4	0.08	0.8	0.8	0.64	0.8	0.8	0.64	1.36
Social Issues	0.2	0.4	0.08	0.8	0.8	0.64	0.8	0.8	0.64	1.36
Legal Issues	0.2	0.4	0.08	0.8	0.8	0.64	0.8	0.8	0.64	1.36
Financial										
EIRR	0.8	0.8	0.64	0.2	0.2	0.04	0.2	0.2	0.04	0.72
Cashflow Disruption	0.8	0.8	0.64	0.2	0.2	0.04	0.2	0.2	0.04	0.72
Satisfaction										
Customer Satisfaction with Scope	0.2	0.3	0.06	0.8	0.8	0.64	0.8	0.8	0.64	1.34
Customer Satisfaction with Quality	0.2	0.3	0.06	0.8	0.8	0.64	0.8	0.8	0.64	1.34
Project Risk Rank										**1.17**

P = probability of the risk occurring and I = the impact intensity—each with a maximum value of 1

Figure 1 - Example LCOF Matrix

Figure 1 provides an example of how a Project Ranking scale could be established for a firm. **Figure 2** provides the worst case Risk Ranking if everything was ranked as 1.0. Thus, the Risk Ranking for the example project would be below the 1.5 average mean for the scale. A firm could then establish a range for risks, for example low being less than 1.2, medium from 1.2 to 1.6, and high above 1.6. As has been suggested in this paper, the Risk Ranking would be evaluated on a regular basis along with each progress update. This is a distinct shift from the conventional process and activity based project management.

Risk Dimensions	Financial			Satisfaction			Sustainability			Sum
	P	I	P x I	P	I	P x I	P	I	P x I	P x I
Due Diligence										
Environmental Issues	1	1	1.00	1	1	1.00	1	1	1.00	3.00
Social Issues	1	1	1.00	1	1	1.00	1	1	1.00	3.00
Legal Issues	1	1	1.00	1	1	1.00	1	1	1.00	3.00
Financial										
EIRR	1	1	1.00	1	1	1.00	1	1	1.00	3.00
Cashflow Disruption	1	1	1.00	1	1	1.00	1	1	1.00	3.00
Satisfaction										
Customer Satisfaction with Scope	1	1	1.00	1	1	1.00	1	1	1.00	3.00
Customer Satisfaction with Quality	1	1	1.00	1	1	1.00	1	1	1.00	3.00
Project Risk Rank										**3.00**

Figure 2 - Worst Case Risk Ranking

The project manager in this scheme of things takes on the responsibility for achievement of the project LCOF's. In addition to the project evolution, its entire life cycle activities are planned. The project team inputs are always evaluated against LCOF's. Risk and uncertainty management is an integral part of the implementation of any activity as also the evaluation of any project plan. This calls for a highly dynamic process which entails constantly looking for solutions to meet conflicting influences on the project options. As this is not static or linear in nature, iterative cycles of planning and evaluation needs to be carried out so before one can not hit on the optimum solution.

There is also a need to revisit the status of LCOF's from time to time keeping in view the dynamic nature of the project variables and constants. By the same token there is a need to constantly evaluate the extent of uncertainty associated with achieving the target LCOF's. It is important that documenting reviews also clearly and comprehensively spell out contextual issues identifying cause-and-effect links.

Uncertainty was defined as an unknown probability of occurrence of an event times its impact. Projects are typically influenced by multiple variables with varying degrees of uncertainties within the context of a changing environment. This paper has suggested a major shift in practice, from the current task and activity based approaches to a strategy-based management within an integrated and collaborative framework, which has the potential to overcome traditional dispersion of responsibilities on these projects. Risk management should form a core function of this strategy-based project management approach, using life cycle objective functions as the main drivers for risk reduction and value addition. Employment of concurrent project management approach involving aligned commercial arrangements between the partners is also a vital aspect in this approach.

Going a step ahead we would like to emphasize that concern with uncertainty will continue to grow rapidly, as the KM field matures. As seen uncertainty management should be a key skill set in the armory of a project manager. In the traditional mould project management deals with uncertainty based on a probabilistic approach. However, many key aspects of uncertainty cannot be analyzed accurately using probability theory. There is a lot of expert judgment necessary and that is based upon knowledge that it turn may be supported by robust KM practices.

For probability theory to succeed in project management context, the project options and events should follow random pattern which is often not the case as human intervention is needed for project functioning which is rarely random in nature. Similarly for achieving a good fit with probability theory it is essential that projects should exhibit a fair degree of repeatability. This too is not the case as mostly the projects are unique in nature and knowledge gained from earlier projects often does not apply exactly for the future projects.

Another limitation arises from the fact that the traditional project management techniques call for breakdown of work structure and decomposition of problem into small comprehensible units. This does not gel well with requirements of the probability tools that need to deal with complete set of possible future outcomes. As such it can be seen that risk management through LCOF's which gives a holistic view of project options could be a better platform for uncertainty management. Therefore, it is suggested that the WBS functions for monitoring and controlling the project be managed separately from the Risk Index efforts.

3. CONCLUSION

If the management of construction projects is benefit from risk management techniques, it is essential that the enterprise factors for the firm or organization be established and considered when preparing a new project. An enterprise risk profile is necessary to rank individual projects. The profile then needs to be adjusted to take account of the lessons learned from ongoing projects, frequently. The PMBOK suggests that this be done during the close-out of a project, but a better approach is to perform this feedback at regular progress update intervals.

Recording, sharing, and analyzing the knowledge that is discovered on each project can help to reduce the uncertainty on construction projects, especially in the international marketplace.

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CROSS-CULTURAL LEADERSHIP IN CONSTRUCTION

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ABSTRACT

The construction industry is slow to change, and the Project Management profession is slow to emphasize the soft skills that are so difficult to discuss, improve, and manage. Since cross-cultural leadership skills are a necessity in all construction markets today, a model for cross-cultural leadership is needed.

Earlier this year as part of the Doctor of Project Management program, research was undertaken to explore the hypothesis that there are cross-cultural leadership dimensions that are effective internationally, regardless of culture. This paper will provide an overview of, and report on the results of that research. The research was based on a definition of leadership as the ability to inspire the desire to follow, and to inspire achievement beyond expectations.

Keywords: Cross-cultural leadership, Culture, Leadership

1. THE INTERNATIONAL CONSTRUCTION INDUSTRY

The mobility of capital, expertise, and resources has led to a market that is dynamic, yet the industry remains staid and conservative (Murray and Langford, 2003). Most all construction projects are unique endeavors because of their technology, location, and people. On many construction projects, the infrastructure for communications and authority must be created rapidly, and placed into operation before testing or improvement can occur. Teams must be built and progress through the forming, storming, norming, performing, adjourning phases described by Tuckman and Jensen (1977). On international projects, the teams are both inter-organizational and intra-organizational. This team building is most often accomplished when the execution of the project has already begun.

In such a dynamic environment, cross-cultural leadership skills are essential for there is seldom adequate time for training and exploration of political, social, cultural, contractual, and technological issues. As the saying goes, the team must *hit the job running*. A leader must have cross-cultural leadership skills to depend upon, and must be able to build *quick trust* (Jarvenpaa, Knoll and Leidner, 1998). One of those strategies was Leadership.

Panteli and Duncan (2004) considered trust in virtual teams from a *dramaturgical* perspective based on the theory of impression management. In this interesting article the authors argue that (Pg. 425): "when virtual interactions are examined through the dramaturgical perspective, a distinctive type of trust, different from traditional conceptualisations of trust, emerges from players' actions and interactions, one that is situated within the virtual context that characterises temporary virtual teams." The authors also point out that Contractual Agreements have been found to be one of the main characteristics of virtual work arrangements and influence (Desanctis and Monge, 1999), (Grisham and Walker, 2005).

Suffice to say that on international construction projects cross-cultural leadership is a key ingredient into the realization of successful projects. The following section of this paper describe the components of what a Cross-Cultural Leadership Model, or XLQ Model.

2. INTRODUCTION

From practice in the international industry, that there are cross-cultural leadership dimensions that are recognized globally (*etic* (Pike, 1967)) trust, empathy, power, and communication skills. As the doctoral coursework and research progressed, the added dimension of transformation emerged. Also, there is a serious lack of published Project Management literature. In a search between 1995 and 2005 of the literature in the Project Management Journal and the international Journal of Project Management there were 1,173 citations, of which 77 addressed leadership or culture, and zero addressed cross-cultural leadership.

Compare this to a search for the word leadership at www.amazon.com for books that yielded over 16,000 references, and for culture over 55,000 references. A search conducted in the electronic EBSCO database for articles at RMIT University yielded over 57,000 articles relating to leadership, and over 62,000 articles relating to Culture.

From experience, there are three aspects to leadership interaction – the leader, the follower, and the situation. The characteristics (personality, intelligence, education, will power, experience, etc.) of the leader are the foundation to the transaction, for the leader must (to use a metaphor) hold the mirror for the followers and situation. The characteristics of the leader have no context without the followers and situation. Therefore, the thesis considers the validation of trust, empathy, transformation, power, and communication to be the domain of the follower and the transaction. The definition of leadership is the *ability to inspire the desire to follow, and to inspire achievement beyond expectations*.

The following sections summarize the finding from the thesis that prepared at RMIT University under the tutelage of Dr. Derek Walker.

3. CULTURE

Cultural theory has predominately been the domain of sociologists, psychologists, and anthropologists. Project Management has paid little attention to the topic in the last ten years. Cultural intelligence (CQ) is a critical attribute for leaders. Cultural Intelligence influences, and is influenced by, each of the five leadership dimensions of trust, empathy, transformation, power and communications.

The starting place for a review of culture is naturally with Hofstede (2001) who performed his original study in 1968 and a subsequent study in 1972. The version of the text referenced thus incorporates his original work. The dimensions are Long/short term orientation, power distance, uncertainty avoidance, masculinity/femininity, and individualish/collectivism. The restrictions of this paper prohibit a discussion of each, but they can be found in the thesis at www.thomasgrisham.com.

There are numerous other authors who have contributed to the body of work on culture such as ((Hall and Hall, 1990), (Arrien, 1993), (Goleman, 1995), (Darlington, 1996), (Luthans and Hodgetts, 1996), (Earley and Erez, 1997), (Gibson, 1997), (Inglehart, Basanez and Moreno, 1998), (Trompenaars and Hampden-Turner, 1998), (Den Hartog, House, Hanges, Ruiz-Quintanilla and Dorfman, 1999)), and (Jarvenpaa *et al.*, 1998) to mention but a few. The range of perspectives includes numerous disciplines and perspectives, and recently more international research.

Another mammoth study was the GLOBE Survey (House and Javidan, 2004). In one of the broadest and most thorough studies of leadership and culture, House and Javidan (2004) reported on Global Leadership and Organizational Behavior Effectiveness Research Program (GLOBE) survey of 17,300 mid-level managers representing 951 organizations (financial services, food processing, and telecommunications) in 62 cultures. The research addressed how organizational practices are influenced by societal forces, and they cross referenced their work with that of Hofstede (2001), and Schwartz (1994). The editors found that leadership is culturally contingent upon the culture in which the leader functions. The dimensions for culture were uncertainty avoidance, power distance, institutional collectivism, group collectivism, gender egalitarianism, assertiveness, future orientation, and performance orientation.. The *practice* was established by asking how things actually are, and the *values* by asking how things should-be. The work on the thesis connected the leadership dimensions back to each of these cultural dimensions.

4. KNOWLEDGE

In the global economy, it is important that people develop the ability to empathize with other cultures, rapidly. In an environment that relies heavily on virtual communications with teams spread around the globe, building trust and providing leadership are critical business and project management skills. There is a significant body of literature on cross-cultural issues, but often it focuses on a thin band of customs and business practices. While this knowledge is essential, it generally is only durable enough for short business engagements. It is not adequate for extended expatriate assignments, or for extended projects with virtual teams. Another method is needed if one is to learn more quickly about other cultures.

One potential method that has emerged is the use of metaphors to provide a window into other cultures that is rich and informative, not judgmental. The literature on metaphors begins with Aristotle, and has a long history of debate between those who believe metaphors to be a knowledge transferable representation of complex ideas, and those that believe it to be an intellectually lazy way to avoid detailed descriptions of complex ideas. There are also those that have argued that metaphors in the cultural domain are in danger of crossing the line into stereotypes. Metaphors are a way to increase the understanding of other cultures, and thus empathy. Further, the study of metaphors will help those from low context cultures, like the Unites States, to develop sensitivity for communications in high context cultures.

The work of Gannon (2004) is most useful in understanding ways to expedite the learning curve and provide richer insights into cultures. It provides far more than just the normal considerations for gift giving, meeting timing, and social etiquette. A model based on six-sigma terminology was developed. Green belt level meaning a person has an understanding of basic etiquette, black belt level meaning a person has a Gannon level of understanding, and master black belt meaning a person has lived in the culture.

5. LEADERSHIP

There are no shortage of leadership theories and studies, and there are numerous overlaps in terminology relating to the differences between leadership and management. This section of the paper will focus on published leadership issues, research, and theory. The starting point for leadership research is Bass & Stogdill (1990), not because they were the first, but because their work was such a complete review of the literature, and such a thorough consideration of the issues relating to leadership. The work of so many top writers of the last century addressed this issue including ((Yukl, 1998), (McGreggor, 1960), (Drucker, 1973), (Goldsmith, Greenberg, Robertson and Hu-Chan, 2003), (Heifetz and Laurie, 1997), (Burns, 1978), (Yeung and Ready, 1995), (Bennis, 1989), (Turner and Henry, 1996), (Hoppe, 1990), (Mullavey-O'Brien, 1997), (Kluckhohn and Strodtbeck, 1961)), and many more.

Turner and Müller (2005) were commissioned by the Project Management Institute (PMI) to conduct research to determine if a projects manager’s leadership style was a success factor on projects, and if it id different on different types of projects. The authors started with a literature review and found (Pg. 49): “surprisingly, the literature on project success factors does not typically mention the project manager and his or her leadership style or competence as a success factor on projects. This is in direct contrast to the general management literature, which views effective leadership as a critical success factor in the management of organizations, and has shown that an appropriate leadership style can lead to better performance.”

This section of the thesis provided a review of the literature on leadership from 1862 through 2005, and highlighted the connections between the works referenced and the hypothesis of the thesis. There is a very rich body of knowledge in leadership that has been explored by psychologists, sociologists, anthropologists, religious scholars, political scientist, business management thinkers, and many more. The research attempted to provide a wide range of perspectives on leadership rather than an exhaustive study of a limited number of authors, for it is believed that this approach is better suited to a study of cross-cultural leadership. It provides diversity of opinion and viewpoints.

6. CONFLICT

Conflict is an integral part of human interaction between people, groups, cultures, sects, firms, and countries. Conflict can, if guided, be healthy and productive. However, if ignored may lead to disastrous consequences, and the deterioration of long-term relationships. In the international marketplace, the potential for conflict is extremely high as cultural beliefs and customs collide with regularity. Therefore, cross-cultural leadership must attend to the inevitability of conflict with guidance, knowledge, patience, and a celebration of diversity. Part of cross-cultural leadership intelligence, is the ability to manage conflict. A strong leader will avoid avoiding conflict, and will imbue this attitude in his/her followers.

As with all of the other section of the thesis, there was an abundance of literature on conflict. One book that is particularly well researched and assembled was by Michelle LeBaron (2003). Ms. LeBaron provides a superb review of the literature, and a concept of lenses that corresponds well to the types of issues that are actually encountered in international disputes. Experience as an arbitrator for the International Center for Dispute Resolution confirms her approach as being a solid and practical way to think about cross-cultural conflict resolution.

Other authors discovered in the research included ((Rahim, 1983), (Augsburger, 1992), (Habib, 1987), (Levinson, 1994), (Singelis and Pedersen, 1997), (Avruch, 1998), (Levine, 1998), (Ting-Toomey, Gao, Trubisky, Yang, Kim, Lin and Nishida, 1991), (Deutsch, 1973), and (Lederach, 2000)) to mention a but a few.

The research led to the creation of the Hourglass model for dispute resolution. The lenses of the hourglass mode start with knowledge, progress through diagnosis, and then intervention. From the intervention will flow lessons, through diagnosis again, and extend knowledge. The model is a general process and is not intended to be a dogmatic or static approach. For example, as knowledge is consulted there will be a possible recognition that more information is required and therefore some diagnosis may be required. Following this same approach there may be a need to engage (subtle intervention) in preliminary dialogue to facilitate the diagnosis and knowledge. The perfect world would be 100% knowledge at the start, with a mindset to acquire as much knowledge as possible. The size of the ellipses represents the amount of time that should be applied to each of the lens. On the output side, lessons are learned and they need to be diagnosed, and then the knowledge base can be increased - this could be from an individual to an institutional perspective.

It is suggested that the model be applied using a preventive approach, but it may be utilized just as well in a responsive way. The key is that the acquisition of knowledge and diagnosis of the conflict are the most important lenses. Many conflicts occur from a lack of understanding or a failure of communications. Both of which can be moderated by increasing the knowledge and diagnosis prior to a formal or structured intervention.

In the knowledge lens, the use of metaphors is a critical technique for developing a richer knowledge of cultures (personal, societal, commercial, etc.). A cultural knowledge of the cultural individuality of the contestants including religion, customs, folklore, music, art, literature, philosophy, language, history, geography, ethics, power, gender, and economic status are critical. Knowledge of the structure of the economic agreement is also important to know whether it is a fixed price contract or an alliance. For diagnosis, an example of a necessary technique would be to employ active listening skills to increase the knowledge of the details or feelings of the contestants. This would also be a skill of great importance with the intervention lens. During intervention, negotiation skills are primary, after communication and effective listening.

7. TESTING AND RESULTS

The hypothesis was tested using a Delphi panel of experts. Two rounds of questions regarding leadership, culture, knowledge, and conflict were posed to the panel. After the first round, the results were shared with the entire panel, so that they could be utilized in the second round. The Delphi panel consisted of 23 panelists with almost 700 years of international cross-cultural experience. The hypothesis was confirmed by the panelists, as were the connections to the GLOBE survey dimensions of culture. The detailed procedures utilized and the test results are available at www.thomasgrisham.com.

8. XLQ MODEL

The goal of the thesis was to develop a model for cross-cultural leadership. To meet this goal the first step was to explore the existing literature on cross-cultural leadership, knowledge transfer through metaphor, and conflict management in a multi-cultural environment. The review included multi-disciplinary sources, and utilized an exegetical approach in the evaluation of the literature.

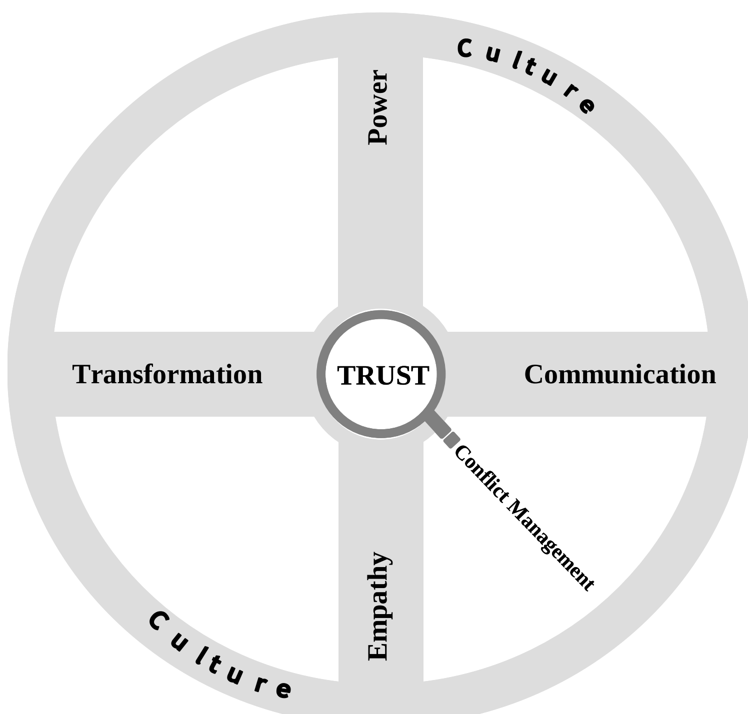
The results of the thesis were the XLQ Model that is shown in Figure 1. The hub of the steering wheel is Trust, without it, leadership cannot function. The spokes of the wheel are Transformation, Communication, Power, and Empathy. The wheel itself is culture for without the effective use and coordination with the other aspects, the wheel would in fact not be a wheel, and would be ineffective. The lubricant for the wheel is Conflict Management. Conflict can be used to stimulate creativity, but if not managed can cause enough friction so that the wheel cannot turn.

The wheel also assumes that the leader has knowledge of each component of the wheel, and of the destination or goal of the drive. A weakness in any component will reduce the effectiveness of the leader, and will potentially lead to a non-sustainable business model. The XLQ Model was constructed from the XLQ Aspects of Leadership and Culture. The XLQ Leadership Dimensions (Trust, Empathy, Transformation, Power, and Communications) are made up of Descriptors and Sub-descriptors that are detailed in the thesis.

International Project Management, and business management, has suffered from a lack of a codified approach to the training of people to work in multi-cultural environments. There are no shortages of cultural training programs in existence, and certainly no shortage of leadership and cultural theories. What the thesis has attempted to do is to provide a simple model for cross-cultural leadership that can be used for evaluating and improving leadership skills, resulting in improved performance. The model provides a simple outline of leadership attributes that can be utilized to structure assessment and training for Project Managers in a consistent and systematized manner. For the model, it does not matter if the Project Manager was born in China and raised in the USA, or born in the USA and raised in Japan since it is a universal *etic* template. So training for leadership skills in Malaysia or Botswana can be structured in the same way, with the emphasis on the XLQ Leadership Dimensions.

The model also provides a structure for future research and testing. For example, if testing a group of executives from three countries for the importance of face, the relationship of face to XLQ Leadership can be linked. Future research can be connected back to XLQ Model to further amplify and confirm/reject the Descriptors and Sub-descriptors. Or research on metrics for evaluation and training can utilize the Delphi panel scores as a benchmarking system.

Figure 1. XLQ Model



9. CONCLUSIONS

International Project Management, Construction Management, and business management, has suffered from a lack of a codified approach to the training of people to work in multi-cultural environments. There are no shortages of cultural training programs in existence, and certainly no shortage of leadership and cultural theories. What the thesis has attempted to do is to provide a simple model for cross-cultural leadership that can be used for evaluating and improving leadership skills, resulting in improved performance.

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RISK MANAGEMENT IN MULTICULTURAL DEVELOPMENT

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ABSTRACT

Dubai is at the center of rapid construction development efforts utilizing multicultural workforces. Risk management plays a critical role in these types of diverse multicultural development projects. The key is to use principles of sustainable construction development with a manageable risk. A well-focused multicultural development industry, designed with a sustainable community development approach, will have a tremendous positive impact on the population. Risk management requires not only identifying, estimating and quantifying risk, but also is a continuous management process which requires sustainable construction development and control, limiting the political and cultural consequences, and proactive government leadership. The objective of this paper is to describe risk management in multicultural construction development in rapidly growing areas, such as the Dubai region. It is recommended that a dedicated research and training center be established for the risk management of multicultural development activities, in order to conduct research and provide up-to-date strategic knowledge and information training on risk management to all parties involved in the development process. The results of such research could be a practical risk management manual that could be used to make multicultural workforces aware of risk management policies. A guideline for developing a decision-support system using fuzzy logic for the risk management of construction development activities is illustrated. Fuzzy logic provides a means to analyze data which cannot be expressed numerically; instead, these are concepts which are expressed verbally.

Keywords: Construction, development, management, multicultural, risk.

1. OVERVIEW

Dubai is long-recognized as the leading multicultural construction development region in the Middle East. Dubai has transformed itself in recent years into a truly first-class international development site with global significance. Dubai has grown rapidly to expand its construction development activity beyond the traditional bases in the region. Due to the large construction development projects, the need for multicultural workforces has increased in recent years. Multicultural workforce diversification in construction development activities will continue to play a key role in maintaining the rapid growth of this region in the future. To have sustainable construction development in such a dynamic region, it is critical to have an effective risk management plan.

The objective of this paper is to describe risk management in multicultural construction development in rapidly growing areas, such as the Dubai region. This paper describes various phases of risk management in multicultural project teams. There are many factors which can cause misunderstandings, false expectations and disappointments within a multicultural development area. These may include: differing cultural expectations; various organizational cultures; mixture of social cultures; use of different languages; differing food, traditions and customs, and religion; and differing levels of expertise with multicultural development projects. This paper illustrates a way to identify potential problems before they arise, analyze situations to identify possible causes, and, most importantly, to come up with workable solutions to manage risk in a multicultural development project. It shows how a strategic risk management plan and effective communication in a multicultural construction region can greatly increase the chances of the success of multicultural workforce teams.

2. MULTICULTURAL DEVELEOPMENT

Multicultural development is defined as a sustainable construction land development project that meets the needs of a rapidly growing region, while protecting and enhancing opportunities for the future. It is a construction development activity which utilizes a multicultural workforce to create an economically sound, financially feasible, socially and culturally acceptable, politically and socially secure, and environmentally safe region for improving quality of life and promoting business. It means creating a balance between high construction development growth and socio-political stability (Elashmawi 2001). Therefore, a sustainable multicultural construction development activity contributes to: Strong economic growth, creation of skilled and semi-skilled workforce, greater export returns, tourism, foreign investments, economic well-being, and social and political stability.

Risk is defined as the chance of something happening that will have a negative impact upon social and political objectives of a rapidly growing region, which is usually measured in terms of consequences and likelihood. *Risk management* of multicultural construction development is defined as a systematic iterative process that supports effective decision-making for understanding social and potential risks. It allows for greater insight into risks and their impacts in responding to a crisis. The risk management process can be applied to a multicultural development situation where an undesired or unexpected outcome could be significant or where opportunities are identified. *Crisis* in multicultural development is defined as any situation that has the potential to affect long-term social confidence or the ability to continue operating normally (Edwards et al 2005).

3. RISK MANAGEMENT

Two key facts emerge from multicultural development. First, construction is a valuable industry that is worth protecting for generating income, creating and sustaining jobs, encouraging foreign investment and facilitating trade opportunities. Multicultural development creates friendships and mutual understanding among those of differing cultures, and is a potential tool for peace in a region. Given these important values, the second key fact is that promoting a sustainable multicultural development is only possible through genuine partnerships. These critical partnerships

must be made across nations and among governments in a region with different cultures, and must include all groups involved in the construction development of the region (Elashmawi et al 1998).
The first step in the risk management process is the identification of potential uncertainty factors in a multicultural construction development activity. A systematic approach is required to capture all potential social, political, cultural threats for the multicultural development in the region. The second step is to analyze or evaluate risk and its consequences. Third, decisions must be made to handle risk through risk reduction, avoidance, retention or transfer. Although crises do not occur frequently, nevertheless, they should be anticipated. Continuous monitoring must be part of risk management of multicultural development, since uncertainty in socio-economic-political risks can quickly develop into a problem.

Because governments play a leadership role in construction development of the region, it should, therefore, utilize its legislative authority and resources to develop a strategic risk management plan to avoid crises in sustainable multicultural development activities. Also, the construction development companies must take proactive and practical steps in implementing these strategic policies prior to, during and after a crisis. Such a strategic plan must encourage partnerships between government and the industry. Risk management in multicultural development can be viewed as both a potential danger and an opportunity. To better understand the risks associated with a rapid multicultural development, a review of the main sources of uncertainty in such an environment is needed. These sources include *political*, *economic*, and *social risks*.

Rapid construction development requires the utilization of multicultural workforces from various areas, each with their own political views. Political risks arise from the poor economic and social conditions of citizens, which can result in anti-government discord. Political risk causing political instability can promote terrorism and negatively impact construction development and other main sources of income (Jasanoff 1986).

Economic risk of a multicultural development can be created due to a period of rapid economic growth followed by an economic depression. This type of growth may have an adverse impact on real estate prices, which may negatively impact construction development projects and immigration of multicultural workforces to the region. In all these aspects, sustainability plays a critical role in the success of the construction development activities. Enhancement of the local population's livelihood via economic prosperities ultimately could be negated in the long-term if the environment and natural resources are destroyed or diminished due to rapid construction development. If sustainability is not an integral part of the construction development plan, the very attractions that a country wants to market will no longer exist. In developing the infrastructure, the impact on local air quality, congestion in the roadways, and pollution due to waste disposal need to be analyzed. The important thing to remember about effective risk management within a multicultural development project is that the following basic steps must be implemented in sequence, and then continually evaluated through monitoring, review, communication, and consultation.

Internal and External Stakeholders

The first step in the risk management process for a multicultural development is focused on the internal and external stakeholders. This is the point where basic parameters or boundaries are set within which risk can be evaluated. This step requires an understanding of crucial elements that will support or impair the risk management process. Among the crucial elements are internal and external stakeholders. In the case of multicultural development, without the support of senior government officials, there is little point in continuing the process. In addition to the government, the following stakeholder groups should be involved in the risk management process at this early stage: politicians; multicultural workforce groups; financial institutions; construction development businesses and related commercial interests; regulators and other government organizations that have authority over construction development activities; and non-government organizations (Lam 2003). A critical decision at this first stage is to determine which group or agency should be given the lead role in risk management. In establishing the risk management framework for any multicultural development, the roles and responsibilities of various stakeholders must be made clear at the outset. This should be documented as part of national policy, and linked to existing wider government disaster management plans.

Prioritizing

At this stage, decisions must be made about what risks in multicultural construction development projects are considered acceptable and will be tolerated, and what risks are unacceptable and, therefore, require treatment. Risk identification should include all multicultural development risk factors by using a well-structured systematic process. The decision to prioritize these risk factors should be made based on various cultural, political, operational, economical, environmental, financial, legal, social, humanitarian and other policies.

Conventional Risk Analysis

The analysis phase of risk management involves assessment of the identified risk factors in multicultural construction development projects, in terms of their impact on social, economical, and political goals. Minor and acceptable risks need to be separated from those major risks that need to be managed. There are several analytical methods that could be utilized in risk analysis. A standard way of making these assessments is to consider the likelihood of occurrence and the impact of the identified risks. As part of the process of assessing the likelihood and consequences of identified risks, it is important to note that even a relatively minor incident can escalate into a public crisis. This step involves comparing the level of risk found during the analysis process with previously established risk criteria. In other words, identifying what is acceptable and what needs to be treated (Crouhy et al 2001).

Risk Analysis Framework

It should be noted that most of the risk factors in a multicultural construction development are not data-driven with numerical values. Rather, they are linguistics (words and sentences) based on people's expertise, such as: "If an effective communication with multicultural workforces are not established, then there is a high possibility of social threat." In this situation, fuzzy logic provides a linguistic approach for risk evaluation. This is one way of incorporating the views and opinions of a multicultural workforce in this process. Fuzzy logic provides an advanced technique for decision-making based on linguistic inputs.

A fuzzy set is defined by its membership function. A point in the universe, x, belongs to a fuzzy set [A] with a membership degree. A fuzzy rule is written as *If situation Then conclusion*. The situation, called rule premise or antecedent, is defined as a combination of relations such as x is [A] for each component of the input vector. The conclusion part is called consequence or conclusion. Fuzzy logic is a type of logic that recognizes more than simple true and false values. With fuzzy logic, propositions can be represented with degrees of truthfulness and falsehood. For example, the statement, *multicultural workforce is good*, might be 100% true if there are no social disturbances, 80% true if there are a few disturbances, 40% true if it's disturbing the environment, and 0% true if it causes a workforce strike. The idea of fuzzy logic was first advanced by Dr. Lotfi Zadeh of the University of California at Berkeley (Zadeh 1973). Evaluation of various multicultural construction development risk factors is a very complex issue. Information on these risk factors can only be obtained based on past experiences of multicultural workforces. Analysis of risk in this situation indicates that most of the factors that determine the risk for multicultural development are not numerical. Fuzzy logic allows information to be elicited heuristically and analyzed based on linguistics rather than traditional numerical systems.

Therefore, fuzzy logic should be used for developing a decision-support system for evaluating multicultural construction development activities. Fuzzy logic is based on fuzzy set theory, which is a generalization of ordinary set theory and provides an adequate conceptual framework, as well as a generalization of ordinary set theory and a mathematical tool, to solve real-world decision problems which are often obscure or indistinct. It is important to note that humans have a capability to understand and analyze imprecise concepts which are not easily incorporated into existing analytical methods. However, some numerical-based methodologies show a concern for precise representation of certain system aspects that are irrelevant to understanding the decision support system's objectives.

Fuzzy logic is used when the quantitative and detailed information to evaluate uncertainty is not available. These conceptual factors can be expressed in qualitative or linguistic terms, that is, so-called fuzzy information. Uncertainty factors, such as "weak management of construction development," or "poor communication among construction development parties," fall into this category. A linguistic variable in fuzzy logic is a variable whose values are not numbers but words or phrases in a natural or synthetic language. Although this introduction of the use of fuzzy sets is relatively straightforward, the practical application of fuzzy set theory in decision analysis is very complex. The following steps briefly describe a framework for developing a risk management model for multicultural construction development based on fuzzy logic.

Step One in evaluation of risk is to collect a comprehensive list of risk factors causing uncertainty in the construction activities by multicultural workforces. These may include social, economical, cultural, political, environmental, legal, technical, and security factors. All of these factors are linguistic in nature. In S*tep Two*, a weight factor should be assigned to each risk factor identified in the first step. These weight factors should show the importance of each risk factor to the decision-maker in the context of multicultural construction development projects. For example, investigation may show that the weight factor for the "Increased Personnel Safety" is very high

(High+). This indicates that safety is a very important factor in the evaluation of risk. The weight factors are based on the opinion of government authorities, views and opinions of experts, and the region's social and political missions. At *Step Three*, using fuzzy logic mathematics, the linguistic risk factors identified in Step One are multiplied by the linguistic weight factors defined in Step Two, and the results are added based on fuzzy set theory, in order to evaluate the total risk. The model could be used as a basis for group discussion and decision-making, and sensitivity analysis for various social and political risk issues.

Other Methods of Risk Analysis

In addition to fuzzy logic, there are many other advanced techniques that could be utilized for risk evaluation. This study has selected fuzzy logic due to the nature of input information which lends itself to natural language. Other major techniques, such as artificial neural network, fuzzy neural network, system dynamics, and portfolio theory might also be considered. The *artificial neural network* is a kind of computer model, loosely inspired by the neural network structure of the brain, and consisting of interconnected processing units that send signals to one another, and turns on or off depending on the sum of their incoming signals. The field of neural networks is an emerging technology in the area of machine information processing and decision-making. The *fuzzy neural network* is a tool for developing complex systems which use fuzzy logic and neural networks technology. The objective is to extend the capacity of the model to include vague (e.g., linguistic) information, rather than crisp (e.g., numerical) information only. *System dynamics* is an approach to model the dynamics of population, ecological and economic systems, which usually interact strongly with each other. Systems dynamics was founded in the early 1960s by Jay W. Forrester of the MIT Sloan School of Management. The *portfolio theory* provides a set of principles to reduce risk and increase returns by combining a well-diverse group of investments. Although this theory was introduced by Harry Markowitz for financial investment, it could also be applied to multicultural risk management for development projects.

Risk Handling Strategies

Risk treatment involves identifying the range of options available to the development industry. A useful way to visualize this process is through a matrix analysis. For multicultural development projects, strategies for treating risk tend to fall into one of the following broad categories, depending on the likely frequency of risks occurring and their severity of impact. When the frequency of a risk factor is low and severity is also low, then the risk is acceptable. At the other extreme, when frequency and severity of a risk factor are potentially both high, the most responsible decision is to avoid risk by cancelling it. The important point that needs to be highlighted again is that most construction development crises do not occur frequently. Many multicultural development regions, therefore, avoid thinking about risk or avoid taking action. Therefore, risk treatment strategies can be divided into the following areas: decisions to avoid or ignore risks, regardless of the information available and costs incurred in treating those risks; and leaving critical choices/decisions up to other parties (Kangari 1995).

4. EXPECT THE UNEXPECTED

Rapid construction development management faces its toughest test in a crisis situation. What government does or does not do correctly can have long-lasting implications for the region. A well-defined risk management program that is developed and implemented in advance can help the government in the region. The most-effective crisis management occurs when a potential risk is detected and dealt with quickly, before it becomes a crisis. Governments with no risk management plan for multicultural development in place will inevitably have to deal with an unforeseen crisis (Howes et al 2003).

In these cases, risk management can be divided into the following phases: Reduce risk by detecting early warning signals; prepare a risk management plan and run exercises; respond to risk by executing effective operational and communication plans; recover; and return the situation to normal.

Another way of looking at risk management is to search for potential shocks to the multicultural development industry by dividing them into direct and indirect events with short-, medium- or long-term consequences for the region. The advantage of this approach is that it places more emphasis on indirect shocks that may not be as obvious for their effects on multicultural development. Examples of indirect shocks include terrorism, financial fluctuations, outbreak of disease and economic downturns.

5. BE READY

There are no clear boundaries with construction development crises. There is rarely a single moment when one can easily identify that a single risk factor or issue for multicultural workforces has transformed into a crisis. While government's leadership is essential to successfully managing many adverse events in multicultural development, the way the development industry responds to a crisis is also important. Partnerships between government and industry, and between industry sectors, are critical to positive outcomes. The goal should be to develop a proactive approach to take control of a situation through early identification and prevention of risk, as well as strategies to manage multicultural development risks to minimize the occurrence of an undesirable event. Effective risk management aims to prevent an event escalating out of control and becoming a crisis in multicultural development. However, not all adverse events can be avoided, so risk management must be used to respond quickly and effectively to negative situations. Government leadership is critical for the success of this process.

To be prepared, the following steps must be taken. First, identify the full range of potential risks and threats to multicultural development, and make decisions about which risks are most likely to occur, what their consequences will be, and how to respond. Then, analyze the impact the risks will have on: the construction development process; social-economical-political-cultural issues; and on the construction development industry's profitability. The key is to identify a potential crisis, and then seek to reduce its impact. To be prepared means developing risk plans and running an occasional test. Government officials need to evaluate its crisis exposure and develop strategic, tactical and communication plans. To be prepared means developing a response plan dedicated to the immediate aftermath of an event when everything is at its most chaotic. A crisis can best be avoided by following the recommendations below:

- Better understand the common problems of poor communication among multicultural workforces and government authorities.
- Deal with the cultural influences that exist when dealing with multicultural development projects in a diverse organizational system.
- Avoid some of the issues which cause misunderstandings and conflict among multicultural teams and prevent existing issues from escalating.
- Establish the extent and detail of the risk management policies.
- Ensure that risk management policies are then translated into specific actions to be implemented, when, by whom and requiring what resources.
- Ensure that the risk management policies are fully in compliance with the government requirements regarding multicultural construction development.
- Carefully review all construction development contracts that require multicultural workforces for risk management-related issues.
- Establish risk management training programs.
- Create risk management policy manual for practical application.
- Develop an annual performance monitoring system.
- Develop public forums and community programs to better understand the risks associated with multicultural workforces in the region.
- Undertake periodic risk audits.

Few risks remain static. This means it is necessary to constantly monitor and review each component of the risk management process, especially the treatment or control measures, in light of changing circumstances and government priorities. Based on these risk management policies, the government should pass the necessary laws to enable multicultural development projects to operate effectively and profitably.

6. RISK MANAGEMENT PLAN

The risk management plan must be updated regularly. This plan should identify and address the management of the major risks and opportunities facing the region due to multicultural workforces. The goals behind a risk management plan are:

- To provide an assurance that the region has identified its highest risk exposures, due to multicultural development, and has taken steps to properly manage these risks.
- To ensure that multicultural development’s planning processes include a focus on areas where risk management is needed.
- To ensure the integration of the various parties involved in the construction development project using a multicultural workforce.
- To be comprehensive and effective.

7. BENEFITS OF MULTICULTURALISM

Immigration has been a definitive social process throughout history, but modern population movements are distinctly different than those of past. In greater volume with increasing speed, millions of people cross borders each year in search of economic opportunity, political stability or a myriad of other reasons. However, it is no longer realistic to view immigrants as temporary workers; rather, they make a profound impact on the social, cultural and economic climate of a nation (NEMSP 2002).

There are numerous examples of a growing multicultural workforce in the construction industry. From Japan to the United States, industry leaders and governments have relied on the contributions of a diverse workforce in rebuilding efforts and large-scale construction projects. As its economy has boomed, Japan has long-relied on Nepalese workers to help fill jobs in the manufacturing and construction industries. Thousands of workers from Central and South America have been recruited to help re-build New Orleans after the Louisiana city was virtually destroyed by Hurricane Katrina. This multicultural workforce is not only playing an integral role in reconstruction efforts following the natural disaster, they are contributing to the cultural and social rebirth of the city, along with its economic redevelopment. The contributions of immigrants, whether in labor, food or language, have defined the history and culture of America and helped it become an international leader. The increasing globalization of business activities has helped facilitate a need to effectively respond to the linguistic, cultural, and ethnically diverse segments of its population. In a multicultural marketplace, encouraging understanding of and communication with a multicultural workforce is critical to ensuring success within diverse environments.

8. RECOMMENDATIONS

Risk management is about having comprehensive plans in place, and knowledgeable people with the necessary authority to respond immediately should a crisis arise. Government, in collaboration with industry, must develop a strategic risk management plan, in order for multicultural construction development activities to support sustainable development in the region. The goal of this plan must be to review existing legislation to ensure that potential risks are adequately covered. This could be accomplished by establishing a national risk management council which includes key government officials and external stakeholders, particularly representatives from the architecture/construction/ development industry, in order to integrate information into the national risk management plan for multicultural workforces. This council should develop formal relationships with international agencies that share similar goals.

The primary objectives of a national council on risk management are to: develop a consistent set of immigration and labor policies for all companies; establish a centralized crises management team to quickly act on related issues on an urgent call; manage unity issues which are at the heart of any rapid economic movement; serve as a resource center for all interested parties; stimulate ideas, ongoing discussions and regulation changes; provide greater transparency and accountability; and provide a centralized policy impact and assessment place. It is recommended that a dedicated research and training center be established for the risk management of multicultural development activities, in order to conduct research and train all parties involved in the development process on up-to-date strategic knowledge and information on risk management. The results of such a research initiative could be a practical risk management manual that could be used to make the multicultural workforces aware of risk management policies.

A guideline for developing a decision-support system for risk management using fuzzy logic heuristics was illustrated. Fuzzy logic provides a means to analyze data which cannot be expressed numerically; rather, these are concepts which are expressed verbally. Unlike traditional decision supporting models, which are based on numerical data, fuzzy logic facilitates a heuristic analysis based on linguistics. In addition to fuzzy logic, application of other techniques, such as artificial neural network, fuzzy neural network, system dynamics, and portfolio theory, were discussed. Both artificial neural network and fuzzy neural network extend the capacity of the model to include both vague and crisp information. Portfolio theory provides a model for reducing risk through a diverse group of communities. Although the model is tailored for government policy-making, private sector projects can be analyzed with a similar approach. In this case, a set of company-level policies based on the government regulations in multicultural activities should be implemented. In general, the private sector should follow government policies within the scope of their projects.

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INTERNATIONALISATION IN ARCHITECTURAL PRACTICE

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ABSTRACT

The construction industry is becoming increasingly global, with services such as architectural and engineering design, project management, and specialist technical services being supplied from global centres such as London and Paris. This paper will explore one aspect of this globalisation process by presenting research on the internationalisation strategies of English and French architectural practices. The qualitative results from a case survey of 59 practices will be presented and aspects of market entry, fulfilling commitments, and human resources will be explored before two distinctive configurations of internationalisation are presented.

Keywords Architectural Practice; Construction Services; England; France; Internationalisation.

1. INTRODUCTION

Over the last few years, there has been growing internationalisation of the supply of construction services (Campagnac *et al* 2000). The aim of this paper is to explore the dynamics of this internationalisation through empirical research of the experience of English and French architectural practices in international markets. The data from a case survey of 59 British and French architectural practices will be presented as a single data set. Our aim in this paper is to stress the commonalities in experience of the two samples of firms; our exploration of the differences is the subject of another paper (Winch 2006). The focus of our enquiry will be on the strategies deployed for foreign market entry; the modes of association selected to ensure the delivery of services abroad, and the human resource strategies deployed to provide services internationally. Conclusions and suggestions for further work follow.

2. THE STUDY OF BRITISH AND FRENCH ARCHITECTURAL PRACTICES

The research reported here had two objectives. The first was to validate the conceptual model developed by Winch and Schneider (1993a; b) for the strategic management of architectural practice to see whether it was actually capturing their strategic thinking. The second was to investigate the internationalisation of architectural practice in the context of the single European market. This latter objective was prompted was prompted by a concern within the French government and architectural community that French architectural practices were relatively unsuccessful in this European market (Contenay 1995), particularly compared to their British counterparts. The research was, therefore, funded by the Euroconception programme of Plan Construction et Architecture, an agency of the Ministère d'Equipement (French construction ministry)[1].

The research deployed a case survey methodology in which a large number of case studies are developed with allows both a qualitative and quantitative analysis (Larsson 1993; Winch 1994). The aim was to interview 30 practices in each of France and England[2], the principal criterion for inclusion being that they had worked either in the other country or in Germany. The English ones were sampled from the Royal Institute of British Architects (RIBA) Compendium of International Practices, from which it was possible to identify practices which had worked in France or Germany. No such document exists in France, and we were obliged to use informal methods - *bouche à oreille* - to identify practices for inclusion in the survey by working with the Ordre des Architectes, officials of the Ministère d'Equipement, and professors at various architecture schools. It proved difficult to find 30 French practices with some international experience, and the data set therefore includes only 29 French cases.

Interviews were conducted with an appropriate partner or other principal of the practice as informant to a structured *aide memoire*. This ensured that the basic data were collected, while allowing for particularly interesting aspects of the responses to be explored further. The fieldwork took place between the summers of 1996 and 1997. Each interview was combined with practice documentation and written up as a case study. Then all 59 case studies were meta-analysed to produce the data presented in the following sections. It should be remembered that these data are not from random samples of practices in each country, but from French and English practices selected because of their experience of working in the UK and Germany, or France and Germany, respectively. The results here cannot be taken as representative of architectural practice in the two countries, but can be taken as representative of those practices that are actively exporting within the European Union. Initial quantitative analysis of the data exploring the differences in international performance between practices can be found in earlier publications (Winch *et al* 2002), while the broader theoretical issues around the internationalisation of professional service firms are discussed in Winch (*forthcoming*). Our aim in this paper is to present the more qualitative data derived from the interviews.

The Winch/ Schneider model was shown to the informant and the two dimensions of project complexity and client's quality preference explained. Most informants were able to identify where their practice sat within the matrix themselves, and we were able to allocate all cases to one of the four generic strategies, and to code the results accordingly. Indeed, one informant redefined the four categories in his own terms suggesting that the difference between the strong ideas and strong experience strategies captured the difference between "constructeurs de bâtiments" and those focused on "création architecturale" before placing his firm in the strong ideas category. All but three of the practices were allocated to the strong ideas or strong experience categories. This is hardly surprising, because the fee levels available in low

[1] The research was conducted in collaboration with Prof. Denis Grèzes, formerly of the Ecole d'Architecture de Grenoble. The data were collected by Brìd Carr.

[2] As with most UK professions, England and Wales, Scotland, and Ireland are treated independently and the RIBA only covers the first two countries of the Union. In this research, "England" is therefore shorthand for England and Wales, not the UK.

complexity projects are unlikely to cover the additional costs of exporting architectural services.

Our findings also uncovered a second organisational form for the delivery of B2B services – the state agency. Two of the French strong experience practices were the technical services arms of SNCF (French railways) and AdP (Paris airports). These had been established to meet the building design needs of these two nationalised industries, and were now successfully exporting the expertise they had thereby acquired. The lack of such agencies in the UK is a product of the Thatcher years when many local government architectural services departments were privatised.

3. STRATEGIES FOR FOREIGN MARKET ENTRY

Four distinct strategies for entry into foreign markets were identified :

- following a client;
- winning a *concours*[3];
- marketing;
- and via network partners.

Following a client is particularly associated with the strong experience practices (χ^2 significant at the 0.01 level[4]). For instance, one practice had become the "house" architects for Carrefour, the giant French retail chain with 90% of the work. As Carrefour rolled out its globalisation strategy, Architectes CVZ were commissioned to build in 15 different countries in Europe, Latin America, and Asia. For a while, a similar relationship with the French holiday company Club Med had led to other international commissions. Patrick Garnett Associates has worked in 5 different European countries as well as Russia. It entered the French market with Forte, the British hotel chain, and has worked in a similar manner with other UK hotel and property companies.

Winning a *concours* is a very different strategy, and much more closely associated with a strong ideas strategy (χ^2 significant at the 0.01 level). Prestigious competitions are often internationally advertised, where there is a concern to encourage an international entry to confirm the status of the project and its clients in the international scene. Up to 90% of Foster Associate's work is outside the UK, and they have *never* worked for a UK-based client abroad. Much of their international work is obtained through responding to international competitions. Their entry into the French market was winning the competition for the Carré d'Art in Nîmes, while their most recent high-profile project in Germany, the reconstruction of the Reichstag in Berlin, was also won in competition. Jourda et Perraudin obtain 80% of their turnover outside France, and have participated in architectural competitions in 10 different countries in Europe and Asia. They have been invited to enter 13 different competitions in Germany, winning three of them.

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[3] The word "competition", of course, means many things in English, but French distinguishes "*concours*" from both "*compétition*" and "*concurrence*" so we prefer the French term for clarity.
[4] The quantitative results are taken from Winch et al (2002).

Our category of "marketing" is something of a residual category covering a variety of ways in which architectural practices obtain work. These include responding to an international call for tenders; being commissioned on the basis of reputation; and sometimes, plain good luck. Both strong ideas and strong experience practices used this approach, although in both cases less frequently than their "preferred" client following or *concours* entry strategies. For instance, Renzo Piano Building Workshop (RPBW) is a strong ideas practice which is typically approached by clients directly due to its reputation. They only enter about one competition a year. Potential clients are invited to the main office in Genoa (Paris is a smaller sub-office) to discuss the project with Piano and others - "ça fait moins de travail pour l'agence et on pense que c'est une toute aussi bonne façon pour un client de choisir son architecte..." By these means RPBW has worked in over 10 countries outside its twin home markets of France and Italy. The anglo-german strong ideas practice Alsop and Stormer also relies more on this approach, although their first project in France resulted from a competition entry. The John R Harris Partnership is a strong experience practice which has designed over 34 hospitals around the world, including two of the biggest in the world in the Far East – these commissions have typically been obtained on the basis of reputation, which has been recognised by the award of a Certificate of Merit by the International Hospital Federation. Experience with this complex building type has also enabled commissions for other large, complex buildings such as the Dubai International Trade Centre.

Reputation-based market entry would appear to work in interaction with the other two strategies. John R Harris as a strong ambition practice received their first break internationally in the early 1950s by winning an architectural competition for the Doha State Hospital in Qatar. A strong ideas practice like Sir Nicholas Grimshaw and Partners Ltd established a repeat relationship with the US furniture company Herman Miller in the UK, and when that company sold part of its business to the German furniture company Vitra, it recommended Grimshaw for a commission for a new factory in southern Germany which became its first German project. This experience in Germany and with German clients – they also had links established in the UK with BMW – meant that they were well placed to win the architectural competition for the Ludwig Erhard Haus of the Berlin Stock Exchange.

Our research identified one formal association of practices using the structure of the European Economic Interest Grouping (EEIG) – another, Eurarc, is analysed in Prost (1997). EPR in London and Groupe Daviel in Paris were the founder members of Architecturo, which has grown to include practices based in Lisbon and Brussels, and deploys a strong experience strategy. EEIG arrangements allowed practices working in one country to bring in specialist expertise from another – for instance Daviel has particular expertise with social housing projects, EPR with commercial office developments and the Portuguese member in museum projects. While each member of Architecturo works on its own projects, they do collaborate on competition entries and it is easier to follow domestic clients to the other country in partnership with the partner from that country.

4. MODE OF ASSOCIATION ABROAD

Once the market has been entered, and the commission awarded, the work has to be done. This raises a number of important organisational issues (Winch 2002). First, architectural commissions typically include both the supply of a design for the building, and the supervision of the execution of that building on site by a construction contractor separately appointed by the client. Second, construction is a highly regulated industry, and a successful design needs to take account of local regulations with regard to both the permission to build (planning or zoning regulations) and the specification of the building (building regulations) with regard to features as varied as behaviour in a fire, access for the less able, energy efficiency, and structural integrity. Third, the vocabulary of construction is a specialist, technical one beyond the capabilities of most commercial translation services suppliers. Fourth, construction projects are governed by complex contracts both for the supply of design services and for the execution of site services, with the latter also placing obligation on the designers appointed under the former. Some sort of local capability is essential for effective service to the client, and the issues revolve around how this is to be organised.

The alternative modes of organisation that we found in our sample were to

- form a temporary liaison with a local architectural practice;
- set up a temporary office;
- use a network partner;
- enter into a joint venture,
- set up a subsidiary.

The first two of these are very much the most popular favoured by 85% of our cases. While strong ideas practices rely almost entirely on the two temporary forms of association, the strong experience practices deploy the three more permanent forms of association almost as much as the temporary ones (χ^2 significant at the 0.05 level). For those practices articulating a strong ideas strategy, there is typically little merit in opening an office abroad for two reasons. The first is that the location of architectural competitions varies almost randomly – even if an office were opened in one city in, say, Germany, it might be in completely the wrong place to service the next project won. A second, and perhaps more important, reason is the concern to retain *design control* where the “name” architect ensures the actualisation of his design and thereby protects his “brand”.

The strong experience practices were much more ready to enter into more permanent arrangements abroad. While a pragmatic approach meant that temporary associations were also used, a number of practices took a strategic approach to developing their international work. One of these is to form an EEIG as discussed above. A second is to develop a set of joint ventures in carefully chosen countries. John R Harris has a network of 10 associated practices in Europe, the Middle East and Asia in each of which John R Harris himself is a partner. BDP has formed BDP International as an umbrella for its subsidiary in Ireland and its joint ventures around Europe and beyond forming 10% of its turnover. The joint venture with Groupe 6 had already enabled allowed this Grenoble-based practice to enter the Paris market, because “they cannot serve the North of France (or) some more centrally located areas so they have to have a base in Paris," and they have worked as a joint venture in three other European countries (Potié 1994). A third approach is to set up a subsidiary firm. Mario Cucinella Architectes specialises in energy conservation projects and has worked in five different countries. It recently set up an office in Genoa to support its work in the Italian market. Ansell & Bailey set up a Paris office to support its work for McDonald's in France; this now trades as Smith & Bailey working for international clients such as Planet Hollywood. Of course, this pattern is also reversed. RTKL-UK Ltd is a subsidiary of a large US practice, with responsibility for Europe and the Middle East with a focus on Germany and Spain. DEGW, another London-based strong experience practice with a reputation for office design, had recently been purchased by a Dutch management consultancy.

5. HUMAN RESOURCES FOR INTERNATIONALISATION

Although new forms of organisation are essential for the realisation of the project in a foreign country, there remain important issues around human resources associated with both the acquisition of the commission in the first place, and then liaising with local collaborators or operating the local office. The skills required include knowledge of the language and culture of the country where the project is to be built; the ability to understand local regulations and negotiate with local suppliers; and where the client has not be followed from the home country, the ability to interact with the client. The majority (82%) of the practices – particularly the smaller ones – had no systematic approach to this issue. They relied on a mixture of *ad hoc* solutions, and restricting their overseas activity to countries where they happened to already have the appropriate skills. However, this approach is not as restrictive as it might first appear. The culture of architecture is a highly international, and ideas flow freely around the world. London and Paris are two of the global centres of architectural education and practice, and so many come to seek their fortune in those cities either as students or newly qualified professionals. The principals of the London-based practices studied included three Germans, one person with dual French/UK nationality, and a Czech; principals of Paris-based practices included a Swiss, two Italians and one person with dual French/UK nationality.

This approach was often complemented by an internationalism in recruitment. For instance, Reichen et Robert employs architects from six different countries amongst its 25 staff; our informant was German. Chapman Taylor employs speakers of five different European languages in addition to English, and is able to sustain a dedicated francophone team within its 75 staff. Alternatively, those hired to work in temporary offices abroad were selected on the basis of being able to speak the appropriate language. Rudy Ricciotti decided not to collaborate with German architects when it entered the *concours* for the Nicolaïsaal in Potsdam, and hired a German who spoke French fluently when it set up its local office. Howard, Fairbairn and Partners won a commission for the extension of a factory in France by competitive tender in joint venture with the French arm of a UK-based construction contractor, and then hired French nationals for its temporary office.

Some of the larger, more internationally active practices have taken formal steps to develop acquire and develop staff. Within the Architecturo EEIG, there is a staff exchange programme, and Groupe 6 and BDP have also exchanged staff within their joint venture. However, it is amongst the large strong ideas practices that the most distinctive approach to human resources is found. The four largest in our sample all deployed a churning strategy (Maister 1982) that gave them both flexibility and capability. The strategy depends on two particular phenomena of architectural labour markets. The first is that students are typically required to spend a "year out" or "*stage*" as part of their studies. Exchange programmes between architecture schools, arranged either bilaterally or as part of EU programmes, mean that many students are from other countries and often seek opportunities to do their *stage* abroad. The second is that one of the keys to a successful architectural career marked by founding a strong ideas firm is to have worked a very successful one early on (Williamson 1991). In effect, this reproduces informally the "up or out" human resource policy familiar in other professional service firms (Malos and Campion 1995).

Architectures Jean Nouvel, Richard Rogers Partnership, RPBW and Foster & Partners all deployed a strategy of accepting significant numbers of *stagières* and hiring large numbers of the brightest graduates from the best schools to give a broad international spread of staff. The churning also meant that capacity could be changed relatively as opportunities arose. For instance, when Foster opened its Berlin and Frankfurt offices they were staffed mainly by German architects who were sent over from the London office, but "these are not German architects, these are 'Foster Germans', which is not the same thing at all." At Rogers people tend to "gravitate" towards the projects where they have relevant language skills and so far as regulations are concerned, "we have German architects; you get the regulations and you ask people to look them over."

6. CONFIGURATIONS OF INTERNATIONAL PRACTICE

The data presented here show that we can identify at least two distinctive configurations of international practice in the supply of architectural B2B services. The first is the *strong ideas* configuration. This is characterised by an internationalisation strategy which focuses on winning architectural *concours*. Even if much of a practice's work is *now* based on approaches from clients due to reputation, the first commission on which that reputation is based is typically established through winning a *concours*. For instance, the *initial* entry of Renzo Piano into the French market was in partnership with Richard Rogers for the Centre Pompidou in Paris, and it is the office established for that project which was the basis for RPBW's Paris office. Success in that *concours* is also the basis for the particularly high profile of the Richard Rogers Partnership in France. It is relatively difficult for strong ideas practices to be proactive in obtaining work. *Concours* entry is, by definition, a reactive process, as it depends on the decision of a client to mount a *concours*. There is also very little repeat work for strong ideas practices. While the HSBC did commission Foster Associates twice to design its prestige headquarters buildings in Hong Kong and London, its design values for the average high street branch of HSBC are less ambitious[5]. Most clients for strong ideas practices typically build only one prestige building – either as a corporate headquarters, or as a culturally symbolic building.

As a result of this inability to structure the market, strong ideas practices need to be very flexible in reacting to market opportunities, either in the form of invitations to

[5] Indeed, such projects are typically the preserve of strong delivery practices.

enter *concours*, or to enquiries from prospective clients. Because of this they tend to favour setting up temporary offices, or entering into temporary associations with local architectural practices in order to ensure delivery of the service. Within this constellation, the strong ideas practice is keen to centralise so as to ensure design control because it is the peer evaluation of the realised building which confirms, enhances, or diminishes the reputation of the practice. Similarly, they also require flexibility in their human resources, because they have difficulty in predicting which national regulatory systems they will be working within next. They recruit widely from young, internationally mobile professionals, and can also draw on foreign students placed with them as part of their education programmes. Some of these staff are retained as associates and future partners, but many go on to found their own strong ambition practices, trading on the reputation of having worked for a “star”.

The second is the *strong experience* configuration. This is characterised by an internationalisation strategy that focuses on following clients as they internationalise. Such practices also have the opportunity to target potential foreign clients who can use their specific expertise. They can therefore be more selective in the foreign markets that they enter, and have a lower requirement for flexibility in their constellations, setting up either overlapping networks of joint ventures or subsidiaries with themselves at the centre such as BDP and John R Harris, or opting for more egalitarian arrangements such as the Architecturo EEIG. These foreign operations tend to retain or develop relatively high levels of autonomy as they adapt to local market conditions, and are relatively decentralised compared to the strong ideas practices. Strong experience practices also have incentives to retain and develop their own staff. By definition, in knowledge-based organisations (Winch and Schneider 1993), the experience of an organisation rests with its staff, only some of which can be made explicit in a knowledge management system. While they can still benefit from the availability of internationally mobile professionals, they would appear to be less focused on churning type strategies.

7. CONCLUSIONS AND FURTHER WORK

Concluding more broadly from these findings, we can suggest that structure follows strategy in the internationalisation of architectural practice. This research supports the proposition (Winch *forthcoming*) that architectural practices internationalise to meet the needs of international clients, but that this is not the only reason for that internationalisation, and occurred in less than half our cases. A first issue is that clients may be resolutely local, but be internationally orientated rather than internationally mobile. Such clients aspire to gain status for their project through the involvement of an internationally renowned architect. Therefore they seek out such service providers, and may deliberately ignore local suppliers. Where the client has a regional orientation, architects based in the national capital may be at a positive disadvantage. A second is that specialist expertise is important, so clients may seek that expertise abroad if it is not available from domestic suppliers. As Linder (1994) has argued, international success in construction services is strongly related to developing expertise in advanced building types in the domestic market which are then required internationally. Thus, amongst our cases, the ability to design functionally superior retail complexes, hospitals, and airports all enabled practices to obtain foreign work based on competence in specific building types (Winch *et al* 2002).

It is also clear from our results that size (Winch *forthcoming*) is important for success in international markets. While these firms may well be modest in terms of their overall number of employees compared to other international B2B services suppliers – the largest amongst our cases was BDP which employed 744 people at the time of interview with an average turnover of around £30m during the previous five years - scale economies can still be identified. On our evidence, these turn around human resources. Larger practices can employ the number of people required to cover knowledge of the regulatory systems in the major markets, and can also have clout when negotiating terms with local collaborators. Around 50 staff would appear to be the point at which such the benefits of such economies begin to be attained. As the principal of one practice of 25 people commented, “si demain on voulait travailler sur l’export on n’a pas assez de capacité interne en homme pour cela.”

It is less clear at what point diseconomies of scale start to emerge. It is likely that this point is lower for the strong ideas practices than the strong experience practices because of the need in the former for the principals to be involved in every project. However, this point is clearly, more related to the number of *projects* at any one time rather than numbers of staff. Strong ideas practices doing a small number of very large projects could still employ large numbers of staff and retain design control. For strong experience practice, diseconomies of scale would set in at larger numbers of employees, but it would also appear that diminishing returns to scale set in fairly early.

We found that centralisation – under the guise of design control (Winch *forthcoming*) - was very important for the strong ideas practices, and also placed an important limit on their ability to grow. The strong experience practices, on the other hand, favoured a much more decentralised approach, and there was little evidence of centralised co-ordination of foreign operations. Only two such practices had set up international “holding” entities. Architecturo used the EEIG structure to create a federation of practices, while BDP set up BDP International to coordinate its network of joint ventures. Other practices such as DEGW, and John R Harris had put together constellations which placed themselves firmly at its centre, while RTKL-UK was part of a US-centred practice. Networks of corresponding firms which routinely referred clients to each other (Winch *forthcoming*) were not found, and most firms preferred informal and temporary liaisons in order to meet the need to deliver for their foreign clients.

The argument here has focused on the commonalities between the English and French experiences, and treated all 59 cases as part of a single data set. There are also important differences in the experiences of English and French architectural practices in international markets. Some of the issues have been identified in earlier publications by the research team (Carr *et al* 1999; Winch *et al* 2002), while the comparative issues have started to be addressed in Winch (2006). Forthcoming papers will address these differences more qualitatively, and related them to the organisation of the national business systems for construction in the UK and France.

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KNOWLEDGE SHARING IN INTERNATIONAL JOINT VENTURES

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ABSTRACT

Knowledge sharing (KS) is an essential element of any effort for organisations and individuals to learn and develop. It is not surprising that KS has become a key component of knowledge management programmes. This paper examined KS in the context of construction projects executed as international joint venture. This issue is important as many countries and organisations expect to acquire new knowledge when embarking on joint ventures with other international companies. The paper focused on the socio-technical perspective to develop a clear understanding of how knowledge can be shared. A model of knowledge sharing has been used to analyse the state of knowledge sharing in foreign-local joint ventures operating in Singapore. The case study showed weaknesses on all levels of the model. The main reason seems to be the lack of clear intent to create an environment that is conducive to knowledge sharing.

Keywords: Knowledge management, knowledge sharing, joint ventures, culture.

1. INTRODUCTION

Knowledge sharing (KS) is an essential element of any effort for organisations and individuals to learn and develop. Therefore, it is not surprising that KS has become a key component of knowledge management programme (Alavi and Leidner, 2001; Earl, 2001; Nahapiet and Ghoshal, 1998; Nonaka, 1994). This increased interest in KS is due to the fact that knowledge is increasingly recognised as a major source of competitive advantage (Grant, 1997; Meso & Smith, 2000) and in its ability to help create the competitive edge in today's global environment' (McCampbell et. al. 1999).

The literature offers several different definitions of knowledge that reflects the different perspectives on this issue. Brooking (1996), for example, refers to organisational knowledge as an intangible asset representing the collective sum of human centred assets, intellectual property assets, infrastructure assets and market assets. Davenport and Prusak (1998) provided a definition that reveals the complex nature of organisational knowledge. Here knowledge is defined as a "fluid mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and applied in the minds of knower. In organisations, it often becomes embedded not only in document or repositories but also in organisational routines, processes, practice and norms".

Equally there are several definitions of Knowledge Management (KM) reflecting the different perspectives and interests. Gartner group for example defines KM as "it is a discipline with new processes and technologies that differentiate it from information management. New technologies are required to capture knowledge that was previously tacit-embodied in the minds and expertise of individuals. Once captured, knowledge must be shared to leverage its value-reused in similar situations and contexts" (Wilderman, 1999). KM is also seen as the process of capturing a company's collective expertise wherever it resides – in databases, on paper, or in peoples heads – and distributing it to wherever it can help produce the biggest payoff (Hibbard, 1997).

This highlights the challenge to business organisations that although they can develop and own tangible assets individuals maintain the ownership of their knowledge. This knowledge will very quickly become outdated without the acquisition of new knowledge and will be lost when this individual leaves the company. Indeed, sharing ''tacit knowledge among multiple individuals with different backgrounds, perspectives, and motivations becomes a critical step for organisational knowledge creation to take place'' (Nonaka and Takeuchi, 1995, p. 85).

Meso and Smith (2000) have stressed the importance of a knowledge friendly organizational culture to facilitate collaboration and knowledge sharing. Davenport and Prusak (1998) suggest that knowledge project managers and chief knowledge officers should possess technical, psychological and business skills in order to succeed in their roles.

The literature reviewed by this research showed greater interest in how knowledge is created and transferred cross cultural barriers, whether between different companies or different national cultures (Gupta and Govindarajan, 2000; Inkpen and Dinur, 1998; Kogut and Zander, 1993; Mowery et al., 1996; Simonin, 1999). A number of recent studies have concentrated on the influence of cultural factors KM and KS (Chow et al., 2000; Ford and Chan, 2003; Holden, 2001; Hutchings and Michailova, 2004).

The focus of this paper is on KS in the context of construction projects executed as international joint ventures. This issue is important as many countries and organisations expect to acquire new knowledge when embarking on joint ventures with other international companies.

2. A SOCIO-TECHNICAL PERSPECTIVES OF THE KS PROCESS

In order to have an effective KS strategy the organization needs to combine technology with people. Riege (2005) argues that the successful sharing of knowledge depends on

- motivating individual employees to "purposefully capture, disseminate, transfer, and apply existing and newly generated useful knowledge, especially tacit knowledge";
- organisational structures that facilitate transparent knowledge flows,
- continuous learning organisational culture,
- clarity of goals and strategy linked to KS,
- modern technology that provides a suitable sharing platform accessible to all those in need of knowledge from diverse internal and external sources.

The importance of an integrated approach to understanding how technology impacts organisations was apparent in the earlier study by Trist and Bamforth (1951) who used the term socio-technical to emphasis the social and technological subsystem of an organization. Later the work Pasmore et al. (1982) viewed that the organization as made up of people that produce products or services using some technology and that affects the operation and appropriateness of the technology as well as the actions of people who operate it.

More recent work of Pan and Scarbrough (1998) extended such arguments to embrace the socially constructed aspects of knowledge within organization, which stresses upon the interplay between technology and organization. This perspective has been summarized in terms of three major layers of knowledge management systems. The first is the "Infrastructure" which refers to the hardware/software, which enables the physical/communicational contact between network members. The second, is the "Infostructure**".** This is the formal rules that govern the exchange between the actors on the network providing a set of cognitive resources (metaphors, common languages) whereby people make sense of events on the network. "Infoculture" is the third system referring to the stock of background knowledge, which actors take for, granted and which is embedded in the social relations surrounding work group processes.

Pan and Scarbrough model draws attention to the role of management in developing and linking these constituent elements and modulating organizational processes in the way they interact with each other. Hence, the dynamic evolution and the complex interaction between the different elements are crucial in understanding KS in organisations.

3. JOINT VENTURES AND KS IN CONSTRUCTION

JVs are often projected as a strategic tool to exploit foreign market opportunities and to overcome lack of local knowledge for international construction firms. Researchers have described how most construction companies use overseas contracts to bring some stability to the cyclical nature of the industry and act as a bolster for home country earnings (Briscoe, 1988; Strassmann and Wells 1988; Hillebrandt and Cannon, 1989). Construction JVs have been identified as a vehicle for technology transfer between foreign and local companies, which may either be project specific or of a longer term nature (Ofori, 1990).

However, JV is not seen to be a universally successful transfer vehicle because it is difficult sometimes to match the foreign partner's commitment to technology transfer with its suitability for the project (Andrews, 1984; Chow, 1985). KS in construction JVs is viewed from the aspect of local firms receiving valuable knowledge from its foreign partners. However, past experience shows local firms failing to acquire specific knowledge because the foreign partner tend to take separate responsibility for their portion of work with local partners playing a minor role in the operation of the JV (Ofori, 1994). Because of this they tend to finish their part of work in separate work environment rather than collaborative work environment and, hence, hinder the effectiveness of the KS process.

4. METHODOLOGY

This research has used the case study approach to examine the effectiveness of KS in construction JVs operating in Singapore. The three elements of infrastructure, infostructure and infoculture, discussed earlier, will be operationalised to support the data collection and analysis of KS in the selected case study.

Knowledge Infrastructure

Knowledge Infrastructure is defined as the physical system of knowledge architecture, which consists of means and repositories that helps the storing and disseminating knowledge. Pan and Scarborough (1998) explain that the main architectural elements of the knowledge infrastructure are humans, organisational entities, documents, books, other knowledge repositories and operating entities'. The means of transaction therefore can be meetings, emails, faxes etc.

The JV's knowledge architecture, and its elements, is judged to be "structured" based on the following criteria.

- Employees know where and in what form a particular expertise exist in the JV, and
- The knowledge repository in the JV organisation, with all pertinent knowledge, is well organised.

However, the knowledge infrastructure is judged to be "Flexible" if

- Employees are able to reach the required expertise without much restrictions, or overcomplicated formal routes, and through any suitable technology, as and when its needed, and
- The knowledge repository can be accessed directly without being restricted by hierarchy and with ease.

Knowledge Infostructure

Knowledge Infostructure is defined as the practices adopted for knowledge exchange by employers in the existing physical system of knowledge infrastructure. Knowledge exchange among JV members, for instance, is governed by the organizational structure of that JV and adopted practices such as meetings and training programs.

This research analyses the formal and informal rules of knowledge exchange in a JV organisation based on the following criteria.

- When the JV's partners agree to adopt either the partner's way of working, or form a new set of rules of knowledge exchange, or "combine" the practices of the JV. Such knowledge infostructure is classified as "Organised".
- When the employees at all levels are well informed with knowledge access rules (like job profiles and updates), trained (by the partners) and the knowledge exchange in the JV is governed by a set of formal procedures (such as a technology transfer agreement) then the knowledge infostructure can be classified as "Explicit".

Knowledge Infoculture

An important aspect of KM in an organisation is the open and trust based culture that is conducive for knowledge sharing among people. Bob Buckman stated "for knowledge-sharing to become a reality, you have to create a climate of trust in your organisation. You cannot empower someone that you do not trust and who does not trust you" (quoted in Pan and Scarborough, 1999).

This analysis of the nature of sharing culture in a JV is based on the following criteria.

- When joint venture partners have acknowledged and expressed the desire to share knowledge, especially when the foreign partner has agreed to let the local partner learn from him. Then the knowledge infoculture can be classified as "Open".
- When the knowledge sharing process implementation is has not been crippled by lack of learning ability of receiving partner. Then the knowledge infoculture can be classified as "Compatible".

5. THE STUDY

The case study approach was adopted by the research to allow more in-depth data collection and analysis needed in this type of study. The study was conducted in Singapore. The data collection involved a number of structured interviews with key informants (general managers and project managers) from the partner firms, and series of meetings with project members as well. Four JVs from one major project were selected. This major project, to be referred to as NAL, was awarded in thirteen separate contracts packages by of the main public authorities in Singapore (the client). The NAL JVs were on going contracts, at the time of the research, from which current and dynamic process and product details could be obtained. However, due to limited nature of this paper only one case study will be examined.

During the structured interviews with key informants, they were briefed on the background of the topic of the research. Informants were asked to express their views, in own words with the examples from their experience of working on the current project. Each interview lasted for forty five minutes to one hour.

Assessment of KS is viewed from socio-technical perspective, using the elements identified in the previous section.

The Case Study

This JV involved three partner firms; a Japanese firm (C1), with 45% share (the leader of this JV, a local firm (C2) with 45% share and another Japanese firm (C3) with 10% share. C3 was not involved in the construction work and did not have staff on site. The project is a two 2-level civil defense stations, together with a 2.5 km of cut and cover tunnel. The contract sum is S$ 216 million. The stated objectives of the JV were to

- Combine the resources of the members of the JV in order to win the contract,
- Use the expertise of each other partner,
- Get specialized technology like tunneling
- Share the commercial risk.

C1 is one of the largest firms in Japan with major activities ranging from engineering and general construction to real estate and housing. C2 is one of the largest Singaporean design-and-build engineering and construction service provider. Its core capabilities encompass building and heavy civil engineering, industrial and process engineering and have a distinct in house multi–disciplinary design office.

Analysis of Knowledge Infrastructure

Knowledge infrastructure consists of the knowledge, in the form of documents (method statements), drawings and experienced people. Knowledge architecture in this project seems to be designed with a clear information exchange network consisting of a comprehensive document control system and clear distribution list. Information Technology (IT) were used to facilitate interaction among members with a networked system that has encouraged more than 50% of the employees to we use emails. The computer network system is structured in the way that all the members of the project are aware of the location of knowledge, which enabled them to act quickly to reach the knowledge repository, when it is needed. For example the special technical know-how on tunnelling can be shared with specialists in Japan when this particular knowledge is not available on site.

The members of the JV are aware of the location of knowledge and its form, which would encourage better knowledge sharing. However, information flow system exposed a horizontal split between the production section and the immediate management. '*They know how to get the necessary information, but for particular section of people. If you see it is split in construction section and supervisory staff section'* (Engineering manager C1). At the same time infrastructure evidences a blend of expertise from both the partners at higher levels. '*No split between C1 and C2. The Project Director is from C1 and Deputy Project Director is from C2'* and *'Supervisory board has member from each of the partners'* (Engineering Manager C1). The Knowledge Infrastructure is judged to be "**structured**".

Although the IT network of the JV has no web-based system project members were connected to the JV database (see figure 1). However, the IT system restricted access to the C1's server in Japan to its subsidiary in Singapore and not by the other partners. Similarly local firm's server is accessible only to their employees. This was due to the fact that there was no central database where JV partners can share their knowledge.

This hierarchical network would restrain access and obstruct the flow of useful knowledge between partners and creates an inflexible knowledge infrastructure and weakens the KS process. The division of work among the partners into independent packages creates further inflexibility where inter-organisational collaboration is low. "*From the practical point of view, C1 provided engineering staffs for the execution of tunnel works. C2 provided commercial staffs to buy services"* (Engineering Manager-C1). The Knowledge Infrastructure is judged to be "**inflexible**".

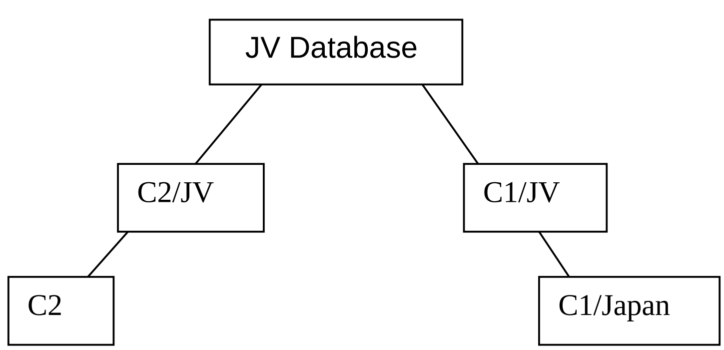

Figure 1 IT Infrastructure of Joint venture

Analysis of Knowledge Infostructure

The formal rules which guide the interaction between project team members and the practices adopted by the project team are highly influenced by the leading team that is Japanese firm. '… *the practice here in civil construction is instructed completely by C1, no input from C2'.* (Engineering Manager, C1). Usually in joint ventures the strong party would be the leader. '*Japanese are taking the lead because of their knowledge and expertise in tunnelling*' (Deputy Project Manager-C2). The Japanese firm's leading team therefore has a dominant role in shaping up the work on site, especially how information is being shared among members. In this Design and Build (D&B) contract the Japanese team would provide the project team *"with method statement, for a particular work, to be reviewed by the construction manager and myself, Safety department, then all make comments in terms of design, contractual, construction requirements"*[Engineering manager C1]. The Knowledge Infostructure is judged "**organised**".

The JV has employed a mix of local and foreign staff for this specific project. The foreign staff were recruited from several European and Asian countries. New recruits were offered training courses on safety, first aid and the use of scaffolding. The general staff and labourers were recruited from Thailand and the Philippine, Engineers from UK, and the supervisors were locals. Additional, experienced construction supervisors and machine operators were supplied by the labour-only-subcontractors.

Apart from the above training programs, learning is stimulated in the work environment as on job training. There was evidence that KS is made explicit by feedback programs though it was not a regular practice. One example was two members of staff have written a paper based on their experience on the project and presented the paper in an international conference. This same presentation was give to JV staff allowing more explicit and organised KS. Further, the foreign contractor decided to retain the local staff who were recruited specifically for this project and later relocated them to another project to benefit from the knowledge gained on this particular project. The knowledge infostructure here is judged **explicit.**

Analysis of Knowledge Infoculture

The local partner has referred to the Japanese firm's organisational culture as a "closed culture". This is not surprising as the Japanese contractor was using the Japanese language rather than English in their communications, other than any formal communication with the partners. This was disappointing to the local contractor as one of their managers stated that "…*because it is a joint venture we stated clearly that we wanted to learn from them. Whatever we ask, they have to be open. We stated this clearly at first"*.

The Engineering Manager (C1) who works with the Japanese contractor further reinforced this view by expressing his dissatisfaction of the Japanese contractor lack of willingness to share their knowledge. It could be that the Japanese firm lack of willingness to share their technical knowledge due to the commercial sensitivity of the technology. If that is the case then the JV agreement should have clarified this issue. Therefore, the Knowledge Infoculture is judged to be **stifled** and "not open".

In terms of existing learning culture in partner firms, Japanese firm has apprenticeship learning culture where young and less experienced staff are assigned to supervisors who are older and more experienced. It was described by one of the interviewees as a seniority-based culture where very few would question their seniors. A project manager with the local contractor observed that "*they start from low level and go to the top. They don't have formal degree; [their] project managers don't have formal degrees*". The local contractor has a different learning culture as explained by the local project manager "*in Singapore, we have formal degrees. We put people in that place from where they have to proceed themselves*". It can be inferred that there in incompatibility between the two learning cultures. The lack of significant and determined effort to bridge learning culture makes the infoculture **incompatible.**

6. CONCLUSION

The expectation of a local firm to share knowledge and learn from an international firm has to be one of the key building blocks of a fruitful alliance. At the same time it should not be very surprising to find that foreign firms do not share this urgency to share their knowledge with local firms. Hence, there is a need to motivate and enable effective knowledge sharing through purposefully designing the JV and project organisational structure, working practices and systems with that objective in mind. The evidence from this case study shows that the JV has serious problems in all three layers of the KS identified by the research. The organisational structure, IT system and the different practices adopted by the JV were more focused on organising the work with little regard of sharing the expertise and knowledge. Equally, there was no evidence that the local and foreign partners initiated any effort to address this issue leading the research to conclude the individuals, at least, were not concerned about the lack of KS. Although, the local partners stated that their desire to learn form their partner there is no evidence from the case of any concrete steps to achieve this objective. A more positive approach to KS requires a clear commitment and leadership from top management of the individual firms and, more importantly, the JV to clearly set the JV's objectives and monitor progress.

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ORGANIZATIONAL CULTURE IN U.S. CONSTRUCTION COMPANIES

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ABSTRACT

Organizational culture has gained importance in the increasingly internationalized and globalized construction business. The dynamics of the construction business have become more dependent than ever on the cultural characteristics of construction companies. It has become clear that sustained profitability and high financial returns are not enough to survive and remain successful in highly competitive markets because there is considerable evidence of conflicts and misunderstandings caused by cultural differences. Consequently, firms need to understand their own and other firms' organizational culture and need to adjust their ways and traditions while conducting business with other firms, organizations or individuals with different cultural values.

Although there is a substantial amount of research demonstrating the importance of cultural issues in the construction industry, the divergence between countries is yet to be explored. This study is a part of an international project initiated by CIB's TG23 (Task- Group 23 of the International Council for Research and Innovation in Building and Construction), and aims to investigate the cultural features of U.S. construction companies. Data are collected by means of a questionnaire based on OCAI (Organizational Culture Assessment Instrument), a well-known and widely used measurement tool developed by Cameron and Quinn. The survey is administered to the top 400 contractors listed by *Engineering News-Record*.

Keywords: Organizational culture, OCAI, U.S. construction companies

1. INTRODUCTION

Culture is a multi-dimensional concept that can be applied to firms, industries or nations. A review of existing literature yields an array of definitions of culture. Smircich (1983) mentions that the concept of culture has been borrowed from anthropology, where there are more than 160 different definitions (Kroeber and Kluckhohn, 1952). By far one of the most widely accepted definitions is proposed by Schein (1985), who defines organizational culture as "*a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration that has worked well enough to be considered valid, and therefore, to be taught to new members as the correct way you perceive, think, and feel in relation to those problems.*"

There are two major ways of linking culture and organization. In the comparative management literature, culture is treated as an independent variable and assumed to be a background factor, which affects organizations indirectly. On the other hand, recognizing organizations as “culture producers”, the second approach considers culture to be an “inter organizational” variable, leading to the idea of “corporate culture” (Smircich, 1983). This perspective stimulated a great deal of interest among researchers mostly focusing on strategic studies in organizations (Quinn, 1980).

A number of researchers investigated the relationship between organizational culture and company success (Deal and Kennedy, 1982; Schein, 1985), performance and competitiveness (Barney, 1986; Hoecklin, 1996), and organizational effectiveness (Denison and Mishira, 1995). Particularly after the 1990’s, parallel to the paradigm shift in the management literature where the adaptation process gained more importance than ever due to increased globalization and internationalization, organizational change became the focus of many cultural studies. However, there still is a need for more empirical research for a complete understanding of organizational culture, and its influences on different organizational issues.

Cultural Studies in the Construction Industry

Particularly after 1990, the number of publications focusing on organizational culture has significantly increased in the Construction Management (CM) literature. The main reason for the growing interest can be explained by the internationalization of the construction markets. Although the construction industry is relatively domestic in nature compared with other industries (Strassman and Wells, 1988), there is substantial evidence of increased international trade in construction services (Loraine, 1992). It appears that organizational culture has gained importance because more construction companies are conducting business in international markets (Low and Shi, 2001).

In addition to the emphasis put on the internationalization of the construction business, several authors highlight the importance of the fragmented nature of the industry (Hillebrant, 2000). One of the reasons for adversarial relations between different stakeholders is considered to be the sensitivity of different project participants to cultural differences (Phua and Rowlinson, 2003). Adversarial relationships have in turn a negative impact on project performance. Moreover, a strong organizational culture is claimed to be an effective way to respond to the environment; thus achieving a superior performance (Deal and Kennedy, 1982). Considering the hyper-turbulent environment and fragmented nature of the construction industry; understanding and managing organizational culture is of particular importance in enhancing organizational performance (Ankrah and Langford, 2005).

The majority of the existing studies in the CM field mostly attempt to appropriate the theoretical models of the management literature, and focus on (i) the impacts of organizational culture on project goals (Liu and Fellows, 1999) and partnering performance (Latham, 1994); (ii) the cultural differences between various construction professionals (Ankrah and Langford, 2005; Rameezdeen and Gunarathna, 2003); (iii) organizational effectiveness (Zhang and Liu, 2006) and (iv) the cultural aspects of organizational change (Rowlinson, 2001). Despite the substantial amount of research demonstrating the importance of cultural issues in the construction industry, this young and relatively immature literature is far from addressing all the dimensions of the issue such as cross-cultural characteristics of the construction industry.

This study is a part of an international project initiated by CIB's TG23 (Task Group 23 of the International Council for Research and Innovation in Building and Construction), concurrently ongoing in 15 different countries. The main stimulus for this paper is to investigate the cultural features of U.S. construction companies. The results of the study are expected not only to produce further empirical evidence which is needed to understand the organizational culture in the construction industry, but also to enable a comparison among the participating countries to the CIB-TG23.

2. RESEARCH METHODOLOGY

Diverse analytical approaches are proposed in the literature, that provide various classifications, describing a number of ideal cultures. These typologies are based on different dimensions of organizational culture, representing the areas of significant differences between the organizations being compared (Ankrah and Langford, 2005). One of the most commonly used typologies was developed by Hofstede (1997) based on four different cultural dimensions: (i) individualism/collectivism, (ii) power-distance, (iii) uncertainty avoidance, and (iv) masculinity / femininity. Covering over 100,000 respondents from 72 countries, Hofstede (1997) distinguished between four culture types: families, pyramids, markets, and machines. On the other hand, Handy (1993) identified the power, role, task and person typologies. More recently, based on the competing values framework, Cameron and Quinn (1999) introduced a different classification including the clan, hierarchy, market and adhocracy cultures. Cameron and Quinn (1999) opted to base their typology on six different dimensions: (i) dominant characteristics, (ii) organizational leadership, (iii) management of employees, (iv) organizational glue, (v) strategic emphases, and (vi) criteria for success.

Working with typologies is claimed to be problematic, since it is hard to label every real-organization with a single typology (Hofstede, 1997). Moreover there is little agreement on classifications of culture. Nevertheless, the use of these typologies is still considered to be appropriate practice in the study of organizations since these typologies make use of numerous relevant dimensions (Ankrah and Langford, 2005). In order to be compatible with the studies conducted in other countries participating in the CIB TG23 research, Cameron and Quinn's (1999) "Competing Values Framework" (CVF) as well as their measurement tool named "Organizational Culture Assessment Instrument" (OCAI) were adopted in this study.

The Competing Values Framework

The Competing Values Framework was originally developed to understand organizational effectiveness (Cameron and Quinn, 1999), and was later applied to explore different issues relative to organizations such as total quality management (Al-Khalifa and Aspinwall, 2001), leadership development and managerial styles (Martin and Simons, 2000); and finally organizational culture (Cameron and Quinn, 1999).

The Competing Values Framework determines two major dimensions and four main clusters (see Figure 1). The first dimension differentiates between organizational focus (internal versus external), while the second one indicates the preference about structure (stability and control versus flexibility and discretion). These two dimensions form four quadrants, each representing a different set of organizational culture indicators. Each quadrant is given a distinguishing label that denotes its most notable cultural characteristic, (1) clan, (2) adhocracy, (3) market, and (4) hierarchy cultures (see Cameron and Quinn, 1999 for detailed information about the framework).

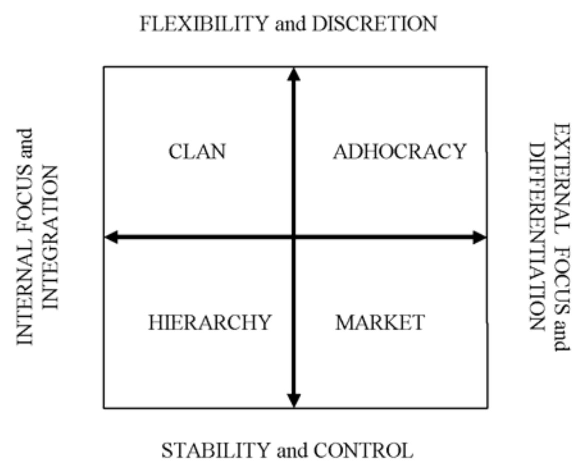

Figure 1. The Competing Values Framework (Adopted from Cameron and Quinn, 1999)

The *clan* culture is observed in family-type organizations. It concentrates on teamwork, employee-involvement programs, and corporate commitment to employees. This type of organization treats its customers as partners, and its employees as family.

The *adhocracy* culture is prevalent in dynamic, entrepreneur, and creative organizations where the major goal is to foster adaptability, flexibility and creativity. This kind of organization focuses on external positioning and is most responsive to hyper-turbulent environments, where change and uncertainty is typical; therefore innovativeness is assumed to be the key to success.

The *market* culture represents externally oriented organizations, which focus on transactions with suppliers, customers, regulators and so on. The core values that dominate these organizations are competitiveness and productivity, which can be achieved through a strong emphasis on external positioning and control.

The *hierarchy* culture is characterized by a formalized and structured workplace, where stability, predictability and efficiency are the long-term concerns.

In order to diagnose the dominant orientation of an organization, Cameron and Quinn (1999) developed an instrument known as "Organizational Culture Assessment Instrument" (OCAI), which consists of six different questions with four alternatives, which are relevant to the current orientation of the organization.

Data Collection and Analysis

The main objective of this research is to determine the cultural profile of U.S. construction companies. To achieve this objective, a questionnaire survey was conducted of the top 400 contractors listed by *Engineering News-Record* (ENR). The questionnaire was mailed to the executives of the construction companies along with a cover letter and a self-paid envelope. The total number of mailed and returned questionnaires was 400 and 31, respectively; giving an effective response rate of 8%.

The questionnaire is composed of three parts. The first part contains questions concerning the demographic characteristics of the respondents, such as job title and length of tenure with the company. The large majority of the respondents (90%) identified themselves as CEO, chairman, president, vice-president or vice chairman. The average number of years that the respondents had been with the company was 27 years.

The second part was designed to seek information about the characteristics of the companies, such as age, work volume, and type of work. The general characteristics of the responding construction companies are presented in Table 1.

Table 1. Characteristics of Responding Companies (N=31)

	Number of Companies	Percentage of Companies
Age (years)		
<30	7	23%
30-50	5	16%
>50	19	61%
Average Annual Work Volume (million US$)		
<150	10	32%
150-249	11	36%
>250	10	32%

As it can be seen in Table 1, 61% of the responding construction companies have been in operation for more than 50 years, while the average age of the firms in the sample is 64 years. About 68% of the companies have an annual work volume of more than US$150 million. The long-time existence and large annual dollar turnovers of the companies are not surprising since the mailing list was selected from the top firms in the U.S. construction industry.

Focusing on the organizational culture of the companies, the third part of the questionnaire was adopted from OCAI. It consists of 6 questions with 4 alternative statements representing the different types of organizational culture described in the preceding section. Respondents were asked to divide 100 points among different alternatives for each question. The overall cultural profile of an organization is then derived by calculating the average score of all statements representing the same cultural orientation. For reliability analysis, Cronbach's alpha values are computed for the culture types used in the study. The results indicate the fairness and suitability of the measurement tool (clan: 0.68, adhocracy: 0.70, market: 0.77, hierarchy: 0.67). The data were analyzed using the Statistical Package for the Social Sciences (SPSS) computer program.

3. FINDINGS AND DISCUSSION

The findings associated with this study are presented and discussed below, in line with the three comparison standards described by Cameron and Quinn (1999): (i) overall cultural profile of companies, (ii) strength of culture, and (iii) cultural congruence. Although there is a number of culture dimensions defined in the literature, this study is limited to these three issues since they are the most common ones treated in recent studies (Cameron, 2004).

Cultural Profile of the U.S. Construction Companies

The cultural profile of the companies refers to the overall culture plot of the companies in the sample. The scores assigned by each respondent to the four culture types indicate the extent to which these cultures are emphasized in the organization. In other words, the culture type with the highest score is considered to be the dominant culture in the organization.

Table 2 shows the distribution of organizational cultures in the 31 companies that participated in the study. The most frequent type of culture that dominates the organizations in the sample is "clan culture" (68%). As seen in Table 2, two companies in the sample were characterized by equally dominant cultures. These companies are classified as "companies with no dominant culture". None of the companies were dominated by adhocracy, which represents innovative and pioneering organizations mostly operating in hyper-turbulent conditions (Cameron & Quinn, 1999).

Table 2. Distribution of Organizational Culture in U.S. Construction Companies

Organizational Culture	Number of Companies	Percentage of Companies
Clan	21	68%
Adhocracy	0	0%
Market	5	16%
Hierarchy	3	10%
No dominant culture	2	7%
Total	31	100%

The characteristics of clan type organizations are team-work, employee development, and commitment to employees. From this perspective, Cameron and Quinn (1999) underline that "*when rapidly changing, turbulent environments make it difficult for managers to plan far in advance and when decision making is uncertain, it was found that an effective way to coordinate organizational activity is to make certain that all employees share the same values, beliefs, and goal*". Although the findings of our study uphold Cameron and Quinn's (1999) claim that clan culture is prevalent among U.S. organizations, this perspective conflicts with the project-based nature of the construction industry, i.e., short-term organizations that rely on non-permanent workers (Ofori and Debrah, 1998). But there seem to be reasonable explanations to fill the gap between the specific characteristics of the construction industry and the predominant aspects of clan culture. For example, Hult et al. (2003) found in their study that large and old organizations, which also constitute the sample of our study, tend to focus on organizational learning and development of teamwork, which are also the characteristics of the clan culture. Also, long history and reasonably stable membership, which is also the common profile of the respondents in our sample, is assumed to be necessary to produce social understandings by Schein (1981), in other words to develop clan characteristics. Moreover, the dominance of an internally-focused clan culture among U.S. construction companies supports Thomas et al.'s (2002) observation that an employee-focused internal orientation is commonly predominant in the construction industry because of the ad hoc nature of construction work.

Strength of Culture

"Strength" of culture is an ambiguous concept which can be defined in various ways. In the literature, strong cultures have been characterized with their homogeneity (Ouchi and Price, 1978), congruency (Schall, 1983), cohesiveness (Deal and Kennedy, 1982), and differentiation (Schein, 1985). In this study, in line with Cameron and Quinn (1999), strength of culture is defined by the score awarded to a specific type of culture, as calculated in Table 3. The other characterizations of the concept, such as homogeneity and congruency are discussed in the next section under "cultural congruence".

As seen in Table 3, the strengths of different cultures were computed by calculating the respective average of the scores assigned by the respondents to each dimension of organizational culture.

Table 3. Average Scores of Dimensions of Organizational Culture (N=31)

Dimensions of Organizational Culture	Culture Types			
	Clan	Adhocracy	Market	Hierarchy
Dominant Characteristics of Organization	38.52	22.74	24.52	14.23
Organizational Leadership	29.52	27.58	22.26	21.61
Management of Employees	41.61	23.71	20.81	13.87
Organizational Glue	54.35	15.48	21.13	9.3
Strategic Emphases	38.23	19.19	20.16	23.06
Criteria for Success	33.23	13.39	27.42	25.97
Overall Organizational Culture Profile	39.24	20.35	22.71	17.96

As stated above, having a strong culture is assumed to be an indicator of not only a clear focus in the organization, but also of higher performance (Cameron & Quinn, 1999). The findings show that, in addition to its dominance, clan culture is significantly stronger than any other type with a mean score of 39.24, while the nearest score belongs to market culture (22.71) (see Figure 2).

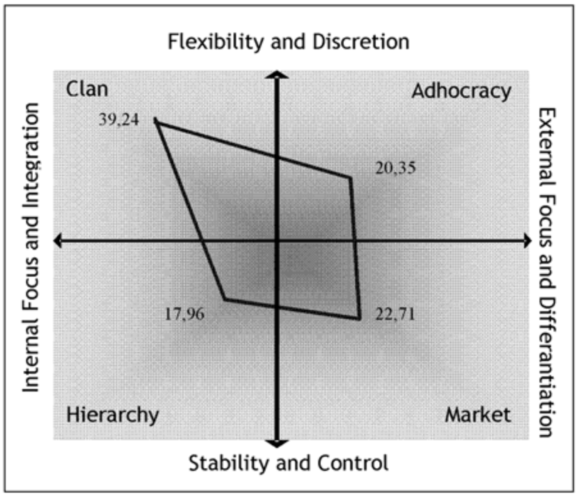

Figure 2. Overall Culture Profiles of U.S. Construction Companies

Cultural Congruence

Cultural congruence refers to the harmony among different cultural dimensions discussed above. According to Cameron and Quinn (1999), in a congruent organization, the overall culture of the organization and various aspects of it (criteria for success, leadership style, organizational glue, etc.) tend to indicate homogenously the same cultural values. Having focused on the same values, congruent cultures are assumed to be high performing organizations (Cameron & Quinn, 1999). On the other hand, cultural incongruence stimulates differences in perspectives and strategies within the organizations, often indicating a need for change. Harris and Mossholder (1996) underline that this diagnosis is helpful for the proper allocation of resources among various culture dimensions.

As to the cultural congruence among the different dimensions of organizational culture in the sampled companies, it is found that all dimensions are strongly emphasized in clan culture which was found to be in the preceding two sections to be the most dominant culture in U.S. companies (see Table 3).

4. CONCLUSION

This study is focused on an empirical investigation of the organizational culture of U.S. construction companies. The results reveal that most U.S. construction companies are dominated by a strong clan culture, which is relevant to internally-focused organizations. In other words, the findings show that U.S. construction companies (i) operate like an extended family, (ii) have a leadership style generally associated with a facilitator, mentor or parent, (iii) emphasize teamwork, participation and consensus, (iv) have workers with a high level of commitment and loyalty, (v) emphasize human development, and (vi) define success on the basis of employee commitment and concern for people. It must be noted however that the results are based on information obtained only from few large enterprises operating in the U.S. construction industry, and may reflect the bias of organizational size and of a low rate response to the survey. Following this exploratory study, further work focusing on a larger sample including organizations of different sizes could be helpful in drawing a more reliable cultural profile of U.S. construction companies.

The findings show that all dimensions of organizational culture are emphasized in clan culture indicating the existence of cultural congruence, which is supposed to be positively related to the organizational performance and success (Cameron and Quinn, 1999). The results also support Deal and Kennedy's (1982) work to some extent which claims that U.S. organizations have a strong culture which constitutes the driving force of their continued success. However further investigation is essential for a better understanding of the relation between the strength and congruence of culture and company success.

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MEASURING CULTURAL DIMENSIONS IN THE GERMAN CONSTRUCTION INDUSTRY

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ABSTRACT

Publications by Hofstede (1981, 1998, 2005), Trompenaars (1998, 2003) and Hall (1990) provide us with different methods and dimensions for comparing national cultures. Hofstede's five canonical cultural dimensions are despite strong criticism (McSweeney 2002) robust and simple categories for determining the impact of different cultures on management (Mead 1994). Based on the works of Hofstede the values for the five dimensions of the German national culture in the construction industry are determined through an online survey of architects and engineers (in design firms and construction companies) as well as university professors. For this purpose, the OCAI-questionnaire by Cameron / Quinn (2005) was translated into German and used. The goal of the research is to find the differences between the four professional groups within Germany and to provide data for international comparison (Liu / Fellows 1999).

Keywords Construction Culture, German Survey, OCAI-Questionnaire, Organizational Culture

1. INTRODUCTION

Germany is the world champion in exports measured as part of the GDP (EU-Commission 2006). This applies to the construction industry as well. There are about 250 German construction companies working abroad and many more architectural and engineering firms. Two of the top ten international construction companies are German. On the other hand, there are also many companies and firms from foreign countries active in Germany. All these enterprises have to solve a score of culturally induced problems while managing their projects (Harrison / Huntington 2000).

Our research provides quantitative data that may help companies and firms to better prepare for the cultural differences in an international context. For this purpose architects, engineers, members of construction companies and professors of civil and environmental engineering as well as construction management have been surveyed. We deem it to be important to include the professors as a separate group because they are instrumental in creating a professional culture. A university education can be interpreted just as such: the attempt to create a common understanding among a group of future professionals by coining the meaning of concepts and by transferring a certain set of methods from generation to generation.

This endeavor is part of the CIB initiative on "Culture in Construction" in which momentarily 15 different nations are involved. Accumulating data from these countries is just a first step. Once there exists a sufficient database, a meta-study is required to evaluate all the different research results.

A second use of the data can be made by determining if there are any noticeable differences between the different professional groups in the German construction industry such as between architects and engineers (art vs. structural analysis?). There is a lot of anecdotal evidence that engineers and architects consider themselves to be fundamentally different. This should show up by different values in the cultural dimensions.
The data have been recorded not only with regard to the professional specialization but also to sex, age, religion, education, employer and company size of the respondent and allow for an analysis within the German construction industry. They also enable us to make a primary assessment by comparison with the data published by Hofstede and Cameron / Quinn.

2. METHODOLGY

The research was conducted in three phases: (1) planning of the data collection, (2) questionnaire, (3) data analysis. These steps are detailed below.

Planning of the data collection

When planning the survey a decision with regard to the means of communication is required. We evaluated the advantages and disadvantages of a written survey transmitted by postal service, a telephone survey, and an online survey (Dillmann 1978). Practical reasons ruled out the use of the telephone, predominantly the budget and the available time. Written surveys are in the moment the curse of the construction industry in Germany. According to our experience they are often treated very negligently. The CEOs of the large German construction companies confided almost unanimously that they pass these written surveys on to their assistants. The same problem exists on first sight with online surveys. However, in our experience people treat their internet connections with more propriety. This is in accordance with research results on this topic (Batinic et al. 1999). An advantage of online surveys is the direct control of participation rate. This information was used for sending a second “invitation” without time delay.

Due to the complexity and the multiple possibilities for answers we refrained from programming the questionnaire ourselves and instead used the services of a commercial service provider. Performance, serviceability, and the costs convinced us to use the platform www.eQuestionnaire.de. This platform does neither require a high-performance computer nor a high-speed internet connection on the side of the respondent which might be an advantage when dealing with very small firms.

The respondents were requested by email to participate in the survey. We obtained the addresses of the different target groups by using the internet pages of the different professional institutions. Predominantly we used the institutions of architects and civil engineers. These are organized in the Federal Republic of Germany separately in each of the sixteen states which helped choosing firms from a wide range of areas all over Germany. Construction companies are generally part of either one of the two professional bodies of this industry, i.e. the Hauptverband der Deutschen Bauindustrie (larger companies) and the Zentralverband des Deutschen Baugewerbes (small companies). For the universities the internet is an all encompassing guide.

Looking at the number of more than 80.000 construction companies and a probably even higher number of architectural and engineering firms, it is impossible with the means of a small scale study to come up with a representative sample. Nevertheless we tried to group companies and firms by region and size so that the sample would in this regard be as representative as possible. The limited and well-known number of universities with departments in civil engineering allowed for easy and complete access. Architectural departments were not contacted to limit the size of the sample. By this approach we singled out 650 different addresses.

Questionnaire

Since this research is part of the joint endeavor "Culture in Construction" by the CIB group TG23 the use of a common questionnaire was agreed on, in order to facilitate comparison. The choice is the OCAI-questionnaire established by Cameron / Quinn in their research of organizational cultures. It is based on their competing values framework that itself draws among others on Hofstede's cultural dimensions (Hofstede 2005).

The questionnaire exists only in English and the first task consisted in translating it into German. The questions comprise numerous figures of speech which cannot be translated literally. As an example, Germans show their flag when Americans stick out their necks (question 1B). More troublesome, however, are different connotations attached to words and ideas that are based on different values. Germany is a consensus society (a social market economy), yet there are companies who aggressively pursue market leadership. However, these companies would seldom phrase their pursuits in the words: "Competitive market leadership is key." These words are politically incorrect and would call for unwanted obstacles while the action itself would not be considered inappropriate. Translation proved to be very difficult.

There are two further alterations to the OCAI questionnaire: (1) question were added, (2) the dimensions were changed. Questions added are (except one) demographic questions concerning sex, age, education, job, employer, professional memberships, nationality, religion. The exception is a question asking for past change in the organization that should allow to evaluate the long-term orientation of the respondent. The change of the dimensions is more profound. Cameron / Quinn (2005) are measuring organizational cultures and describe these with four terms: clan, adhocracy, hierarchy, and market culture. We are looking for a comparison of national cultures and by evaluating the meaning of the four different cultures we equate each culture to one of the four original dimensions in Hofstede's framework. The descriptions given by Cameron / Quinn (2005, 66) and Hofstede respectively are to a large degree comparable. Therefore, high values for clan culture are equated with femininity (low ones with masculinity which will still be used as heading), high values for adhocracy culture with low uncertainty avoidance, high values for hierarchy culture with high power distance, and high values for market culture with high individualism. It needs to be noticed that the direction of the values is sometimes inverse to Hofstede's understanding.

The main questions from the OCAI-questionnaire have values ranging from "completely true” to “never true”. They are grouped in six sets (1-6), where the first question (A) in each of the six sets represents clan culture, the second (B) adhocracy culture, the third (C) market culture, and the fourth (D) hierarchy.

Data Analysis

124 fully completed questionnaires were evaluated. This is equivalent to a return rate of 19%. The first step in evaluating the data is just the calculation of the mean for each respondent and category, i.e. the sum of all values for the six “A-questions” divided by six gives the mean for masculinity. By grouping respondents according to their demographic data, further more comprehensive means can be calculated.

Since we wished to compare our data with those obtained by Cameron / Quinn, we had to transform them linearly, since the original OCAI questionnaire allows for a distribution of a hundred points between the four questions of each of the six sets.

The transformation consists of equating “completely true” to 100 points and “never true” to 0 points, with the intermediate steps being 75, 50, or 25 points respectively. The remaining problem of normalizing the numbers of points for each set was solved by calculating a correction factor. All values of a set were added and then divided by 100 which gives the adaptation factor. All individual values were then multiplied by this factor.

Example:

Original values			
value A	value B	value C	value D
75	50	100	25

Calculation:

$$\frac{valueA + valueB + valueC + valueD}{100} = correction\ factor$$

$$\frac{75 + 50 + 100 + 25}{100} = \frac{250}{100} = 2{,}50$$

$$\triangleright\ valueA = 75 / 2{,}5 = 30$$

$$\triangleright\ valueB = 50 / 2{,}5 = 20$$

$$\triangleright\ valueC = 100 / 2{,}5 = 40$$

$$\triangleright\ valueD = 25 / 2{,}5 = 10$$

$$\triangleright\ \sum_{A-D} value = 30 + 20 + 40 + 10 = 100$$

Normalized values:

New values			
value A	value B	value C	value D
30	20	40	10

These transformed values correspond with those given by Cameron / Quinn and allows to compare our values with theirs.

3. RESULTS

The following table contains all values for the different demographic groups. Columns three to six contain the values for masculinity (MAS), uncertainty avoidance (UAI), individualism (IDV), power distance (PDI), and long-term orientation.

Groups		Number of Forms	MAS	UAI	IDV	PDI	LTO
All	all	124	27	23	26	23	32
Gender	male	108	27	23	26	23	32
	female	16	28	22	26	24	34
Age	up to 40 years	42	26	23	28	23	35
	over 40 years	82	28	23	25	24	31
Educa-tion	Bachelor	31	27	23	26	23	37
	Master	50	28	23	25	23	31
	Doctoral level	37	27	23	25	24	31
	other	6	27	23	26	24	25
Profes-sion	Architects	24	30	23	24	22	38
	Professors	40	26	24	25	24	28
	Engineers	39	28	23	26	23	36
	other Professions	21	27	22	27	25	29
Employer	Architect. firm	21	29	23	26	23	38
	Construction c.	23	25	23	28	24	26
	University	49	27	24	25	24	29
	Engineer. firm	31	29	22	24	23	39
Staff	1-5	26	29	23	25	23	42
	6-20	20	29	24	26	21	30
	21-50	12	27	23	25	25	21
	51-100	12	28	21	24	25	42
	101-500	25	27	24	26	23	28
	501-2000	12	25	22	28	25	29
	> 2000	17	26	22	24	25	29
Profess. Member	yes	63	29	23	25	24	34
	no	61	26	23	27	23	30
Religion	Protestant	51	27	23	27	24	33
	Catholic	33	28	23	24	24	33
	Atheistic	16	27	24	25	24	22
Cameron / Quinn	Ø 1000 companies		21	15	32	25	-
	Construction n= 9 companies		24	18	32	22	-

Table 1: Summary of the cultural dimensions from all groups

The last two lines contain the results given by Cameron / Quinn in their diagrams (2005, 75 and 77). The first line gives the average for 1000 companies with approximately 25.000 respondents. It must be assumed that the vast majority of the respondents are US Americans, Cameron / Quinn do not reveal their nationality. The second line gives values for nine construction companies with an unspecified number of respondents. Again we assume the nationality of the respondents to be US Americans. Values that are equivalent to a long-term orientation are not produced by the original OCAI-questionnaire.

Evaluation

The first surprising observation when looking at the data is their uniformity. Without considering LTO, the values range from 22 – 30. Before a disappointment over the selectivity of the questionnaire settles in, a word of caution is required. Hofstede has normalized his own data by assigning 100 points to the highest and 0 points to the lowest values. This not only makes the data more readable, it also spreads them over the specified range regardless of how close together they initially were. We have rearranged our data in a similar way and they indeed look familiar to the results by Hofstede. However, we feel that such a representation is not warranted since we used a completely different questionnaire. Therefore our data do not provide the possibility of a direct comparison with the values given by Hofstede.

A second major point of observation are the values for long-term orientation. They show a markedly wider spread than the other data and are based on a single question about change in the organization. Since the behavior of the data deviates so much from the other columns we suspect that this is due to the different form of data collection (one versus the average of six answers). Averages tend to unify data around the mean. For these reasons we will not put much emphasis on the results. They might not be irrelevant, as is shown when looking at the results grouped according to religion. A religious affiliation provides a perspective that transcends the horizon of life. Thus LTO values should be higher for adherents of religion compared with atheists. On the other hand, there should be little difference among people of Christian faith, since the concepts of life after death are the same. This is exactly what the data show. (33 points for Protestants and Catholics, 22 points for atheists).

A comparison between male and female respondents is not elucidating, which can at least be partially attributed to the one-sided distribution in favor of male respondents (108 to 16). There are basically no differences in our sample.

The major difference with regard to age is in the dimension of individualism. Younger respondents are more individualistic. Could it be that a long service in firms and companies has a tendency to strengthen our ability to become stronger team players?

The level of education has practically no influence on the values of the first four dimensions. LTO shows erratic behavior for the reasons already mentioned. Within one national culture we would not expect difference due to education. Least of all in Germany where we traditionally avoid elite institutions in higher education. This is a marked difference with regard to France, the USA or the UK which should show in the results of those countries.

Larger discrepancies can be found comparing the different professions. Femininity is relative high among architects, relatively low for professors (sometimes an ego boosting profession?). If we go back to the dimensions of Cameron / Quinn, then these data represent a clan culture. Clan-like behavior is not common among professors. Surprising is the uniformity of the data when comparing architects and engineers. There is a marked tendency among architects and engineers in Germany to see the other group as very different. Yet, there are only two relative small differences: architects are more feminine, engineers are more individualistic. The last point is also startling. Are not the architects as artists the synonym for individualism? Hofstede (2005) sees the difference in individualism at the job in the fact whether it requires more initiative from the individual or the group. With the words of Cameron / Quinn "People are competitive and goal-oriented." (2005, 66). Before this background the values seem reasonable. The major point, however, when comparing professions is that there are only small differences. There is a common culture between architects and engineers.

This point is further strengthened when looking at the different employers (fig. 1 and 2). There is no distinctive difference between architectural and engineering firms (LTO set apart). Giving the same organizational setting (small firms), architects are more individualistic. Compared with larger construction companies they are less individualistic. These findings support the above argument that competition rather than the product determines individualism among different professions.

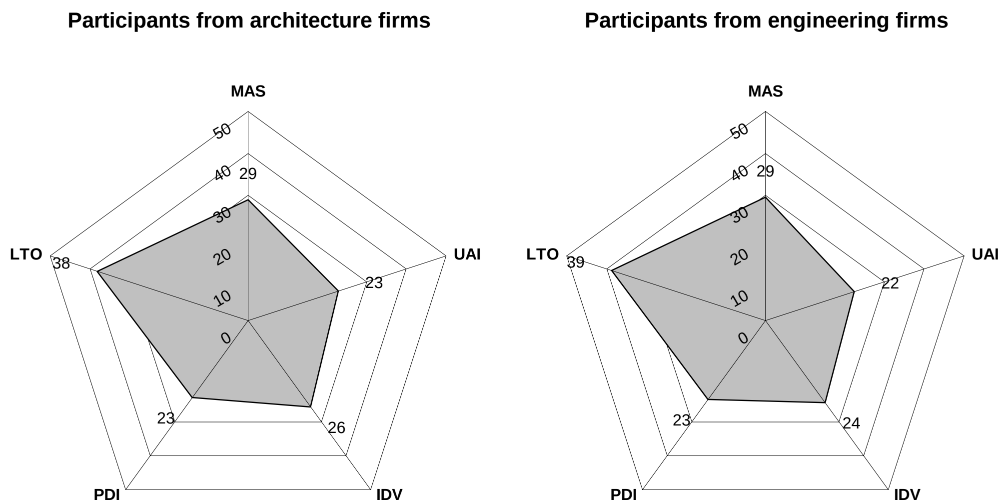

Figure 1: Profile of participants from architectural (left) and engineering firms (right)

The highest values for masculinity are found in construction companies as well, another sign for a competitive environment. Uncertainty avoidance is very uniform among all employers as well as power distance.

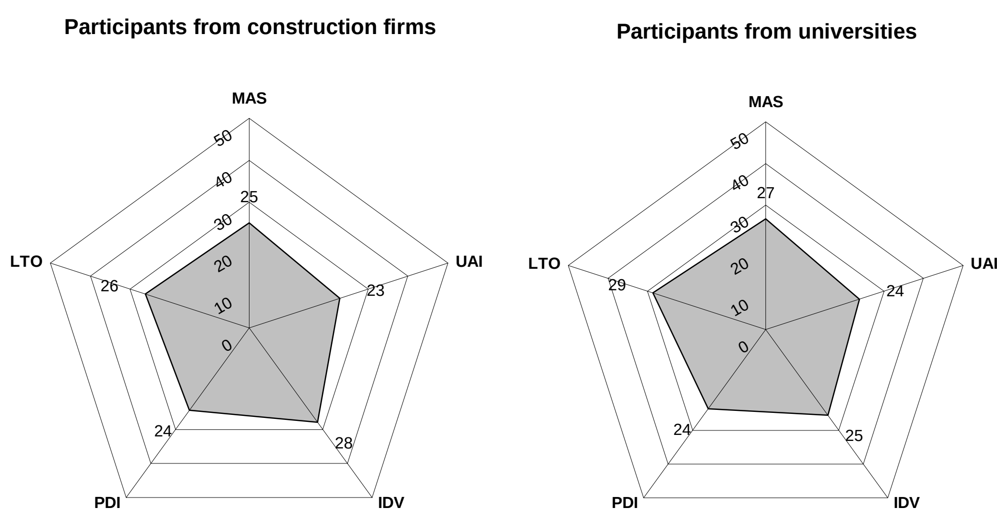

Figure 2: Profile of participants from construction companies (left) and universities (right)

Looking at the size of the organization, the data reconfirm that masculinity is higher in larger ones. There are no clear trends detectable for the other dimensions. Since the data are inconclusive, further hypothesis testing research is required at this point.

People with a professional membership are less masculine (and more clan culture) and less individualistic (more group-oriented). This is an expected result while clarifying little. Yet it is another sign that the data are reliable.

The same can be said about religious affiliation: few differences except for LTO. An explanation was given above and it can be said again that the tendency of the data is confidence building in the instrument.

There are no clear subcultures to be found in construction within Germany. The interpretations given for the data are hypothetical. They need to be cross-checked with more data from other countries. This must be done in a meta-study combing results from a group of countries. We have formulated our ideas so that they can be evaluated in such a study. Until then they are nothing but hypotheses.

Validation

Our data can be validated by comparison with the values obtained by Cameron / Quinn (2005, 77) and by using the values for the different national cultures of the US and Germany. In figure 3 comparative data are given from our research and that of Cameron / Quinn supposing these represent the US. Neglecting LTO, Germans are les masculine (remember: a high value for the dimension masculinity represents high femininity!) , have a higher uncertainty avoidance, are less individualistic and have a slightly higher power distance.

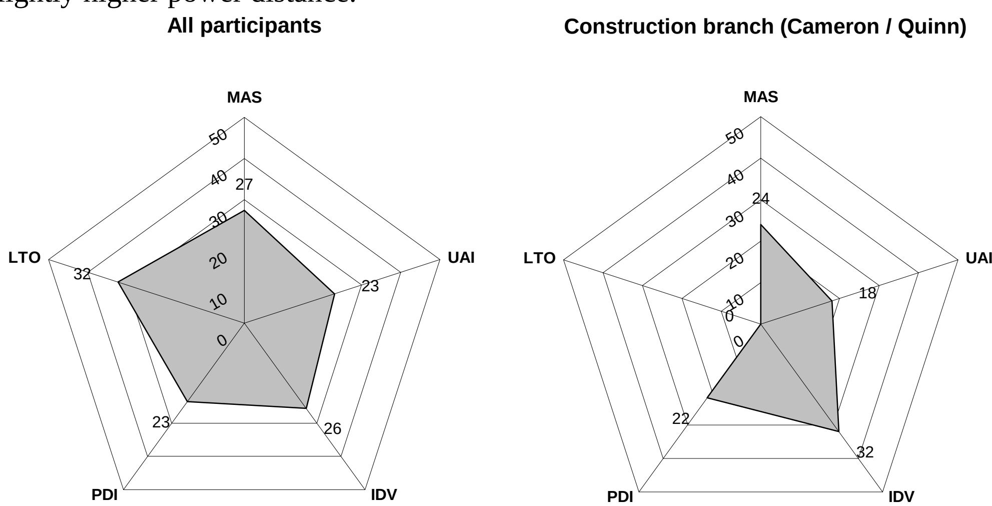

Figure 3: Profile of all participants in this survey (left) and the construction branch from Cameron / Quinn (right)

Here a word of caution is required: What is true for a comparison between national cultures does not need to be true for a comparison between professional cultures. However, if we take the national values of Hofstede to be indicative for the professional cultures between German and the US, there are surprising similarities.

Germans are not as masculine as US-Americans (66 vs. 62 for Hofstede, 3 points difference for our research, inverse result). Germans have a higher uncertainty avoidance (65 vs. 46 for Hofstede, 7 points difference for our research). Germans are less individualistic (67 vs. 91 for Hofstede, 10 points difference for our research). Germans have a smaller power distance (35 vs. 40 for Hofstede, 1 point difference for our research, inverse result).

Whenever there is a large differences between the German and US-American results according to Hofstede, our data confirm this result by also showing large differences in the same direction. Whenever there are small differences according to Hofstede, there are small differences in our findings, yet the results are inverse. These can be explained either through differences between national and professional cultures or by a lack of selectivity in either one of the questionnaires, we suspect in the applicability of the OCAI-questionnaire for measuring Hofstede's dimensions.

4. CONCLUSION

Our research has used the OCAI-questionnaire for measuring values of the dimensions of national cultures as proposed by Hofstede for the different groups in the German construction industry. There are some methodological shortcomings in this approach. The sample is not representative (although we tried to obtain such a one). There is no clear connection between Hofstede's dimensions and those introduced by Cameron / Quinn using their competing values framework (although we tired to establish one). There are no interpretations possible between different national cultures, unless we have data from other nations (these are being gathered).

Despite the shortcomings there are two evident results arising from this study. First, there are no largely different subcultures in the German construction industry. Second the data obtained can in most cases be validated in general and give an idea of the professional culture in the German construction industry.

We eagerly await the results from other countries and a meta-study using all the different data obtained through such a joint research endeavor.

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INDUSTRY CULTURE IN CONSTRUCTION AND MANUFACTURING

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ABSTRACT

National cultures (Hall 1990; Hofstede 1980, 1998, 2005; Trompenaars 1998, 2003) have been extensively researched. The same holds true for organizational culture (Cameron / Quinn 2005; Peters / Waterman 1982; Schein 1985). Nothing similar can be said about industry culture. While values are shaped by national cultures, the practices of engineers are formed by environments such as apprenticeship, technical school, university, work, and of course also by organizations. Nowhere in this regard is the cultural influence of professions as easily detectable as in studying the medieval guild system (Mackie 1988; Wagner 1867). Looking at the three frameworks set by Hofstede (2005), Riley / Clare-Brown (2001), and Woodward (1965) we evaluate the professional culture of civil engineers and mechanical engineers. These cultures are as distinctively different as are their organizations, their management, and their technology. Cultural change is not possible without change in these respective environments.

Keywords Culture, Professional Culture, Construction, Manufacturing Industry

1. INTRODUCTION

Schein (1985, 6) has given a definition of organizational culture that is as well applicable to professional culture: "The pattern of basic assumptions that a given group has invented, discovered, or developed in learning to cope with its problems of external adaptation and internal integration, and that have worked well enough to be considered valid, and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to these problems." Outside and inside pressures form a professional culture in a similar way to an organizational culture. There are, however, different forces at work coining either a professional or an organizational culture. The two cultures that we are comparing are the construction and the manufacturing culture represented by an automobile producing company. We are using the words professional and industry culture as synonyms.

Technology and culture

Production in construction has often been described as project based unit production, contract production, and on-site production. Manufacturing is inversely characterized by mass production, stock production, and factory production (Barrie / Paulson 1992). Comparing this with the different technologies proposed by Woodward (1965), construction belongs to group I/II: unit production of technically complex units one by one. Manufacturing of consumer goods would be part of group II/VII: mass production. The ensuing industry cultures are given in table 1.

For the construction industry we would therefore expect an organic structure with flat hierarchies, a medium span of control, little administration, little formalization, and little centralization, all tied together by a high degree of verbal communication. The organizational dimensions of manufacturing industries are just the opposite and making the two industries an ideal pair for comparison.

Organizational Dimension	Unit Production	Mass Production
Levels of management	3	4
Span of control	23	48
Administrative ratio	low	medium
Formalization of written communication	low	high
Centralization	low	high
Verbal communication	high	low
Overall structure	organic	mechanistic

Table 1: Technology and organization (Woodward 1965)

Industry and culture

Riley / Clare-Brown have found that different manufacturing industries show similar cultures (2001), yet this group does not include continuous process production as in the chemical or oil industries (group III in Woodward's typology).

Results of the research by Riley /Clare-Brown (2001) are given in table 2. The authors found differences between an automobile manufacturer and a brewery to be negligible. However there are five categories with significant differences between a construction company and the group of the two manufacturing companies.

Organizational Dim.	Construction	Manufacturing
Culture	- not well defined - two cultures: headquarter vs. projects - company philosophy is not known on project level	- well defined - more innovative values - company philosophy is well known
Communication	- the voice of each employee is valued	- employees have no voice
Technology	- technically not very innovative	- technically more innovative
New products/processes	- little awareness	- high awareness
Structure	- steep hierarchy - not well known to everybody	- flat hierarchy

Table 2: Technology and organization (Riley / Clare-Brown 2001)

There is one remarkable difference between the two tables: one predicts a flat, the other one found a steep hierarchy in construction. It seems that this can be tied to the questionnaire used by Riley/Clare-Brown. They add the hierarchy on the project level with all subcontractors to that of the headquarter. Their description is not convincing at this point. There is little further research on comparative studies between industry cultures including the construction industry. Riley/Clare-Brown do not list a single source.

Dimensions of industry culture

A third framework for evaluating industry culture was proposed by Hofstede (2005). He uses four pairs of opposites: process vs. result orientation, organizational vs. professional culture, weak vs. strong control, normative vs. pragmatic approach. We assume, as a hypothesis that the construction industry has a result orientation with strong controls, is professional and pragmatic. The meanings and connotation of these labels are given in table 3. We feel that "strong controls" is an unfortunate choice of wording, yet the meaning ascribed by Hofstede to this label is understandable.

Cultural Dimension	1	2
(1) Process vs. (2) result orientation	- means oriented - risk avoidance - limited personal input - repetitive tasks	- goals oriented - risk acceptance - high personal input - changing tasks
(1) Organizational vs. (2) professional	- norms of the organization are universal - identity is provided by organization - family life is important - personally short term orientation	- private life and business life are separate - task competence is important - personally long term orientation
(1) Weak vs. (2) strong control	- costs are unimportant - meetings do not commence on time - many jokes about the company and work	- cost oriented - meetings are on time - few jokes about the company and work
(1) Normative vs. (2) pragmatic	- keeping the rules - keeping the procedures - dogmatic view of ethics	- customer orientation - result is more important than procedures - pragmatic view of ethics

Table 3: Dimensions of industry cultures (Hofstede 2003)

We will use these described three frameworks (Woodward, Riley/Clare-Brown, Hofstede) to evaluate the results of our independently conducted research. They provide the hypotheses against which our research is evaluated. It needs to be stressed that we only looked at the theory after obtaining and interpreting our data. This is a standard procedure when using grounded theory (cf. methodology) to gather and evaluate data. It serves the purpose not to "contaminate" the data analysis by preconceived ideas.

Hofstede makes an additional important point when illustrating that there is a change in emphasis when comparing national, industry and organizational culture: the shift is from values to practices (cf. fig. 1). An industry culture shows accordingly an equally weighted set of values and practices. When comparing the construction with the manufacturing industry, we are looking for differences in values and practices.

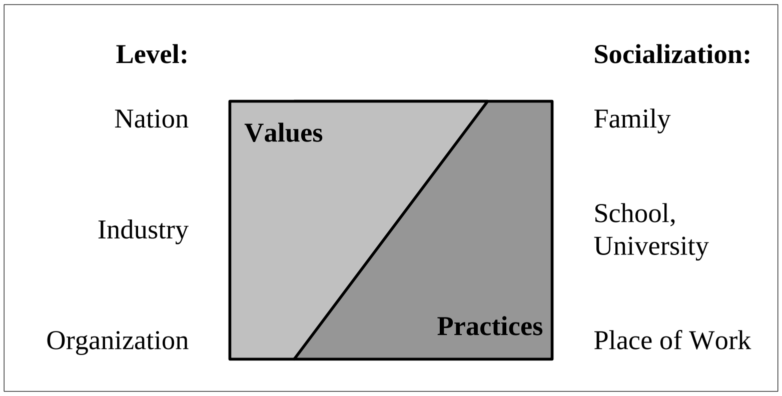

Fig. 1: Values and Practices at Different Levels of Culture

External environments
If culture is the "software of the mind", then the environment is the programmer. How different are the environments in the construction and the automobile industry? This can be organized into two lines: input criteria and process criteria.

The inputs are labor, materials, and plant. For Germany the percentage of the total cost are 58% (construction) vs. 19% (automobile) for labor costs, 26% (construction) vs. 67% (automobile) for material costs, and 2% (construction) vs. 4% (automobile) for plant depreciation (Dstatis 2004). The remainders are other costs. In sum, construction is by this comparison three times as labor-intensive, 0.4 times as material-intensive, and 0.5 times as plant-intensive as the automobile industry.

The different process criteria are: site construction vs. assembly line production, mechanized vs. automated construction, discontinuous vs. continuous production, unit vs. mass production.

It is evident that many of these criteria form the basis for the framework of Woodward, but they also have an influence in the other two.

2. METHODOLGY

We have conducted ten interviews in the construction industry and ten in the automobile industry. The construction companies were either mid-size companies in Bremen or subsidiaries of large-size companies in Germany. These produce the full range of construction projects: residential, building, industrial and heavy civil construction. The automobile company is one of the well-known German high-class automobile producers. In Bremen they assemble sports cars.

The hierarchical rank of the interviewees were as follows: two branch managers (construction) and three division heads (automobile); five construction managers and four team managers (automobile); three specialists (both in construction and automobile). Since we compare large to mid-size construction companies with a global automobile producer we have taken the different organizational hierarchies into account and allowed for a shift in rank to arrive at the pairs above.

The interviews were partially structured. The answers have been evaluated statistically where possible, otherwise by using grounded theory.

A word is required at this place concerning the German university system. Civil engineers work in the construction industry, mechanical engineers in the automobile industry. Construction engineering management (CEM) is taught as a part of civil engineering programs, not separately. Everybody shares in the same basics and specializes later in some areas. The same holds true in a different context for mechanical engineers. The label “civil engineer” includes CEM, “mechanical engineer” automobile design and manufacturing. Many engineers have gone through an apprenticeship before entering into the universities. In our sample this holds true for six interviewees in civil and four in mechanical engineering.

3. RESULTS

The results are presented in two parts, first quantitative and then qualitative results.

Quantitative results
The first set of questions pertained to the characteristics of civil or mechanical engineers (Question 1: What characteristics should a civil/mechanical engineer typically have? Question 2: What characteristics apply to you?). There was a list of possible answers in four categories:

- way of thinking (rational, innovative, flexible, analytical)
- behavior (considerate, polite, direct, firm)
- interaction (team-oriented, open for conflicts, communicative, fair)
- purposefulness (motivated, consistent, committed, ambitious)

The results are given in table 4. The respondents were asked to choose five characteristics out of the set of 16, and to weigh these from high (5) to low (1). Since there were ten respondents in each group, a maximum value of 50 (5x10) could be reached in theory.

The data obtained by these questions are about values not practices. Civil and mechanical engineers are different with regard to their values. There is quite a variance between the idea how things should be (question 1) and how they are (question 2). This is definitely more pronounced for mechanical than civil engineers. The sum of all deviations is (22 + 8 + 28 + 4 = 62) for civil and (46 + 8 + 38 + 5 = 97) for mechanical engineers. Civil engineers perceive themselves to be markedly closer to their ideal.

Most important for engineers are: Analytical thinking (36), innovativeness (23), team orientation (19), and commitment (17). The order for mechanical engineers is: Analytical thinking (44), innovativeness (27), and rationality (16). Most of these characteristics belong to the group “way of thinking”

Behavior does not play a role for either of the two groups.

Interaction is important and civil and mechanical engineers have a “better” view of themselves compared to the norm. They are more team-oriented (+5/+21), more communicative (+19/+4), and fairer (+3/+12).

Purposefulness is also important with commitment being in the top spot for both groups. In this part there are the smallest deviations between ideal and actual perceptions.

Most predominant in the perception of actual values of civil engineers are: Analytical thinking (34), team orientation (24), communication (21) and commitment (17). For mechanical engineers the order is: Analytical thinking (35), team orientation (31), fairness (12), and communication (11). While civil and mechanical engineers have quite a few values in common, there are also differences.

The biggest differences are that civil engineers see themselves as more communicative (+10), more flexible (+9), not as fair (-9), less team-oriented (-7), more engaged (+7), more motivated (+6), and less consistent (-5).

Category	Civil Engineers		Mechanical Engineers	
	Question 1 (others)	Question 2 (self)	Question 1 (others)	Question 2 (self)
Way of Thinking				
Rational	8	2	16	2
Innovative	23	9	27	7
Flexible	13	13	1	4
Analytical	36	34	44	35
Behavior				
Considerate	0	5	5	8
Polite	0	0	0	2
Direct	0	1	0	0
Firm	2	0	6	3
Interaction				
Team-oriented	19	24	10	31
Open for Conflicts	7	8	6	7
Communicative	2	21	7	11
Fair	0	3	0	12
Purposefulness				
Motivated	8	10	4	4
Consistent	6	5	7	10
Committed	17	17	10	10
Ambitious	4	3	1	3

Table 4: Evaluation of Characteristics for Civil and Mechanical Engineers

The data of table 4 are presented in the following two bar charts. The first one (fig. 2) depicts the comparative results for the perceived ideal characteristics (question 1). The second (fig. 3) illustrates the results of the perceived actual values (question 2). The differences between the two groups of engineers are evident. The graphs include only values of 10 or higher for either of the two groups.

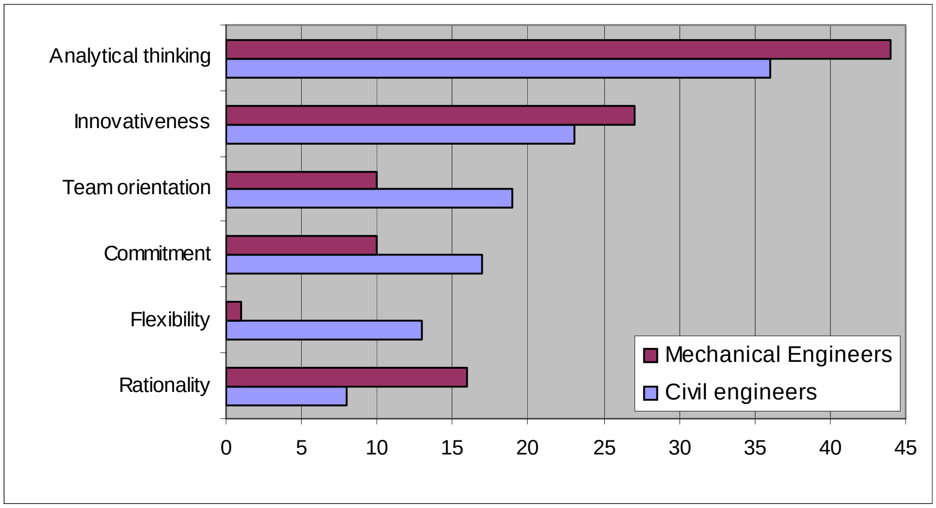

Fig. 2: Ideal Characteristics of Civil and Mechanical Engineers

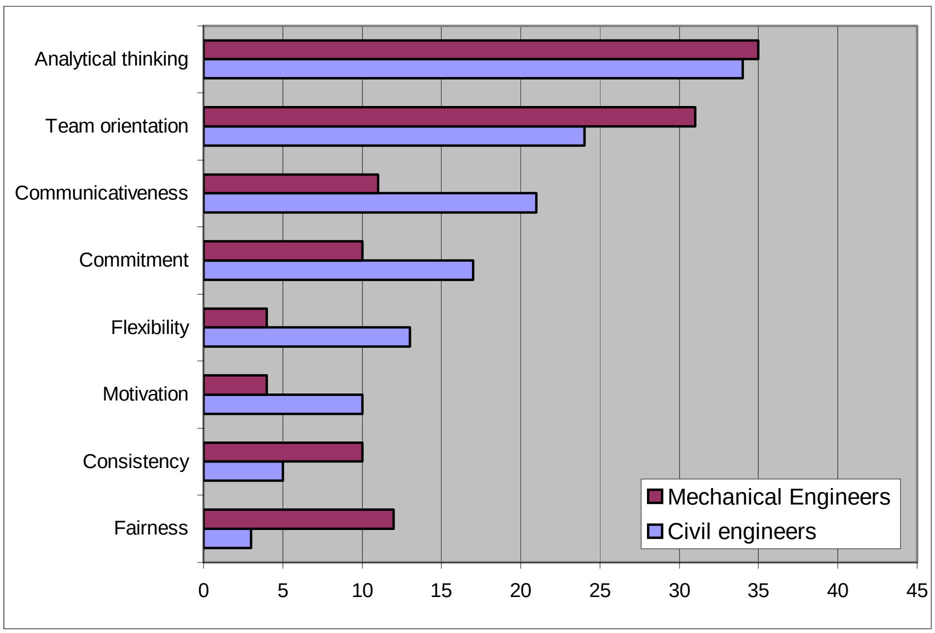

Fig. 3: Perceived Actual Characteristics of Civil and Mechanical Engineers

Qualitative results

- Ethics are deemed to be important to both groups of engineers. Yet civil engineers see a close connection between ethical behavior and the attainment of career goals.
- Identification: Mechanical engineers identify themselves strongly with their company, civil engineers identify themselves strongly with their work as civil engineers, i.e. their industry.
- Motivation: Most motivating for civil engineers is a good place of work. Both groups thrive with the idea that they add value with their own work. Civil engineers hate administrative tasks, mechanical engineers leadership problems.
- Hierarchy: There is a stronger hierarchy felt by mechanical engineers. They make often use of the slogans of their company.
- Satisfaction: Important for the satisfaction is for both groups constructive teamwork and a well functioning organization.

- Uncertainty: Both groups do not enjoy living with uncertainty.
- Controls: The upper echelons in the automobile industry see controls as positive, all the other engineers as negative.
- Job descriptions: They are prevalent for mechanical engineers, non-existent for civil engineers.
- Culture: Mechanical engineers define this as the way they deal with each other, i.e. as their company culture. Civil engineers think of music or art, i.e. they do not have such a concept.

While the quantitative data have provided insights into the differences in values, the qualitative ones provide mostly explanations for different practices.

4. EVALUATION OF RESULTS

First and most important of all, our data reconfirms strongly that there are significant cultural differences between the construction and the manufacturing industries, both in values and practices. Based on the previously given definition by Schein (and in accordance with the overall discussion on culture) we tie these differences to two distinct external and internal environments.

- Woodward: The data confirm the observations by Woodward with regard to structure of the organization. Since we were not looking specifically at structure, not all points were touched, however. The fewer levels of management (a flatter hierarchy), less formalization, less decentralization, the importance of verbal communication, and a more organic structure could be validated for the construction industry.
- Riley / Clare-Brown: Their observations are only partially proven correct: The culture in construction companies is less defined; the company philosophy is little known, verbal communication is very important. A sharp difference can be found for the levels of hierarchy. The statement that construction companies have a steeper hierarchy than automobile manufacturers is not corroborated. Riley / Clare-Brown make according to their paper the mistake to compare a multi-organizational construction project with an automobile company. While it is understandable that the multi-organizational project indeed has a steeper hierarchy (if following the line of command from the project to the head of the construction company), this does not hold true for the construction company. In addition there are scant differences with regard to innovativeness in our data. Civil engineers place the normative value a little lower (23 vs. 27), yet the actual value higher (9 vs. 7) than mechanical engineers. Striking here is the disparity between norm and actual value. It is significantly higher for the automobile industry (20) than for the construction industry (14). There seems to be a lot more talk about innovativeness in both industries than fact, much more so in the automobile industry. An explanation can be found in the structures of the automobile industry. There are design departments responsible for an innovative product. Everybody identifies with this product, but the engineers in production are not asked for further innovation but for controlled quality.
- Hofstede: Again, having conducted a partially structured interview, we have not obtained data to all the dimensions given by Hofstede. The ones we have fit well into his framework and let us conclude that construction companies have a result orientation, are professional with "strong controls" and a pragmatic approach.

> Automobile companies have a process orientation, are organizational with "strong controls" and a normative outlook.

This evaluation is based on the dichotomy high personal input, changing tasks (construction) vs. limited personal input, repetitive tasks (automobile) for process or result orientation. The mechanical engineers accepted the norms of their organization and identified with it (organizational culture), civil engineers do neither but they identify with their work (professional culture). Both groups stress adding value with their work, which signifies what Hofstede calls "strong controls". In the automobile industry keeping the rules (job descriptions) and a dogmatic view of ethics are prevalent (normative culture), in the construction industry ethics are pragmatically treated as a way to advancement (pragmatic culture). Overall our hypothesis of culture in construction has been validated.

5. CONCLUSION

Dealing with external and internal pressures, engineers in construction and automobile companies have developed different cultures. This fact shows up when comparing the values and practices of the two groups. The differences in the environments and cultures are summarized in table 5.

Construction industry	Automobile industry
Environment	
Higher labor intensity	Lower labor intensity
Lower material intensity	Higher material intensity
Lower plant intensity	Higher plant intensity
Site production	Assembly line production
Mechanized production	Automated production
Discontinuous production	Continuous production
Unit production	Mass production
Structure	
Fewer levels of management	More levels of management
Not formalized	Formalized
Decentralized	Centralized
Much verbal communication	Little verbal communication
Organic structure	Mechanistic structure
Culture	
Not well defined	Well defined
Highly communicative	Little communication
Result oriented	Process oriented
Professional	Organizational
Pragmatic	Normative

Table 5: Differences in environment and culture between construction and automobile industries

The purpose of the paper is to be a starting point for further research. While it gives strong indications of different cultural values of civil and mechanical engineers, its base is too small. If these cultural differences are accepted, we would need research on the implications for projects where both groups work together, such as in the oil industry.

The data are gathered for both groups from German companies. The companies are located in the same city and interviewees hold comparative ranks within their respective organizations. More important, the data are mostly conclusive with previous research. Where this does not apply, we found good alternatives as explanation.

In a joint endeavor by the CIB task group data are collected around the world describing the construction industry. The instrument used is the OCAI-questionnaire by Cameron / Quinn (2005). It would be interesting to see, if our results could be confirmed when using this questionnaire within the automobile industry.

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THE CODE OF CONDUCT: A CONTRACTOR'S PERCEPTION

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ABSTRACT

The paper discusses issues relating to unethical conduct and the role of a code of conduct in aligning business and professional conduct in the construction industry. It reports findings of a study carried out in Botswana to gauge the perception of contractors regarding the two issues. Firstly, whether they perceived prevalence in unethical behavior in the industry and secondly, whether they perceived the newly promulgated code of conduct as being effective in combating unethical conduct. The results were affirmative for the first question and a negative for the second question. Plausible explanations to the observations are also offered.

Keywords: Ethics, Code of conduct, Construction industry, Procurement, Botswana

1. INTRODUCTION

In order to create fairness, accountability and transparency for any business transaction, regulations are necessary, particularly in a competitive environment. These attributes may be achieved through various mechanisms of compliancy. These may manifest as statutory instruments and codes of conduct. The latter are normally promulgated for observance by associating members of professional or trade associations. They provide members with behavioural norms, or ethics, expected when taking actions and making decisions relating to business transactions.

In the construction industry (CI), a three tier types of codes of conduct may be construed to exist namely, enterprise codes, professional codes (e.g. for engineers, architects and quantity surveyor) and trade organizations or industry based (e.g. for suppliers) codes. The latter is the subject of discussion of the paper.

In 2006, the Public Procurement and Asset Disposal Board (PPADB) of Botswana promulgated a set of codes of conduct (referred here after as the Code). The Code is to be observed while carrying out any transactions relating to the procurement and disposal (here after referred to as tendering) of public assets by suppliers (PPADB, 2006). PPADB suppliers are enterprises or individuals who provide services, supplies and works (the latter shall be referred to here as contractors) to the central government and parastatals.

The paper reports findings of an exploratory study carried out to investigate the perception of contractors on issues relating to ethics industry and how they perceive the effectiveness of the Code in combating unethical behaviour. In pursuit of that objective, the paper provides a brief background on the ethical position of the construction industry (CI) in Botswana and the role of the PPADB. The subsequent section of the paper provides an overview of the methodology used to investigate the problem, a presentation of the results and a discussion of the findings. The paper ends with some conclusions and recommendations.

2. CODE OF CONDUCT

Code of conduct in general

Transparency International (TI) adjudged the construction industry as the most corrupt sector of most economies (TI, 2002). The corruption cases of the CEO of Lesotho Highlands Water Project (Reina, 2003) and the collusion of the Dutch contractors (Priemus, 2004), are examples of the vulnerability of ethics in the industry.

Over the years, there have been signs of increasing malpractices in the constriction industry in Botswana, ranging from media reports (e.g. Daily News, 2004), to commissions of inquiries (e.g. Republic of Botswana, 1991) and court cases (Republic of Botswana, 1995 and 2002)). Such an onslaught of an unethical and unacceptable behaviour warranted fighting the scourge from all angles, including providing players in the industry with the Code on which to judge their conduct.

The role of codes of conduct is defined by various authorities in many different ways. The code of conduct is a broad framework within which an action, or inaction, by those engaged on a business transaction are judged (CIDB, 2000). Action or inaction which is in conflict with the code or which is illegal by law constitutes a malpractice that is not acceptable in contemporary business environment (Ssegawa, 2005).

The Australian Procurement and Construction Council (APCC), for example, provides typical pillars of a code of conduct namely conformance to national principles, competitive behaviour, continuous improvement and best practice and security of payment for sub-contractors and suppliers (APCC, 2005). Similarly the Construction Industry Development Board (CIBD) of South Africa, through its code of conduct, provides key elements of corporate governance namely; discipline, transparency, independence (objectivity), accountability, responsibility, fairness and social responsibility. In particular, the CIDB Code makes the assertion that parties in any public procurement should in their dealings with each other and insofar as relevant, in the interest of public at large, should (i) discharge their duties and obligations timeously and with integrity; (ii) behave equitably, honestly and transparently; (iii) comply with all applicable legislation and associated regulations and treasury instructions; (iv) act so as not to prejudice the interests of, or damage the reputation of, another party without good cause and (v) satisfy all relevant obligations and responsibilities established in the procurement documents.

PPADB Code

The idea of a code of conduct is not new in the world and even in Botswana. However, what is new is that for the first time, there is a code of conduct that embraces a heterogeneous group of players associated with PPADB. While there are several professional (e.g. architects, quantity and land surveyors and engineers) and various contractor associations in the country, there is no mechanism which requires mandatory membership and hence a compulsory adherence to any code of conduct. It is clear why an all embracing code of conduct is necessary in the Botswana industry.

The Code has several aspects it addresses the major ones being: the need for honest and ethical behaviour; avoidance of conflict of interest; avoidance of any consideration (e.g. bribes, gifts, kickbacks and other benefits) for action or inaction; acceptance of competition and fair dealing; avoidance of collusion and accepting fair dealing; need for professional conduct and integrity; provision of accurate and timeuos disclosure of information and documentation; compliance with the law; and prompt reporting of any violation of the code or law by any entity registered with PPADB (PPADB, 2006).

It is against this background that the research problem was premised and the next section describes the methodology used in the investigation.

3. QUESTIONNAIRE SURVEY OF CONTRACTORS' PERCEPTIONS

Questionnaire design

The investigation into perceptions of contractors regarding unethical behaviour and the effectiveness of the Code was guided by two research questions namely:

- *What is the contractors' perception regarding the prevalence of unethical conduct in the construction industry in Botswana?*
- *What is the contractors' perception regarding the effectiveness of the Code in combating unethical behaviour?*

Perception was construed to mean experiences contractors have encountered while transacting business in the industry or transactions incidental to their business outside the industry. In addition, perceptions was considered to arise from what contractors other say and thus deduced to be happening by piecing the information together. The latter is important to appreciate and not to be dismissed as unscientific as most unethical behaviour is most often concealed (Ssegawa, 2005).

In view of the above a measuring instrument was designed in form of a questionnaire to investigate the two issues. The questionnaire contained a mix of structured and open ended measuring questions probing the two research themes (Blumberg *et al.*, 2005).

For the structured questions, a Likert scale of (1 to 5) was used, where respondents indicated the strength of a measured property (Kaming *et al*., 1997). A relative importance index (RII) was constructed in accordance with the formula given in Equation 1.

$$RII = \frac{5n_1 + 4n_2 + 3n_3 + 2n_4 + 1n_5}{5N} \qquad \text{Equation 1}$$

where, for example, n_1 are the number of respondents for ' 1= very significant', n_5 are the number of respondents for '5= not at all significant' and N being the total number of responses for each question . The RII scores provided a means of ranking of items that respondents considered most important or significant, with the highest score of 1.00 indicating total agreement or high importance of the item.

Open-ended questions allowed respondents to freely express themselves and include additional dimensions that may not have been captured in the structured questions.

The conduct of the survey

The study group was identified as contractors registered with PPADB, whose head office is located in Gaborone and in classes other than OC (i.e. A, B, C, D and E). Further screening was based on ability to participate in the study. Finally, a total of sixty contractors were selected, twelve from each of the five classes of contractors.

The reason for screening of contractors in the manner mentioned was three fold. This being an exploratory study, systematic sampling was not considered very important (Leedy, 2005). Thus, conveniently, the number was set to a limit of sixty contractors. In addition, only Gaborone City based contractors were selected for easy distribution of the questionnaire using the drop-and-collect strategy which according to Ibeh and Brock (2004), provides a higher response rate. The OC class was excluded from the study because of the difficulty in tracing the physical addresses of contractors in this category (Ssentongo, 2005).

The next section discusses the results of the investigation relating to the two research questions.

4. QUESTIONNAIRE RESPONSE AND FINDINGS

Response rate

A response rate of 60% (36 out of 60) was achieved, distributed in the classes as shown in Table 1.

Table 1 Response rate

Class of contractor	A	B	C	D	E	Total
No.	8	6	6	4	12	36
Ratio	22%	17%	17%	11%	33%	100%

Despite agreeing to participate in the study and repeated reminders, some of contractors (24) did not complete and return the questionnaire. The unequal distribution of enterprises in each class (e.g. there were 12 responses from class E as opposed to 4 from class D), thus led to no attempt in finding the differences in perceptions arising from the different classes of contractors.

Perception of unethical conduct

The first question required contractors to provide their opinion on how they perceived the level of prevalence of unethical conduct in the industry. A number of items were identified from literature and the Code as constituting unethical conduct as given in Table 2.

Table 2 Contractor perception of some of the typical unethical behaviour*

Q1 How often have you encountered the following unethical behaviour while doing business in the industry?		
Unethical behaviour being probed	RII Score	Rank
Provision of inducements for action or inaction	0.80	1
Fronting	0.76	2
Fraud or misrepresentation of facts, documents, etc	0.74	3
Collusion	0.65	4
Undue influence	0.55	5
Racketeering	0.54	6
Nepotism and favouritism	0.49	7
Malicious allegation against competitors	0.46	8
Pollution of the environment	0.37	9
Tax evasion	0.20	10

*Source: Ssegawa (2005) and PPADB (2006)

The results showed that the provision of inducements, fronting and fraud are the most common form of unethical behaviour from the point of view of the contractors. The results may partly be explained by the following situations. Competition has increased over the past periods, not only by more local individuals venturing into construction but with more foreign firms coming to operate into the country. Secondly, at the time of conducting the study, the industry was experiencing a serious down-turn where contractors were bound to use whatever means to get the only few available jobs in the market. Thirdly, the issue of fronting has escalated in the industry in the past few years, partly due to the introduction of the preference schemes directed at favouring citizen-owned companies during tendering. This has created an artificial barrier in the market that some contractors on both sides have exploited. In essence, fronting involves contractors obtaining jobs reserved for citizen-owned firms and then 'selling' them off for a fee to non-citizen owned firms.

The last three ranked unethical conduct related to malicious allegation against competitors, environmental pollution and tax evasion. The findings show that the industry has not degenerated to the extent of competitors engaging in malicious acts against each other. The last two issues were not considered as significant in the industry either because it is true or perhaps due of the lack of awareness of nature of importance of these issues (Ssegawa, 1999). Some contractors believe that there is someone else to cater for the protection and cleaning of the environment, for example, one contractor mentioned as that the City Council is responsible for collecting garbage including construction debris. Their attitude becomes more entrenched in a situation where there is lack of effective environmental policing. Tax has been seen as business burden, with most contractors finding means of avoiding it and ultimately evading it (an unethical behaviour). This has been reinforced by the fact that in past the government derived its revenues from diamond revenues and thus there was laxity in the tax assessment and collection processes. Thus the contractors do not perceive it as a very serious unethical problem.

The second question requested contractors to describe the overall state of unethical conduct in the industry using a scale of 1 –'very low' to 5- 'very high' and the results are shown in Table 3.

Table 3 Contractors overall perception of level of unethical behaviour in the industry

Question	Score
Q2 How do you describe the overall level of unethical conduct in the industry?	3.2

A mean score of 3.2 was obtained indicating that the contractors perceived the ethical conduct below an acceptable level, if the middle score is 2.5. This perception is a serious indicator confirming the need for the timely introduction of the Code.

The third question, requested contractors to indicate the areas where they often encounter unethical behaviour in construction including activities incidental to construction operations but excluding the design process. Table 4 summarises their responses and the ranking arising thereof.

Table 4: Contractor perception of project phase susceptible to unethical behaviour

Q3 Which phase of the project delivery (excluding design) have you <u>often</u> encountered unethical conduct?

Phase of the project delivery susceptible to unethical behaviour	Score	Rank
Technical evaluation of tenders	0.86	1
Issuance of permits and licences (e.g. work, building, vehicle permits, etc)	0.81	2
Requests for extension of time	0.70	3
Claims requests, assessments and award	0.69	4
Tender adjudication	0.67	5
Valuations	0.61	6
Payments processing	0.57	7
Certification for completion of a project	0.51	8
Compilation of final account.	0.50	9
Refusal of payment by main contractor	0.36	10
Tax returns (VAT and corporate tax)	0.35	11
Resolution to disputes	0.25	12

Tender evaluation came on top of the ranking followed by issuance of various types of permits and licences. Some contractors indicated that technical evaluations are easy to manipulate if the evaluator wants to favour a particular contractor. Providing reinforcement to this position was a comment from one of the respondents who said that '…otherwise how can an evaluator have the confidence of telling a particular contractor, most likely a friend, that they have won a tender before it is adjudicated...' The latitude for manipulation of evaluation and adjudication data for the two processes may explain why contractors scored the tender evaluation with a higher score than adjudication. Also, noted was the fact that eight of the twelve items scored above 0.5 (50%) indicating that the contractors perceived frequent incidents of unethical behaviour in the various areas of project delivery.

The next section discusses the findings relating to the effectiveness of the Code.

Awareness and effectiveness of the Code

Several questions probed contractors to state their awareness of the Code, its contents and whether they perceive it as an effective tool in restraining participants in the industry from pursuing unethical behaviour. In this section the questions required respondents to provide a simple ‘Yes’ or ‘NO’ answer. Table 5 summarises the awareness questions.

Table 5 Extent of awareness of the Code

Question	Yes	No
Q4 Are you aware of Code?	56%	44%
Q5 If you are aware of the Code, was it through PPADB’s efforts?	60%	40%
Q6 Q5 If you are aware of the Code, have you read its contents?	88%	12%
Q7 Does your company have a code of conduct or a set of value statements?	67%	33%

A simple majority (56%) of contractors interviewed were aware of the code. In addition, only 60% knew the Code from PPADB’s effort. PPADB used seminars, media and letters to associations to introduce and seek input to the Code. This finding highlights a communications problem between PPADB and the industry. However, discussions with officers of PPADB revealed that in most of the workshops organised very few contractors turn up. This also reinforces the observation made by a number of scholars (e.g. Upson, 1987 and Adrian, 1986) that contractors rarely attend to any other matters, like seminars, which are not directly connected to construction work.

Furthermore, the contractors who indicated that they were aware of the Code were asked if they read the various sections of the Code. Majority (87%) indicated that they are not familiar with the contents. This also raises eye brows as to the anticipated effect of the Code on the PPADB clients. Another question sought to find out whether indeed ‘charity begins at home’ by requesting contractors to indicate whether they have any company codes of conduct or a set of value statements. Majority (67%) did not have such statements. However, a few commented that some of the employees are members of professional bodies which have codes of conduct (a good number of professionals in Botswana belong to various foreign professional bodies in South Africa, UK, Australia and USA). Others were more generous in their expectations by commenting that ‘employees know what ethical or professional conduct is and should act as such’. These comments depict the frailty of the issue of ethical conduct in the industry.

The last set of questions probed the perception of the level of effectiveness of the Code in combating unethical behaviour. A mean score was calculated based on the responses (5-‘strongly agree’ and 1-‘strongly disagree’) with a score of 3.0 (out of 5) being considered significant for an item. The results are shown in Table 5.

Table 5 Anticipated effectiveness of the Code

Question	Mean score (max 5)
Q8 Will the Code provide contractors a yardstick to guide ethical behaviour?	3.77
Q9 Will the Code raise the ethical level of contractors?	2.22
Q10 Will the PPADB be effective in monitoring the Code (and unethical behaviour)?	2.28
Q11 Will the contractors report parties violating the Code?	2.28

The results showed an interesting pattern. While contractors agreed, as judged by the high score of 3.77, that the Code will provide guidelines for ethical behaviour, they were sceptical as to whether it will raise the ethical level in the industry. They also doubted PPADB's capacity to monitor unethical conduct in the industry. This falls in the usual dictum that promulgation of a law does not necessary provide the effectiveness in combating the intended crime or malpractice unless a more holistic approach is taken. The last question probed the contractors to state what would be their reaction to knowing that another person or entity is unethical in their conduct. The low score indicated a high unwillingness to expose unethical behaviour and to which some added that 'only if it affects them'.

5. CONCLUSION AND RECOMMENDATIONS

Conclusions

A code of conduct is a yardstick on which unethical behaviour may be judged. It is an essential ingredient in shaping conduct of participants in a competitive environment so that transparency, fairness and accountability can be achieved in order to foster confidence in the stakeholders of the industry and the public, particularly tax payers.

The study revealed that there is some level of unethical behaviour in the industry and identified the areas where it is most prevalent. This underpinned the necessity to promulgate the Code. However, the study has also shown that in order the Code to be effective, further strategies and tactics need to be adopted to increase awareness, acceptance and to monitor and investigate any incidents of violation of the Code. In addition, some form of sanctions for violators should also be formulated and made part of the Code.

Recommendations

Thus PPADB needs a three prolonged attack to make the Code effective. First, is the provision of education on ethical issues and making contractors aware of the Code and its expectations? Secondly, to send a strong signal that it will investigate violators and thirdly that sanctions will be lashed out to violators. The aspect of sanctions (e.g. blacklisting, fines, etc.) is missing in the entire Code.

The study being an exploratory study requires a more detailed analysis of the unethical issue covering a more representative sample of contractors and also to include the perceptions of consultants. Secondly, it would be opportune to conduct the study when the Code has been in operation for more than two or three years in operation and evaluate its effectiveness.

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A CORRELATION BETWEEN KNOWLEDGE MANAGEMENT IN SMALL-TO-MEDIUM ENTERPRISES WITHIN THE CONSTRUCTION INDUSTRY AND WORKFORCE DIVERSITY MANAGEMENT.

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ABSTRACT

A rapid changing environment driven by globalisation, knowledge-based economy coupled by fast development of information, communication and technology collectively posses many challenges and equally opportunities to Small-Medium Enterprises (SMEs) within the construction sector. Large construction organisations are seen to be in a better position to undertake initiatives to adopt new management tools, techniques and philosophies from a process, product and people perspective. SMEs however, seem to be lacking behind with this regard due to their lack of resources. This in turn may have a negative impact on knowledge management and thus organisational performance. A number of large organisations have recognised the importance of managing their workforce diversity in a more structured manner. Managing workforce diversity is more than ever seen as an effective tool for retaining the best people regardless of their differences and similarities. It is therefore argued to be an important management tool with direct relevance to managing organisational knowledge. This argument is based on many research findings including the wealth of diverse information such workforce might potentially carry within it. The findings of this paper presents the argument that SME organisations are in a position to potentially associate managing their diverse workforce effectively with retaining a wealth of information and the benefits of this on the organisational performance.

Keywords: knowledge management, Learning, Small Medium Enterprise (SME), Diversity

1. INTRODUCTION

Continuous learning in the construction industry is known to be inhibited because of the culture of the construction work being project-based, short term and task oriented in addition to the high turnover rates in the labour force. The high labour turnover rate arguably means that organisations specialists and their technical knowledge are lost from one project to the next and therefore organisations become unable to retain specific expertise and develop knowledge and generate new ideas. The construction industry is essentially an information processing industry (Aish, 1999); where most knowledge comes from the successful completion of projects (Conheeney et al, 2000). It is therefore necessary to capture, transfer and reuse project knowledge and use lessons learned from previous projects to improve project performance. The reliance on project participants to share knowledge in order to succeed in project delivery has never been greater (Walton et al., 2002). In addition, bearing in mind that knowledge resides in people's minds and are represented in their skills as well as in various technological equipment and filing cabinets, it is possible to appreciate the loss of information caused by loss of skilled individuals. Thus, the need for Knowledge Management (KM) in the construction industry is not to be separated from the need for a good strategic workforce Diversity Management (DM) in order to motivate efficiency, creativity, innovation and employee satisfaction, thus improved business performance.

Reasons behind this high labour turnover are many but one has been closely attached to SME organisations lacking the ability to manage the diversity of their workforce appropriately. Based on the US experience (e.g.O'Reilly, 1997; Orlando, 2000) and others, many researchers in the UK and Europe believe that managing diversity in the workplace will prove profitable by retaining and developing knowledge (Egbu & Botterill, 2002), in which case it is in the companies own interest to support it (e.g. Sanglin-Grant, 2003). With the large plethora of knowledge management tools and solutions on the market, they seem to be targeted and at very large multinational organisations, with little at the small medium enterprises (SMEs); and even less at construction related organisations. However, with over 99% of the construction industry in the UK made up of SMEs, these organisations are in need of knowledge management just as much as large enterprises in order to remain competitive.

2. THE MEANING OF 'DIVERSITY'

The term diversity often provokes intense emotional reactions from people who perhaps, have come to associate the word with ideas such as '*Affirmative Action*', '*Equal Employment Opportunity*' and *'Positive Action'*; yet it is a word that simply means *'variety'*, *'heterogeneity'* or a *'point or respect in which things differ'*. *Diversity* in the English Oxford dictionary is the noun of diverseness meaning; variety, assortment, mixture, range, multiplicity, heterogeneity, unlikeness, dissimilarity and distinctive. Therefore, it could be concluded that, 'Diversity in the Workforce' is a term that includes within its definition the variations between people on various dimensions including: race, ethnicity, gender, disability, education, skills, culture, age, social class, language, personality, nationality belief, left handed, hobbies, political views and many other factors. These dimensions all are believed to contribute largely in making up the individual personal identity and the organisational culture. These significant and non-significant characteristics are viewed, identified and ranked according to how important they are to the individual, and the organisation as a whole.

In recent years, there have been lively worldwide discussions on managing workplace diversity. The related issues were first raised in the US in the 1960s with the introduction of new legislation concerning discrimination on grounds of race, sex, ethnic background and religious faith (Cox, T. & Bake, S. 1991). Affirmative action programmes - equal employment opportunities - were also introduced in the US aimed at groups which traditionally had been disadvantaged and often marginalised. These programmes were criticised in the late 1980s and the early1990s for being all-exclusive, and therefore, not including everyone. Today everyone is talking more about diversity as an all-inclusive management strategy, setting the focus more on the advantages, which are brought to the organisation through diversity rather then only focusing specifically on social aims as was associated with previous programmes.

3. THE IMPORTANCE OF MANAGING WORKFORCE DIVERSITY

Although there have been many references to the changing demography of the workforce, diversity is not new to scholars. In the past 40 years research on the effects of diversity on group process and performance, has been conducted by researchers in many domains. Psychologists, sociologists, anthropologists, economists, communication and education researchers, and organisational scholars have conducted theoretical and field studies examining the effects of diversity on various characteristics on group performance and communication issues (Aronson, et al., 1978). Many researches have argued that diversity, when properly understood and applied, can be beneficial for organisations and ultimately improve performance, also known as *value–in-diversity* hypothesis (Cox, Lobel, & McLeod, 1991), while others have shown strong evidence that diversity is detrimental to group functioning (e.g., Brewer, 1979; Guzzo & Dickson, 1996). Milliken and Martins (1996, p. 403), in their comprehensive review of the diversity literature, concluded that ‘‘diversity appears to be a double-edged sword, increasing the opportunity for creativity as well as the likelihood that group members will be dissatisfied and fail to identify with the group.’’ This is potentially the dilemma organisations face.

In Europe, interest in diversity as a strategy grew during the mid 1990s as the labour market significantly changed and the awareness that immigrants were discriminated against in the market increased (Wise & Fugerlind, 2000). In the UK, the make-up of the workforce is continuously altered as a result of the increasingly diverse workforce placed within supply chain partners or wholly owned subsidiaries or plants in other countries, and through greater mobility of labour choosing to immigrate and settle in the UK (BBC News website, 2002).

Understanding the origin of diversity and its related benefits and challenges has become an essential tool for all organisational behaviour practitioners. With the change of the workforce throughout the world caused by the world economic recessions, globalisation and increased migration, managing diversity is no longer just an option. In addition, since the European Union (EU) aimed to develop a common market for goods and services by eliminating internal trade barriers, developing external trade policies, improving the mobility of labour, technology and capital within its boundaries, and the apparent fact that companies are actually acquiring or merging with one another, giving them operations in a number of countries. Construction organisations in the UK, including the construction sector, as well as others in the EU are therefore inevitably affected by these dynamic changes.

4. DIVERSITY MANAGEMENT AND KNOWLEDGE MANAGEMENT

A combination of workforce demographic trends and increasing globalisation of business has placed the management of similarities and differences amongst the workforce high on the agenda of most corporate leaders worldwide. The workforce in any organisation are, and will be, in generic terms increasingly heterogeneous on dimensions including: race, ethnicity, gender, disability, education, skills, culture, age, social class, language, personality, nationality and many other factors. These dimensions contribute largely to the makeup of the individual's personal identity, his/ her communication skills and hence the organisational culture. Potential benefits of diversity have been found by many researchers to include improved communications and sharing of information leading to better decision making, higher creativity and innovation, greater success in collating and disseminating information, and a better distribution of economic opportunity (Cox and Blake, 1991). Many researchers argue that managing diversity is one paradigm for thinking about difference in organisations. The paradigm's primary underlying value is increased organisational effectiveness and profit. As described by Thomas (1993), developing each individual's potential is a key goal. However from an organisational perspective, diversity is not an individual characteristic; it is the mixture of the different characteristics of all of the organisation's members. Therefore, diversity involves everyone, by decreasing backlash by previously excluded groups and making all members accountable for diversity-related initiatives (Thomas, 1993).

Literature suggests that *valuing* and *managing* diversity is about appreciating and understanding that there are differences among employees and that these differences, if properly managed, are an asset to work being done more efficiently and effectively. Managing diversity means capturing the richness of these experiences and harnessing them for the betterment of employees and the organisation. (Bartz, Hillman, Lehrer & Mayhugh, 1990). The Institute of Personnel and Development (IPD) in the UK in its position paper on managing diversity explained that: 'Managing diversity is based on the concept that people should be valued as individuals for reasons related to business interests, as well as for moral and social reasons (Adapted from The IPD guide on managing diversity, 1999).

Where much construction work is project-based, short term and task oriented, promoting a culture where continuous learning is inhibited, It could be argued that for construction SMEs diversity management could potentially be a vital tool in improving the management of experience and collaboration between individuals. In addition, construction SMEs are well known for being unable to own specialised range of technological competencies as could larger organisations have, and are unable to fund training and education and long term and risky knowledge management programmes. (Egbu, 2001).However, because of their ability to react fast to changing market needs and their informal network and strategy, improved management of diversity could lead to improved communication of knowledge and employee commitment and speed of decision making.

Therefore, since the management of diversity is linked to innovation and rapid individual and hence organisational development it could be argued that by successfully managing diversity the organisation could be potentially successfully managing knowledge. SMEs need to know what their assets are then how to manage it in order to remain competitive. It is well known that knowledge moves from one organisation to another. Therefore, diversity management is not just about knowledge management per se but more about the management of learning from diverse individuals and strategies put in place for sharing information.

5. THE BUSINESS ARGUMENT FOR DIVERSITY

In arguing the business case for diversity it is important to address the reasons behind the appearance of diversity as a concept. As presented in Figure 1, diversity as a concept appeared because of two main reasons: globalisation and the world economic recession experienced in the eighties. These main reasons affected the way business is performed and changed the business objectives of organisations in relation to the market place, customers, and the workforce.

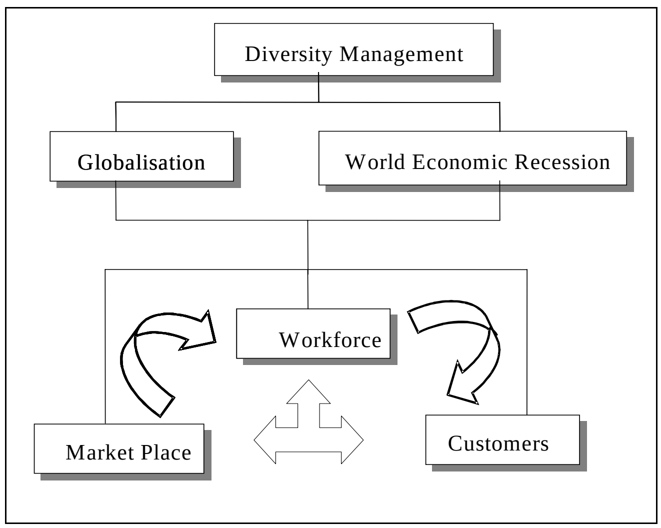

Figure 1. The main reasons behind the appearance of Diversity concept

Globalisation created new customers and the way customers' perceived organisations. The global economy moves labour across national boundaries. New global organisational structures appear, where firms move towards flatter organisational structures featuring groups and teams. The world recession and the continuing development of communications meant that the international market led to more competition then ever before, making distinctive personnel management more and more important. Technology as well as capital goods, seems relatively easy to duplicate on the international market.

Many commentators in business press have hailed the positive contributions that increasing diversity, especially at management levels, is likely to bring to organisational performance. For example, Harvard Business Review (Nichols 1994) has indicated that increased workforce diversity offers new opportunities as well as new challenges. Literature suggests that more and more, organisations understand that they cannot take their survival as a given any more without taking into account the changes in their marketplace, customers needs and their workforce and how these three issues interrelate and inter-depend on one another.

Diversity should be understood as the varied perspectives and approaches to work that member of different identity groups bring (Thomas and Ely, 1996). Employee diversity is likely to bring about enhanced creativity, innovation and adaptability (Cox and Blake, 1991). It is indubitable that a whole new industry has even materialised *diversity training* to help organisations address the challenges that diversity creates (Ferguson, 1994). Diversity is therefore, best analysed in economic terms, both short term and long term, which means that the interest in diversity in terms of knowledge management should not be at all surprising. Managers can learn to assess whether they need to change their diversity initiatives, and if so how to accomplish that change (Thomas and Ely, 1996).

According to the marketing perspectives, organisations achieve their goals by satisfying their customers with greater effectiveness and efficiency than their competitors. The term effectiveness and efficiency are used precisely in this context. Effectiveness refers to the extent to which customer requirements are met, while efficiency is a measure of how economically the firm's resources are utilised when providing a given level of customer satisfaction (Barnard, 1962). If one accepts Banard's definitions, than the organisational function can be said to contribute to the attainment of the organisation's goals by efficiency providing products and services, which meet, or exceed the customer requirements.

Diversity is seen as important and is valued especially with those that can evaluate the benefits of it and consider themselves at the leading edge with regards to this domain. Managing diversity means managing people who have and can structure, disseminate employ knowledge for the benefit of the organisation. Therefore, the authors argue that good diversity management would indirectly indicate good knowledge management.

Diversity management is high on the agenda of most private organisations. Some are formal and others are still informal. Some have developed tools and measurements for managing diversity. Many different ways for approaching and interpreting the value of diversity surfaced. The value of diversity has been found to be particular to each organisation as was the meaning of diversity; each one had a varying priority with regards to the organisational prospective of diversity.

Smaller organisation identified valuing diversity as up to the discretion of the manager. The main variables for managing diversity vary from managing diverse skills and talents to providing opportunities to appreciating and valuing differences, to communications issues, acknowledgment of problems, leadership role, inclusivity of all, ownership of all, and performing structures for change, EO issues and meeting legislation. Benefits vary according to the business objectives, but mainly include: knowledge management, compliance with legislation, improvements on quality, reduction of turnover, flexibility, productivity, effectiveness, change of culture – integrated culture, cost structures and catching up with the new trend. Challenges of diversity were mainly found to be short term costs, required for initiating any activities, which has been found to be considered as minimum compared to the size of the organisation and its activities. However, most practitioners were found to be positive of the future implications of valuing diversity.

6. MANAGING TACIT AND EXPLICIT KNOWLEDGE THROUGH DIVERSITY MANAGEMENT

Nonaka and Takeuchi (1995) defined tacit and explicit knowledge relevant to people management. Tacit knowledge as suggested is hidden and can not be easily represented via information technology whilst explicit knowledge is what can be captured and shared through information technology (Martensson, 2000). The latter can be transmitted to others and can be stored and managed whereas the former is more subject to decay or loss if not managed well through workforce diversity management. It has been argued that knowledge of this kind is often more difficult to commodity and therefore maybe considered of higher value (Shariq, 1999). What is lacking at the moment is a complete understanding of effective knowledge transfer within organisations, especially where tacit knowledge is involved (Goh, 2002). The argument presented in this paper is that efficient diversity management could potentially transform tacit knowledge to become reproducible and usable and thus capturing it into explicit knowledge.

In the construction SMEs communication barrier is always a problem when dealing with people, whether it be people from various departments involved in same projects talking in two different dimensions or having no formal communication channels in place or the individual not empowered enough to be appraised for contributing his/ her ideas or people being overstreached and they simply can not afford the time for the knowledge capture.

Therefore, since the main variables for managing diversity vary from managing diverse skills and talents to providing opportunities to appreciating and valuing differences, to communications issues, acknowledgment of organisational issues, inclusivity of all, empowerment and ownership of all, and performing structures for change. It could be argued that the communication issues argued once identified and managed in the context of people management could result in Benefits that vary according to the business objectives.

7. CONCLUSION

Managing workforce diversity is more than ever seen as an effective tool for retaining the best people regardless of their differences and similarities and thus looking at benefits in an overall business advantage. It is therefore argued to be an important management tool with direct relevance to managing organisational knowledge by improving knowledge and learning management. For SMEs to implement knowledge management systems, understanding diversity and improvement in managing diversity amongst employees could potentially lead into improving communications, empowerment and decision making as well as reduction in costs through loss of vital information. More investments in education and training could be the key to bringing improvement to business performance. Therefore, it will be possible to capture and store the diverse tacit knowledge within the organisation. The findings of this paper presents the argument that SME organisations are in a position to potentially associate managing their diverse workforce effectively with retaining a wealth of information and the benefits of this on the organisational performance.

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VALUES AND VALUE – TWO PERSPECTIVES ON UNDERSTANDING STAKEHOLDERS

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ABSTRACT

Whilst most teams understand that delivering value is the key goal of a project or business, many do not have structured ways to make explicit and measure aspects of value that go beyond functionality and cost. The aim of this paper is to present Value in Design (VALiD), a new approach to help project teams identify and maintain a value delivery culture. A value framework is outlined that could help stakeholders articulate, in a structured way, their values and judgements of value by consistently stimulating their discussions during project activities to express and agree stakeholder priorities and expectations. Ultimately it is hoped that project teams will critically appraise their own approaches to determine whether they are successfully integrating stakeholder values and value in their design delivery processes. VALiD (see www.valueindesign.com), has been developed by Loughborough University and adopted by Constructing Excellence in the UK as an approach to move away from a short term cost focus to a broader stakeholder view. It equips construction teams with a cultural toolkit, that can be customised and integrated with other methods that address more objective time, cost and quality criteria, to enable them to better understand stakeholders' value judgements as they are framed by values and beliefs.

Keywords: Culture, Management, Stakeholders, Value, and Values.

1. THE CHANGING CULTURE OF UK CONSTRUCTION

The new millennium coincided with the reappraisal of value in UK construction and calls from a wide range of influential individuals, professional institutions and government bodies that the industry must deliver greater value. Design has been identified as an aspect of construction that has been unacceptably compromised by the 'least cost' approach taken by the UK Construction Industry (Construction Task Force 1998; Strategic Forum for Construction 2002). Given its importance in improving quality of life, the Government are clear on the need for change: "… good design provides a host of benefits. The best-designed schools encourage children to learn. The best-designed hospitals help patients recover their spirits and their health. Well-designed parks and town centres help to bring communities together." Department for Culture Media and Sport (2000).

Today Governments are making much clearer statements of their values priorities and are eager to demonstrate value against them. The Office of the Deputy Prime Minister (2005) identified the need to understand the diverse values and interests of particular areas and places in the delivery of the sustainable communities planning policy statement. In the schools white paper choice, fair admissions, parental support, personalised learning, diversity and fair access are defined as guiding principles, DfES (2005) and in the Urban White Paper DETRA (2000) attractive, clean and friendly urban environments that promote enterprising and innovative cultures are identified as critical to success.

The Royal Institute of British Architects sees design providing fundamental ways for humans to realise their values, gain a better quality of life and enhance individual and social well-being, Worpole (2000). Worpole calls for better ways of understanding what is important to people and societies before solutions can be designed to fit their specific values, needs and expectations. He calls for ways, beyond the aesthetic, to design spaces and places that instil in people a greater feeling of safety and security, enjoyment and sense of identity and so give them a better quality of life. Social scientists and philosophers have, unbeknown to many construction industry professionals, used values to acclaim or condemn buildings for many years. The philosopher Roger Scruton, when talking about the Tellick Tower, a social housing high rise built in the 1970's, said that it was 'a contemptuous conception of life's values', because it conflicted with the way people wanted to live their lives, Merrick (2004).

If the UK Construction industry is going to achieve its mission "to realise maximum value for all clients, end users and stakeholders and exceed their expectations through the consistent delivery of world class products and services." (Strategic Forum for Construction 2002) organisations must start to understand how they can build customer-oriented cultures. The CEO of Microsoft in New Zealand (Peat 2003), says companies that can focus on defining value as customers do, designing offerings based on what customers value, and measuring performance in terms of the value that customers experience will be well on the way to creating successful customer relationships.

The construction industry needs to engage stakeholders in a dialogue of value delivery to understand what they need from their products and services. The content of any dialogue must extend the investigation of business or functional need as practiced today (Thomson et al. 2003) to expose stakeholders' values as understood from their language, attitudes and behaviours. Values frame peoples view of everything in the world, and as such will help construction professionals understand what is expected of them and how they can ensure the delivery of value.

Rather than a team approach to value, disciples have built their own understanding of how it is defined and delivered. All construction disciples, who pride themselves on professionally delivering construction solutions on behalf of their customers, may have conflicting views. Designers may be guilty of thinking they are the single best judges of value and so select building solutions against their own values, without a full understanding of all customers' priorities and expectations; Quantity Surveyors, while understanding detailed elemental cost break downs, may eliminate costs without a clear understanding of associated stakeholder benefits. Project Managers may quickly arrive at design solutions by minimising stakeholder involvement and Engineers may search for a functional solution, without an understanding of how they could achieve or even exceed stakeholder expectations. Clients may seek to reduce design spend and objectively specify design requirements that act as a constraints and limit design creativity. Whilst Value Managers may limit their definition of value to objective and functional criteria, eliminating more subjective cultural factors that define the very nature of the people affected by the project.

This paper helps address the recommendations made by Saxon (2005) that the construction industry needs to:

1. develop a vocabulary of value and quality and a toolset of methods to enable the elicitation of stakeholder values;
2. to educate the industry and its customers in the provisions of value through setting out a skills agenda to inform employers, educators and the relevant learning and skills councils;
3. and develop means to engage stakeholders in the assessment of design activities so that value can be efficiently delivered and monitored.

2. VALUES AND VALUE IN CULTURAL THEORY

Many authors over the past sixty years have emphasised the importance of shared values in creating successful business cultures, a view that still persists today. For example Peat (2003) stated 'Companies which are most successful over the long term are those which incorporate their cultural values at the core of their everyday business operations'. It is Peters and Waterman (1982) who are perhaps the most well known for emphatically pronouncing shared values as the core of excellent corporate cultures, however according to Swindler (1986) the idea of shared values driving action is derived from Talcott Parsons who substituted Max Weber wider conception of human beings as “interest maximizing actors” being driven by material and ideal interests, and replaced it with his concept of global shared values.

Sociological ends or core values play a large part in defining culture, however it is important not to forget that the diverse stakeholder interests and influences, historical, environmental and political social contexts and organisational practices such as: symbols, heroes, organisational structures, control systems, rituals and routines, and stories and myths (Hofstede 2001; Johnson 1992; Swindler 1986) also play a part in identifying culture. A concept that has received much attention in the literature on human values is behaviour (the enactment of appropriate actions, that accord with values). This concept is explored by the authors in future papers, however critically it is often only through the enactment of words that people start to build trust in one another and see the frequency with which value is delivered. What is interesting in the study of organisational cultures is that we can in-part understand both values and behaviours using the same universal values structure. What this paper presents is an approach that provides project teams with an ongoing understanding of the complex trade-offs between stakeholders’ values and engages stakeholders in value dialogues in which stakeholder and project value priorities inform decision making. We postulate that a value dialogue on a project will have both a structured and unstructured form. The structured form, presented in this paper, comprises a language and a framework. The unstructured form will comprise a common knowledge and culture, shared between individuals and organisations.

Some may argue that language reform is superficial and cosmetic, and may have no impact on the real behaviours of people that form a culture. However knowledge about language enables people to make more informed choices and as such by changing peoples language we can change a culture. However given that people filter new ideas and concepts through what they already know, existing values act as a constraint in the adoption of anything new. Mutual understanding is created through language, it broadens choice and gives people confidence to talk and act, because people know their ideas will be accepted. Commercially this joint understanding leads to efficiency and effectiveness and reduces anxiety by reducing misunderstanding and ambiguity.

According to Schein (2004) leaders embed their values within a culture because people are guided by what leaders pay attention to, allocate resources to, reward, measure and control. As such this apparatus must be harnessed to ensure that business leaders can deliver and demonstrate corporate ethics. The classic view that the ultimate purpose of a corporation is to make profit for its shareholders is becoming outdated. Stakeholder approaches are providing a major alternative, given the need of today’s corporations to act with social responsibility and protect the various rights of all stakeholders. The concept of value provides a useful means of measuring the trade-off between what each stakeholder gets and what they have to give up, and we argue it is essential that project teams understand value from stakeholders’ own perspectives in addition to reaching a project consensus (such as in existing value management approaches). Stakeholders can express their “gets” and their “gives” in terms of the benefits they seek from the project, the sacrifices they are willing to make to get those benefits, and the resources they are willing to consume in doing so (figure 1). This is a modification of the definition presented by Thomson et al (2003).

$$\textbf{Value} = \frac{\textbf{Benefits - Sacrifices}}{\textbf{Resources}} \quad (\text{related to})$$

Figure 1: Value definition: an equation that demonstrates the value trade-off

Given that values are critical in identifying culture, a systematic means of comparing the values of individuals and organisations is needed to inform values dialogues. Universal values provide such a means and Schwartz is a leading authority in this area. He has carried out the most extensive values survey completed and as such has provided data to separate cultural specific values from universal values. This understanding of 56 comparable and general values, rather than those which are unique and specific, provides the opportunity to compare individuals and organisations. (Schwartz 1992; Schwartz 1994) proposed a five feature definition of values that has gained widespread agreement in the field of human values theory. He sees values as concepts or beliefs that pertain to desirable end states or behaviours. They transcend specific situations, guide selection or evaluation of behaviour and events, and are ordered by relative importance. The universal values model developed by Schwartz from literature and then validated, through use by some 64,000 people, across 67 countries, from highly diverse geographic, cultural, linguistic and religious backgrounds is applied to construction in this paper.

3. EXISTING PRACTICES TO IDENTIFY A PROJECT VALUE CULTURE

3.1 Value Management

Value Management has been adopted by some in the UK construction industry as a management approach to realising customer value. Many Value Management practitioners take a functional approach, designed to identify and eliminate unnecessary costs. As such decisions are often made on objective fact finding, with little emphasis on less easily measured subjective cultural factors. A handful of academic authors, such as (Connaughton 1996; Kelly et al. 2004; Liu and Leung 2002) advocate a less strict and softer value management approach, however the pervasiveness of functional methods such as functional analysis, which identifies concise criteria expressed as an active verb and noun, prevail. Such methods largely strip away the subjective humanistic values that provide the design team with a cultural context. For example a value criteria, expressed in a stakeholders own words as "somewhere to sit outside, and freedom to sit close to friends", may be modified and defined as the project value criteria "provides outdoor seating". The later provides a designer with far less direction than the former which allows them to think specifically about how the value ‘freedom’ of a user can be realised through the design of outside places. A project vision or mission is often used as a starting point in defining a value tree using functional analysis; however this would not capture the specific ends in the case above.

One of the major deficiencies with the application of Value Management over the past 40 years has been practitioners’ push to reach a consensus view of value rather than allowing different stakeholders with diverse needs to express their various interests and values. As such the process can arrive at an objective consensus view with few subjective values being expressed. Added to this is the fact that people will often find values difficult to express, in particular within group situations. It is unlikely that values will be exposed through value management workshops without concerted effort, time and the use of a highly skilled facilitator and scribe who can elicit and record them.

3.2 Vision and Missions

Project visions and missions are abstract statements of a project’s purpose which stems from the key motivating essence of the clients’ values system. According to Johnson and Scholes (2002) the project mission is the overriding purpose in line with the values or expectation of the stakeholders. Mission statements are invaluable in capturing, in a clear, short and inspiring way the core purpose of an activity in achieving its vision (the ultimate picture of excellence and an aspiration for the future). Once an appropriate project Mission has been defined it is then the role of the project leader or champion to continually articulate the mission (and what this means given the resource envelope), to infuse it into the project throughout the value delivery lifecycle.

A project mission or vision may be too abstract to allow for the translation of the value culture into a design solution. A project vision statement is often the only subjective definition in a design brief, however this abstract description will usually represents a top down corporate view, rather than representing the hearts and minds of the broader employees and stakeholders.

3.3 Initial Client Briefing

Client project briefs, or outcome specifications as they are sometimes referred, are often written by a small client team and specify functional outcomes and design requirements. This team is well placed to understand the relationship between stakeholder benefits as they trade-off with project costs. They have a large influence over the design process, and may objectively express product requirements stated as compliance criteria. As such the project mission and project objectives in the brief are often the only subjective expressions of the value culture.

The criteria contained within a client brief are often expressed as outcomes to be complied with to ensure a fundamental level of project success, and as such these objectively stated criteria might not inspire a unique and culturally specific design solution. These documents may contain may detailed criteria that have not been prioritised to show their relative importance and the extent to which a criteria can be realistically delivered to a given cost. As such the design team may be left to make their own decisions on what is most important for inclusion or exclusion as framed by their own value systems rather than those of the users who's views may matter most.

3.4 Design Review Process

Through the briefing process the design team will often build a tacit understanding of the personalities and culture of different stakeholder groups from their meetings with them. Stakeholder values may be elicited and captured as design requirements or in the selection or prioritisation of particular valued means or ends. Designers often talk of their time with stakeholders giving them a feel or sense of what is required. This feeling is an intuitive approach to understanding the values or value drivers to reflect in their design solution and much of the designer's time in upfront design is in encapsulating these in their spatial design solutions. Highly experienced design teams, who have previously delivered specific building design solutions, will be skilful in realising project value, however may not have an awareness of all stakeholder views or a design rationale that can be quickly and simply translated to designers down the supply chain.

Values often remain implicit, because people find them difficult to express and understand. As such it is likely that values will not be effectively exposed without a concerted effort and understanding from the brief taker or Architect. Because values identification does not go on in any formal way, the values exposed may not be the most important to the group or the individual expressing them. Architects may, without an understanding of the effect of their own values, overemphasis those that are important to them, rather than to the project. Opportunities to realise particular values may be missed as design decision making evolves ahead of stakeholder engagement. The communication of values down to the supply chain may be poorly executed because values and value are not fully understood.

3.5 Organisational Values Statements

Values statements demonstrate the broader goals that should direct business strategy. They define what is most important or highly prioritised by an organisation. Brainstorming is often used to identify values statements, however because of the difficulty in involving large numbers using this approach only relatively small groups of individuals are used to understand the whole culture of an organisation. As a result values are often defined by an executive board with few representatives from the broader organisation.

The values statement identification process is often unstructured, so the range of values is often limited. The values of a small sample group may not be a true representation of an organisations culture or the values enacted in practice through employees' behaviour. What is more, if employees have not been included in the definition process they may not be as motivated and committed to the resulting statements. Values statements are often defined by an organisation, but are rarely considered in a project context due to an absence of tools. As a result the values of the lead client are often substituted to represent those of the project, however all stakeholders may not fully commit or share the motivation for these same statements.

4. A FRAMEWORK OF VALUE IN DESIGN

Before we explain the value framework it is important to distinguish between values and value: as one is not the plural of the other. Values are the guiding principles held by people. Value, on the other hand is a judgement of something as framed by a persons values.

The VALiD Value Framework defines the broad concepts that may help the industry better understand, define and deliver value in its broadest sense. This framework has been developed to structure and stimulate design dialogue between customers, designers, contractors and other stakeholders. By exposing the values, needs and expectations of individuals. It is hoped that this dialogue will build trust by helping project teams understand each other and agree satisficing projects objective and product solutions, Simon (1957).

Identifying value and values does not automatically produce a value culture. However if stakeholders are engaged in the design process they may be more likely to be aligned and committed to the guiding principles for the project. The Value Framework presented in this paper provides a common language that will aid an organisational or project to build a value culture, where people have greater understanding of each other and are equipped to build consensus, achieve compromises and mitigate conflicts during design and project delivery.

The Value Framework in Figure 2 seeks to help stakeholders identify an appropriate value culture by:

- Facilitating a dialogue on stakeholders' needs and expectations
- Agreeing a shared project purpose based on the values of key stakeholders and aligned with the values of the broader stakeholders
- Aligning the values of the project with the business strategy and objectives of the client organisation.

The Value Framework has three parts. The first involves a method to help organisations reveal and explore their values, based on the work of Shalom Schwartz. The second allows each stakeholder group to define a unique set of criteria and the third uses these definitions of value to subsequently measure performance. This paper concentrates on the first two parts which contribute to the identification of a value culture, rather than the third which maintains the value culture by validating the value definition and assessing value in the emerging design decision making process.

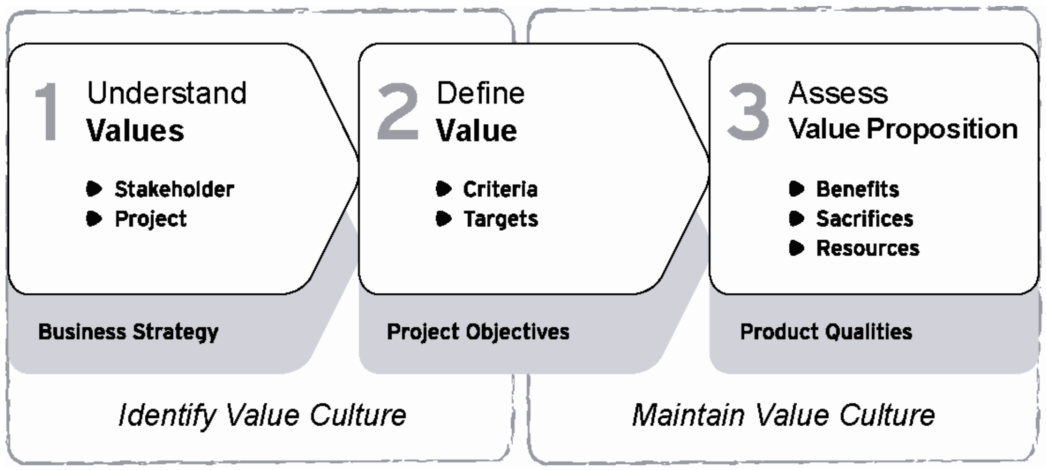

Figure 2: Value Framework to identify and maintain a value culture

4.1 Understand Values

The Value Framework attempts to describe the structural nature of the relationship between values and value. In the first "Understand Values" step of the framework are six potential levels of values: societal, industrial, organisational, professional, project and individual, Devine-Wright et al (2003). However, we are particularly concerned with the content and relationship between organisational and project values. Organisational values describe the culture of a particular stakeholder group that has formulated a specific strategy, while project values are the shared guiding principles agreed by all project stakeholders. Organisations in a project will come together with other stakeholders such as users and local community members who may have values which are compatible, or potentially conflicting. Given that project success depends on collaborative work and that there is often little time and a lack of skill in understanding cultural similarities and differences before a project, there is a need for a universal language of values to enable people to highlight compatibilities and potential conflicts among values systems. The result may be that the severity of cultural clashes may be reduced.

According to Schwartz, values, approximately speaking, fall into one of ten universal values dimensions that form into a circular values system, Figure 3. As such values form a motivational continuum with fuzzy lines of segregation. When values in the figure are adjacent they are congruent because they share an underlying need or motivation goal; while those which are opposite in the circle conflict, because their underlying motivations are opposed. This Figure is an adaptation of Schwartz own model, which pictures the "total pattern of relations of conflict and compatibility among values priorities", Schwartz (1992). It is this complex concept of a human values systems that can help individuals understand their own priorities, inform their interactions with others, and their judgements and attitudes towards almost everything. Whilst for an organisation, this structure provides an understanding of how they can define organisational values and business strategy.

The most basic values relationship is between individual and collective interests, where the attainment of values that serve individual interests are by their nature opposed to those that serve collective interests. This relationship between individualism and collectivism is perhaps the most well known cultural dimension ever conceptualised, made particularly so by Hofstede (2001). At the next level, which segments the ten motivational types into two higher-order bipolar value dimensions are: self-transcendance versus self-enhancement and openness to change versus conservation. In realty people have to prioritise between the values that form their own values systems and balance these with the collective group to which they belong.

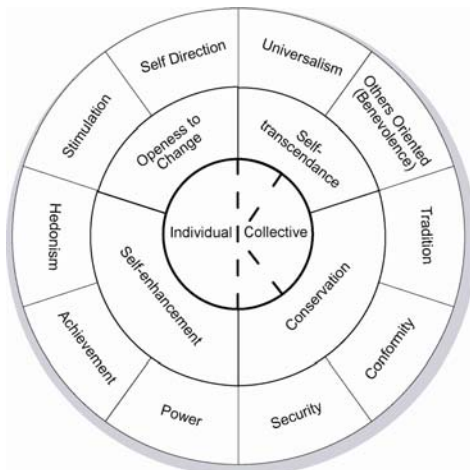

Figure 3: A universal values system/structure, adapted from Schwartz (1992)

A values questionnaire is used to capture individual values that can then be aggregated with other individuals into an organisational or project view using simple radar chart illustrations. This approach to capturing and communicating values has proved to be effective at revealing the core cultural aspects of organisations. Its insight was such that it stimulated further industrial participation and research is ongoing. The Collaborative Working Centre used the method to understand their working culture and Currie & Brown, following a case study conducted in their Birmingham office, have adopted the method throughout their UK offices to help new employees understand and develop the company vision and strategy, Zhang et al. (2006). Which much more detailed discussion is presented elsewhere, Mills et al. (2006).

4.2 Define Value

The demonstration of stakeholder and project value requires a system of measurement that subjectively allows stakeholders to define and assess value from their own perspective. The VALiD approach asks a stakeholder representative to be responsible for what their group gets (beneficial and sacrificed outcomes) and the resources they give up. To do this they express their groups priorities by selecting value criteria and indicating their groups expectations by defining targets for value delivery. Design teams can then use the overall project value definitions as a guide to direct their attention and effort to make significant improvements where they are most needed. A periodical demonstration of values and value (against original targets) confirms that the projects direction is right which helps maintain ongoing awareness of the value culture.

In the VALiD approach defining value starts from a generic list of value criteria defined by industry experts using cognitive modelling. 118 generic outcomes were identified (in 25 thematic groups) and 49 generic resources (in 6 groups) for any new project. This generic list is only a starting point. Our most recent work, on a series of education capital projects, demonstrates the anticipated customisation of this model. In an exercise to define a set of criteria specific to education projects and a particular project culture the criteria list was increased from 118 to 239 - 68 new criteria were identified from a review of sector specific literature, 20 new criteria were identified by specific stakeholder individuals or groups and 30 new criteria were identified by a group of facilitators who ran 13 workshops to elicit cultural specific design principles.

In order to simplify and better ensure VALiD's adoption the approach has been adapted in two ways. Firstly, the re-categorisation of the criteria into groupings consistent with the Design Quality Indicator, Gann and Whyte (2003) which is becoming established in the UK construction industry. Secondly, due to the breadth of the value model and need to streamline stakeholders' involvement, an expert group went through an exercise to reduce the number of criteria each stakeholder selected (approx. 60 criteria), according to each stakeholder's role, interest and influence. This implies that stakeholders may not be equally good judges of all criteria. Figure 4, shows the outcome of the exercise in which experts mapped stakeholder and value criteria. It shows which categories are more or less relevant to specific stakeholder group, for example criteria in the project management category are more relevant to providers, whilst those in urban and social integration are more relevant to customer stakeholders.

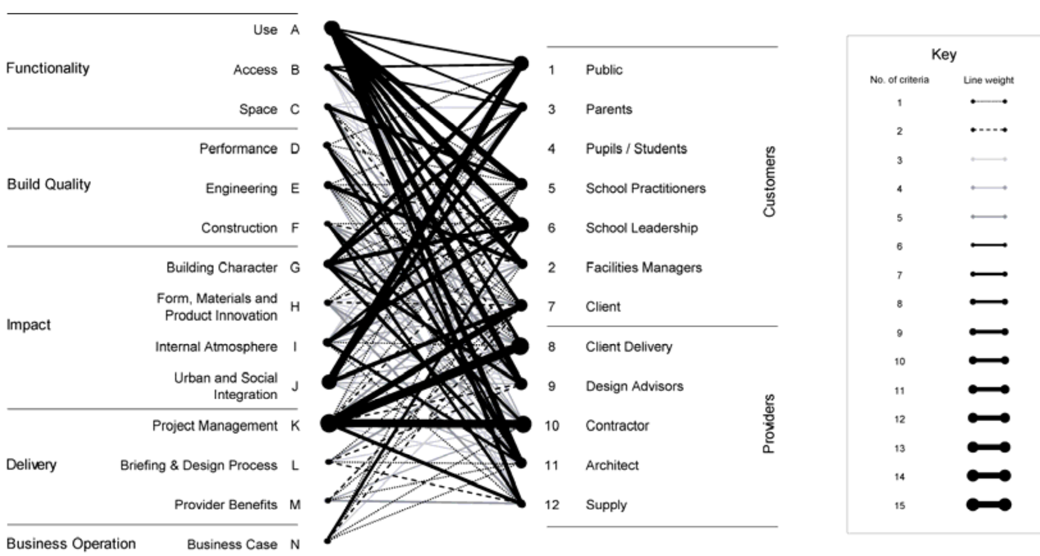

Figure 4: The relationship between benefit criteria in both category and stakeholder groups

Some may argue that this method imposes criteria on stakeholders, however this is not the case. Stakeholders are free to select from a larger list, define their own criteria or customise existing ones.

5. CONCLUSIONS

The UK Government have stated clearly the importance of understanding cultural aspects in delivering construction projects; however few structured tools to elicit these subjective criteria go beyond functionality and cost. As such the industry and its customers must further develop tools and skills to enable dialogues centred on the understanding of cultural values and stakeholder value.

VALiD is a new approach that may address some of the key shortcomings of the conventional approaches of the Construction Industry. This paper has demonstrated the application of the framework in identifying a project value culture. The approach contains a suite of simple and practical tool that can be customised to engage and stimulate stakeholder dialogues throughout the design process. Support on the application of VALiD in your organisation or project is available from the authors, while information and case studies are also available at www.valueindesign.com.

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ORGANIZATIONAL CULTURE PROFILE OF CONSTRUCTION COMPANIES IN THAILAND

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ABSTRACT

A construction organization should understand its culture as a means to improved performance and effectiveness. This study assesses the organizational culture profiles of construction companies in Thailand using questionnaire survey data. The analysis of organizational culture and effectiveness was classified into groups, based on job position and age of company. Overall, the strongest culture of contracting companies in Thailand is characterized by Hierarchy culture followed by Market, Clan, and Adhocracy culture respectively. Thai contracting companies do not focus on innovation, growth, and resource acquisition, but rather they are growing as hierarchical organizations.

Keywords: Construction companies, Organizational culture, Thailand

1. INTRODUCTION

Organizational culture is very important for organizational success (Newstrom and Davis, 1993) and it is a key ingredient that differentiates the successful firms from the others, because it is the major distinguishing feature, the most powerful factor, and the most important competitive advantage in gaining success (Cameron and Quinn, 1999). Schein (1985) also stated that organizational culture can determine the level of effectiveness of an organization through its strength and type. Therefore, it is important to clearly understand organizational culture; particularly in the construction industry. By understanding an organization's culture, organizational leaders can manage the culture in order to improve organizational performance (Maloney and Federle, 1993).

Although recent economic growth has brought good opportunity for development of the construction industry in many countries, the industry faces many obstacles and uncertainties resulting from the changing environment. There is still poor performance and low effectiveness in construction quality and organizations face many problems when attempting to improve organizational performance (Liu and Zhang, 2003). One major cause of problem in improving organizations is the lack of means for assessing organizations (Maloney and Federle, 1993).

Given that organizational culture plays an important role in performance and effectiveness of contractor firms, this study examines the organizational culture profile of representative contractors in Bangkok as a first step towards establishing a relationship between culture and organizational effectiveness. In order to meet this objective, two logical steps were taken. First, we have assessed and constructed organizational culture profile by classifying construction firms into groups. Second, we make recommendations regarding organizational culture to assist construction organizations in identifying their culture in order to improve performance and effectiveness.

2. LITERATURE REVIEW

According to Schein (1985), organizational culture is defined as “A pattern of basic assumptions which is invented, discovered, or developed by a group since it learns to cope with its problems of external adaptation and internal integration that has worked well to be considered valid, and therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems” (Brown, 1998).

There are a large number of functions that have been attributed to organizational culture. The most significant functions of culture according to Brown (1998) are: conflict reduction; coordination and control; reduction of uncertainty; motivation; and competitive advantages. Therefore, a strong organizational culture can help an organization to be successful in the market place.

Theorists have examined different aspects of organizational culture (Brown, 1998). Below are the well-known classifications of organization culture’s elements as per Schein’s model (1985):

1. *Artefacts.* According to Schein, this is not the organizational culture itself, but only the most visible, apparent, accessible aspects, and superficial manifestation which can be perceived by people (Buchanan and Huzynski, 2000).
2. *Values, beliefs, and attitudes.* Values are the social principles, goals, and standards held within a culture to have intrinsic worth. They define what the members of an organization care about (Hatch, 1997). Beliefs, on the other hand, concern what people think is and is not true. (Brown, 1998). Attitudes connect beliefs and values with feelings. An attitude is a positive or negative feeling or mental state of learned predisposition to respond in consistently favorable or unfavorable manner to a particular objects, people or idea.
3. *Basic Assumptions. A*ccording to Schein, this level is the organizational culture. Basic assumptions represent what members believe to be reality and thus influence what they perceive and how they think and feel (Hatch, 1997).

The Competing Values Framework

A brief review of the framework is presented here to bring the reader up to speed. The purpose of using the Competing Values Framework is to diagnose and facilitate change in organizational culture (Cameron and Quinn, 1999). The model dichotomizes organizational types into a 2 x 2 matrix, in which the organizational types on the diagonals are competing and those adjacent are complementary (Maloney and Federle, 1993).

Using Figure 1, which presents organizational culture framework, the competing values paradigm can be discerned. An organization in the upper-half of Figure 1 is oriented toward decentralization and differentiation, with an emphasis on spontaneity and flexibility. On the other hand, an organization in the bottom of the figure is oriented toward centralization and integration, with emphasis on predictability and control. An organization on the left side emphasizes maintenance of the socio-technical system, has an internal focus, and focuses on long-term horizon. An organization on the right side is oriented toward the competitive position of the overall system, has an external focus, and focuses on short-term horizons. The values of upper-half of the picture are competing with those of the bottom-half, as well as those of the left and right sides (Maloney and Federle, 1993). Therefore, the framework identifies four types of culture as in Figure 1.

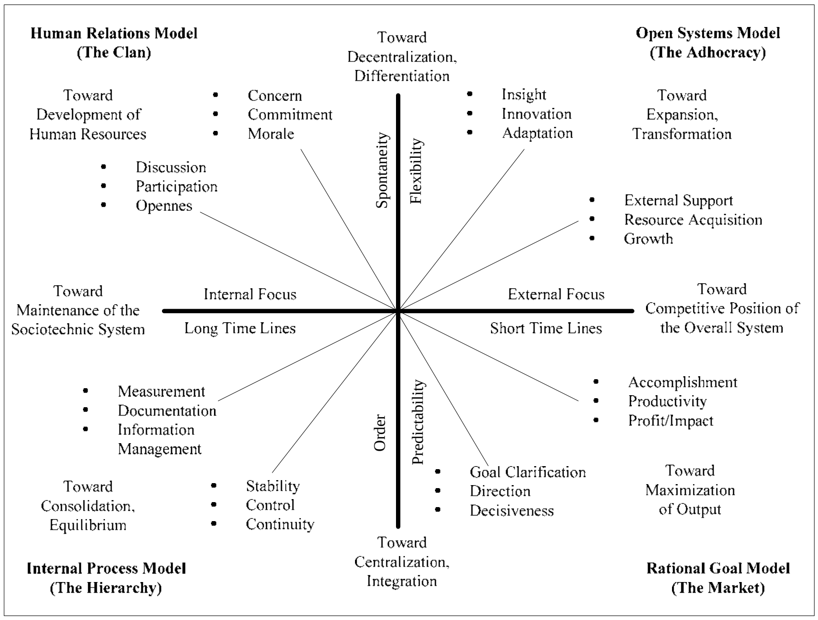


Figure 1: Competing Values Framework: Culture
Source: Adapted from: Quinn (1988)

3. RESEARCH METHODOLOGY

The major hypothesis in the study is that there is a dominant culture of contractor companies in Thailand. The OCAI (Organizational Culture Assessment Instrument) developed by Quinn and Cameron (1999) for measuring organizational culture profile was used. The instrument has been tested for reliability and validity by many researchers and results have been published in journals and books such as Maloney and Federle (1993), Lamond (2003), and Cameron and Quinn (1999). The OCAI assesses six key elements of organizational culture. The questionnaire was pilot tested on five contractors. Organizational culture is divided into six elements, each element having four statements representing each culture type. The six key elements and the measures can be gleaned from Table 2.

The questionnaire was presented with a series of statements using a 5-point Likert scale. Respondents were asked to give labels ranging from “never true” or “completely true” to each statement and each was given a numerical score to reflect the degree of attitudinal favorableness.

Data Collection and Analysis

The target respondents of the research were one manager and two engineers for each contracting firm. Therefore, three sets of questionnaires were distributed to each company. Due to time and budget limitations, the target location was in Bangkok and its surroundings and samples were selected randomly from the Thai Construction Association Directory 2000. The questionnaire was translated into the Thai language to aid understanding by the respondents.

The sampled companies were classified into groups based on job position and duration of company existence. To construct an organizational culture profile, the study followed the OCAI. The score of each culture was plotted on the diagonal line and the organizational culture profile was interpreted based on the picture. The culture with the highest average score is considered to be the strongest and dominant culture.

Microsoft Excel and SPSS 10.0 were used for the analysis. The t-test and Mann-Whitney U test were used to determine the significance of mean differences between groups. Spearman Correlation Coefficient is the measure of significant rank correlation between two groups.

3. RESULTS

One hundred and twenty three (123) respondents returned questionnaires from forty eight (48) companies; i.e. forty two (42) managers and eighty one (81) engineers. Thus, the desired (1:2) ratio between managers and engineers could not be maintained in a few of the companies.

Organizational Culture Profile of Contractor Companies

The research intended to measure the organizational culture of the companies, and to determine the dominant or the strongest culture in the companies.

1. General Case.

Overall, Hierarchy culture is emphasized most in the contracting firms (Figure 2). It means that the firms most emphasize formalized and structured place to work and focus on internal maintenance with a need for stability and control. The result shown in Table 1 reveals that Hierarchy culture is stronger than the other types of culture with the average score of 3.74, followed closely by Market culture (3.64), Clan culture (3.57), and Adhocracy culture (3.33). Hierarchy culture is the strongest culture; it contrasts with Adhocracy which is the weakest culture.

As shown in Table 1, the differences in average score of the four types of culture are not great. It can be said that although the culture in the bottom two quadrants are stronger than the upper two quadrants, the respondents perceive their organizational culture to be relatively balanced. It seems that the contracting firms require a balanced culture where similar emphasis is placed on each culture type.

The six elements of organizational culture (presented in Table 1) are dominant characteristic, organizational leadership, management of employees, organizational glue, strategic emphasizes, and criteria of success. All respondents perceive that the dominant characteristic of the contracting firms is represented by the Clan culture. In organizational leadership, most of the contracting firms are strongly Market oriented (3.85) wherein leaders focus on being hard drivers, producers, and competitors.

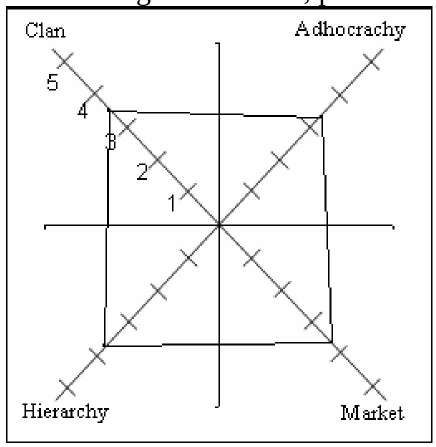


Figure 2: Overall Organizational Culture Profile

The management style used to manage employees is strongly Hierarchy oriented (3.55), followed by the Market culture (3.34). The organizational glue that holds companies together is Clan culture that respects loyalty and follows tradition. The company strategic emphasis is strongly Hierarchy oriented (3.80); followed by the Market culture (3.73). Companies define success based on the Hierarchy culture (3.97) that stresses efficiency, dependable delivery, smooth scheduling, and low-cost production.

From the explanation above, it is evident that there is a presence of cultural incongruence in the contracting firms because the strategy, leadership style, reward system, approaches to manage employees, and dominant characteristic tend to emphasize different culture types. This may have resulted from a mixture in the Thai market place. Nowadays, the market demand is changing rapidly. Hence, the contractor companies desire to modernize their organization in a society or business environment that requires them to be hierarchical organizations.

Table 1: Overall Organizational Culture Profile

No.	6 Elements of OC	Average Score			
		Clan	**Adhocracy**	**Market**	**Hierarchy**
1	Dominant Characteristic	3.55	3.53	3.54	3.53
2	Organizational Leadership	3.65	3.53	3.85	3.72
3	Management of Employee	3.28	3.09	3.34	3.55
4	Organizational Glue	3.68	3.11	3.64	3.63
5	Strategic Emphases	3.41	3.32	3.73	3.8
6	Criteria of Success	3.60	3.13	3.48	3.97
	Overall OC Profile	**3.57**	**3.33**	**3.64**	**3.74**

N=123

1. Classification by Job Position

The perception of culture types in an organization may be affected by the job position of the employees. For instance, the leader may a have different perception from the sub-ordinates. Therefore, the respondents were classified into two groups based on their job position separating managers from engineers. Their responses are plotted and summarized in Figure 3 and Table 2.

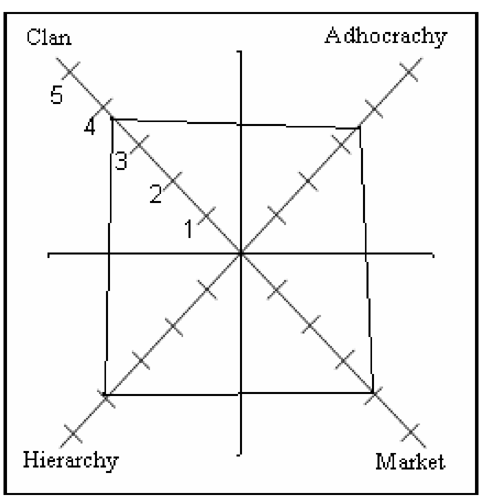
Table 2 shows that the rank correlation for each pair (*r*) is very strong and significant. Thus, managers and engineers alike perceive that the Hierarchy and Market cultures are stronger than the Clan and Adhocracy cultures. The classification by job position does not show differences in the rank ordering of the four culture types. As seen in Figure 3, the two lower quadrants are stronger than the upper two quadrants.

Seventeen (17) of forty two (42) managers perceive Hierarchy culture as the dominant and the strongest culture in contracting firms, followed by Market culture, Clan culture, and Adhocracy culture respectively. Twenty nine (29) of eighty one (81) engineers also perceive Hierarchy culture as the dominant and strongest culture in the contracting firms, followed by the Market, Clan, and Adhocracy culture respectively (Table 2).

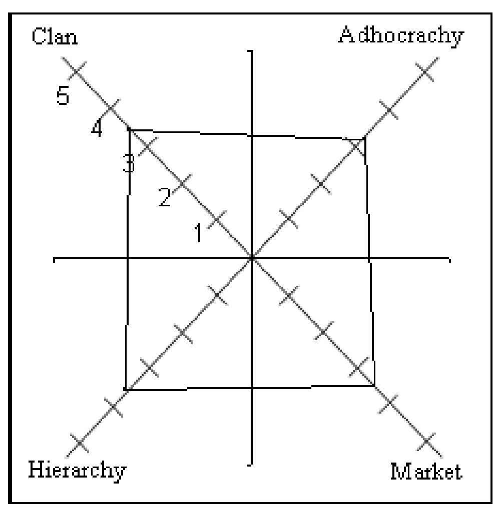
The statistical result shows that there is a significant mean difference between managers and engineers in the four culture types. The managers' average score is higher than engineers' average score as shown in Table 2. Thus, the managers have stronger feelings regarding the organizational culture profiles in their companies than the engineers.

It can be concluded that the hierarchy culture is the most dominant in the contracting firms. It means that contractor companies tend to improve their effectiveness by emphasizing on value stability, control, and continuity which are obtained through measurement, documentation, and information management.

In addition, the six elements of organizational culture are presented in Table 2. In the first element, the forty two (42) managers perceive that Market culture is more dominant than the others. On the other hand, the eighty one (81) engineers perceive that their organization is dominated by Hierarchy culture. Nevertheless both groups perceive Clan culture as the weakest culture in terms of the dominant characteristic. In the second element, both managers and engineers perceive that the organizational leadership used in the contracting firms is strongly Market culture, whereas Adhocracy culture is the weakest.



OC Profile by Managers



OC Profile by Engineers

Figure 3: Organizational Culture Profile Classified by Job Position

In the third element, both groups perceive that the management style in the companies is strongly characterized by Hierarchy culture which focuses on security of employment and predictability, whereas Adhocracy culture is the weakest. In the fourth element, both managers and engineers perceive Clan culture as the organizational glue holding contracting firms together and Adhocracy culture is the weakest culture that cannot be applied to hold organizations together. Thai people have a tradition of loyalty to the family group, it may have colored their opinion regarding organization glue element.

In the fifth element, both managers and engineers alike perceive that companies emphasize permanence, stability, efficiency control and smooth operations (Hierarchy culture) as being important to their strategy. In the sixth element, both managers and engineers perceive that companies define success on the basis of efficiency, dependable delivery, and smooth scheduling. They still believe that Hierarchy culture makes their companies successful. Adhocracy culture still has the least effect as criteria of success.

From the foregoing, it is evident that there is incongruence in culture based on job position. Each element of organizational culture tends to emphasize a different culture type.

2. Classification by Age of Company

Responses were divided into two (2) groups based on the age of companies: companies that are younger than twenty (20) years and companies that are older than twenty (20) years. The objective of the classification is to determine whether or not culture changes occur as companies age. The analysis and discussion consider the views of managers and engineers separately.

The result for managers shows no significant mean difference between the two classes of companies. However, companies younger than 20 years give less average values than those that are older than 20 years. There is weak but non significant rank correlation between the two groups. Therefore, the age of companies have affected the ranking of the four culture types - as per the views of managers. The dominant culture in older companies (personal place) is different from that in younger companies (production).

Based on managers, nine (9) of eighteen (18) companies younger than 20 years, are dominated by Market culture. Whereas eight (8) of twenty four (24) contracting firms older than 20 years are characterized by Hierarchy culture as the dominant and strongest culture. By contrast, Adhocracy culture is perceived as the weakest culture for both classes of companies.

The analysis for engineers shows that there is no significant mean difference in organizational culture between the two groups of companies. In addition, there is strong but non significant correlation between the two groups in ranking the organizational culture types (sig. value > 0.05).

Engineers perceive that both classes of companies are strongly Hierarchy oriented and Adhocracy culture is the weakest culture opposite to Hierarchy culture. Engineers report that the contracting firms focus on formalized and structured procedure, documentation, stability and control. This may have resulted from the fact that the engineers are made to always follow procedures and rules by their companies. In addition, some contracting firms have adopted international standards for products or services which must be followed by the employees.

The result for the six elements of organizational culture shows that there is incongruence in culture because each element of organizational culture of contracting firms tends to emphasize a different culture type. For example, based on managers' perception, contracting firms younger than 20 years are dominated by Market culture, but they define their criteria of success based on Hierarchy culture.

4. CONCLUSIONS AND RECOMMENDATIONS

The most common culture types reported in the analysis are Hierarchy and Market culture, which emphasize formalized and structured place to work, and goal achievement respectively. Clan and Adhocracy cultures were less prominent in the construction companies.

- The dominant characteristic of the contracting firms is Clan culture emphasizing personal place, like an extended family, and comfort at work. However, in this element, there is not much difference among the four types of cultures. Hence, it can be said overall that there is no dominant culture characterizing the companies.
- The leadership style used in the contracting firms is Market culture, which is generally considered to exemplify aggressive, result-oriented focus, hard driver, producer and competitor.
- The management of employee in the companies is strongly Hierarchy oriented which is characterized by security of employment, conformity, predictability, and stability in relationships.
- The organizational glue that holds the companies together is characterized by Clan culture that stresses loyalty and mutual trust, and commitment to companies runs high.
- The strategic emphasis in the companies is represented by Hierarchy culture which emphasizes permanence and stability as well as efficiency, control and smooth operation.
- Companies define success on the basis of Hierarchy culture, which values efficiency, dependable delivery, smooth scheduling, and low-cost production.

The presence of cultural incongruence in the construction companies may have resulted from a mixture in the Thai market place. The contracting firms tend to modernize their organizations in a society or business environment that at the same time requires companies to have strong Hierarchical organization. In addition, the characteristic and the culture of Thai people may influence company values, beliefs, and basic assumptions.

There are no differences in perception, based on job position classification, in ranking the overall average scores for the strongest and weakest culture types. Managers and engineers agree that the strongest culture is the Hierarchy culture and the weakest culture is Adhocracy. However, there are differences in perception in some elements of organizational culture, such as dominant characteristics, management of employees, and organizational glue.

Table 2 Organizational Culture Profile Classified by Job Position

No.	6 Key Elements of OC	Manager		Engineer	
		Average	**Rank**	**Average**	**Rank**
1	**Dominant of Characteristic**				
B.1.a	Personal Place (CC)	3.76*	4	3.44*	4
B.1.b	Dynamic and entrepreneurial (AC)	3.83*	2	3.37*	2
B.1.c	Production oriented (MC)	3.86*	1	3.37*	2
B.1.d	Formalizes and structures (HC)	3.81*	3	3.38*	1
r = 0.316 sig.(2-tailed) = 0.684					
2	**Organizational Leadership**				
B.2.a	Mentor, sage, or parent figure (CC)	3.76	3	3.59	3
B.2.b	Entrepreneur, innovator, or a risk-taker (AC)	3.67	4	3.46	4
B.2.c	Hard-driver, producer, or competitor (MC)	4.07*	1	3.74*	1
B.2.d	Coordinator, organizer, or an efficiency expert (HC)	3.86	2	3.64	2
r = 1.000** sig.(2-tailed) = 0.000					
3	**Management of Employee**				
B.3.a	Teamwork, consensus, and participation (CC)	3.31	3	3.27	2
B.3.b	Innovation, freedom, and uniqueness (AC)	3.17	4	3.05	4
B.3.c	Production and achievement (MC)	3.62*	2	3.20*	3
B.3.d	Security of employment and predictability (HC)	3.90*	1	3.37*	1
r = 0.800 sig.(2-tailed) = 0.200					
4	**Organizational Glue**				
B.4.a	Loyalty and tradition (CC)	3.93	1	3.56	1
B.4.b	Innovation and development (AC)	3.21	4	3.06	4
B.4.c	Production and goal accomplishment (MC)	3.86	2	3.53	3
B.4.d	Rules and Policies (HC)	3.81	3	3.54	2
r = 0.800 sig.(2-tailed) = 0.200					
5	**Strategic Emphases**				
B.5.a	Participative and comfortable (CC)	3.69*	3	3.26*	3
B.5.b	Dynamics and readiness (AC)	3.50	4	3.22	4
B.5.c	Competitive and confrontational (MC)	3.98*	2	3.60*	2
B.5.d	Permanence and stability (HC)	4.02	1	3.69	1
r = 1.000** sig.(2-tailed) = 0.000					
6	**Criteria of Success**				
B.6.a	Sensitivity to customers, concern for people (CC)	3.88*	2	3.46*	2
B.6.b	Product leader and innovator (AC)	3.40*	4	2.99*	4
B.6.c	Market penetration and market share (MC)	3.67	3	3.38	3
B.6.d	Dependable delivery, smooth scheduling (HC)	4.19*	1	3.85*	1
r = 1.000** sig.(2-tailed) = 0.000					
7	**Overall OC Profile**				
a	Clan Culture (CC)	3.75*	3	3.48*	3
b	Adhocracy Culture (AC)	3.51*	4	3.24*	4
c	Market Culture (MC)	3.88*	2	3.52*	2
d	Hierarchy Culture (HC)	3.97*	1	3.62*	1
	N=	**42**		**81**	
r = 1.000** sig.(2-tailed) = 0.000 ** = correlation is significant at 0.01 level (2-tailed) * = difference is significant at 0.05 level (2-tailed)					

Analysis based on job position and age of company did not reveal much. In most cases, the strongest culture is Hierarchy culture and the weakest culture is Adhocracy culture; except that managers in companies that are younger than 20 years perceive that their companies are strongly market oriented.

Overall, irrespective of classification, Adhocracy culture seems to be the weakest or the lowest culture. This may have happened because adhocracy does not relate well with hierarchy culture which is the strongest culture. Support for this comes from Maloney and Federle's (1991) observation that typically, the culture that is opposite to the strongest culture is the organization's weakest. It does mean that contracting firms do not focus on innovation, growth, and resource acquisition, but rather the companies are growing as hierarchal organizations.

By knowing the dominant culture applied in the companies and the demand of the business environment, companies can determine the feasibilities of changing in order to achieve effectiveness. For instance, managers wishing to encourage innovation may need to manage themselves from a strongly hierarchical culture towards adhocracy or incorporate the appropriate elements into their organizations.

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VALIDATION OF A VISUAL PERCEPTION MODEL

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ABSTRACT

Validation of a perception model is presented. Based on a newly developed mathematical perception theory the visual perception is modelled as a probabilistic process obtaining and interpreting visual data from the environment. A perception derivative, namely *visual openness* perception, is investigated. The openness perception is quantified by means of a mapping function which converts distance data to perception information. In an experiment 30 human experimenters provided 180 openness perception statements. From this data a representative set of statements is derived by means of clustering, where the statistical properties of the data set are duly taken into account. From this representative set the openness perception model is optimized by means of a genetic algorithm. This way minimal difference between modelled perception and the perception statements is achieved. The outcome of this work is a validated openness perception model, which is representative for the perception of the experimenters in the spatial environment considered. It can be applied to measure the visual openness of spaces during architectural design, which can be essential information provision guiding the design. It is also applicable in the analysis of existing architecture to determine its openness perception properties.

Keywords Visual perception, perception modelling, perception measurement, model identification, genetic algorithm

1. INTRODUCTION

Architecture is mainly concerned with the creation of spaces. Next to satisfying functional and cost requirements, architecture should also have other qualities, in particular those regarding the quality of form. People expect an *additional value* from architectural designs, namely a value associated with the *perception of space*. Not only should a new building look attractive, but people should also feel good inside the building and in its surroundings. As the architect's task is to provide such perception related qualities, it is easy to understand why visual perception is one of the important subjects of architecture and architectural design. Despite the evident relevance surprisingly few is known, however, about what perception exactly is and how we can treat it scientifically.

When we perceive an environment, it is likely that we "overlook" some items in it. This familiar phenomenon appears not to be striking at first glance. However, when we wish to explain it we need to know what perception is. If we think that perception is like taking a photograph, it should not be possible that we miss any items of a scene, since all information is captured. So, obviously, perception must be more complicated than that. The complication stems from the fact that in human vision, not only the eye is involved but also the brain.

The involvement of the brain is the main source of difficulty for treating perception scientifically, because the brain processes are complex and essentially unknown. Brain researchers, for example, see (Hubel and Wiesel, 2004; Arbib, 2003), trace visual signals as they are processed in different components of the brain. However, due to the great complexity of the processing, the relation between environmental stimulus and the corresponding mental act of seeing remain unknown.

Psychologists, e.g. (Gibson, 1986; Palmer, 1999; Ashcraft, 2006), as well as Philosophers, e.g. (Foster, 2000; Robinson, 2001), offered various verbal definitions on perception. Such definitions are helpful to understand what perception is about. However, they do not hint on what it is exactly, and how to treat perception quantitatively. Demystification or precise description of perception is necessary for proficient executions in architecture, where decisions about the built environment should be taken based on some solid reasoning.

In the area of virtual reality (VR) attempts were made to model visual perception, e.g. (Herrero et al., 2005). In that approach human vision is modeled using classic, deterministic methods, so that the fundamental uncertainty of human visual perception is not accounted for. That is, deterministic methods are unsuitable to model the common perception phenomenon that the presence of an object within the visual scope of an observer does not warrant that the observer will see it. Hence such models are not models of human visual perception.

Summarizing the state of the art in perception research we note, that vision related concepts are only verbally described until now. Therefore their definition does not have precise consensus in the literature, although they roughly coincide in essence. There exists no theory of perception, which defines vision, perception, and derivative concepts, such as visual openness perception, in precise terms or quantifies it.

Having noticed that, in this research a novel theory of perception is developed, which is named *Probabilistic Perception Theory* (Ciftcioglu et al., 2006a). In this theory, the human visual perception is put on a firm mathematical foundation. This is accomplished by means of the well-established probability theory of mathematics. Through the novel theory twofold gain is obtained. Firstly, the perception and related phenomena are understood in greater detail and the reflections about them are substantiated. Secondly, the theory can be effectively introduced into architectural design, where perception and related aspects of designs can be quantified. It is foreseen that this can be a significant step in architecture. Namely, intuitive design-decisions are supplemented or backed-up by some solid reasoning. Next to that existing architecture can be assessed without unwanted bias, which may be desirable.

In this work, the probabilistic perception theory is implemented in a virtual reality (VR) environment, where a virtual human is equipped with human-like vision. Visual information, which the agent perceives from the environment, is treated computationally to measure the agent’s visual openness perception of the environment (Bittermann and Ciftcioglu, 2006a). Visual openness is an important concept in architectural design. It directly relates to a number of relevant design criteria, such as overview, way finding, and comfort.

The aim and scope of this paper is the identification of a visual openness perception model, which represents the openness perception of a number of persons. The openness model is based on the newly formed probabilistic perception theory mentioned above.

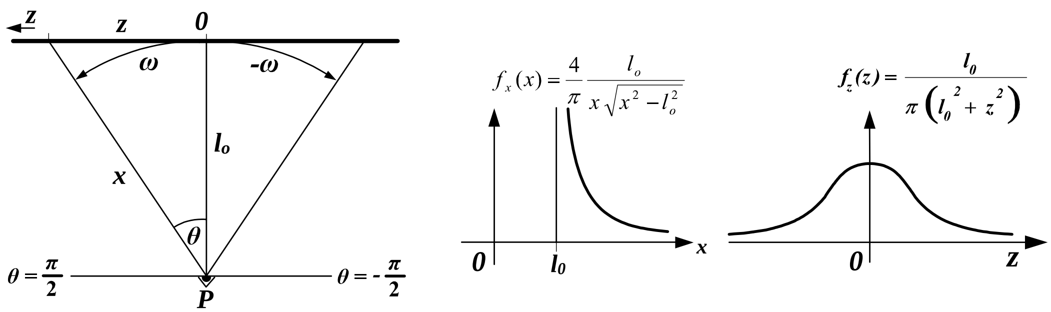
The paper is organized as follows. First the probabilistic perception theory is described and the perception derivative *visual openness* is defined. Then the model identification process is explained and the results of model validation are presented.

2. A THEORY OF VISUAL PERCEPTION

Probabilistic Perception Theory
Vision is a complex process. It involves image acquisition with the eye and interpretations in different regions in the brain. Since this process is formidably complex and details of it are not known, its modeling is formidably difficult when classical, deterministic methods are used. The well-established probability theory of mathematics is particularly suitable to handle such high complexity and uncertainty. The main principle of modeling by probability theoretic considerations is to absorb complexity and uncertainty into probability.

To illustrate this, let us consider a coin-toss experiment as an example. When a coin is tossed it undergoes a large amount of physical interactions with air molecules around, the surface it lands on, etc. Modeling this process is a formidable task, if we endeavor to model each of the interaction events. However, if we are interested in modeling the result of the process we can model the situation perfectly by stating, that the probability of the outcome is 0.5 for the event that the coin lands on either side. The meaning is, that when we make a single coin toss, we cannot predict with certainty, which result will appear. However we attach a probability to the possible outcomes, which absorbs the total complexity of the experiment. When we make a large amount of experiments, the model is verified as the ratio of the results approaches to the number assigned as probability.

With respect to human vision, a probabilistic model is most appealing, as it absorbs the complexity of the eye/brain process by the probability theoretic considerations. This results in a robust match between model outcome and the perception phenomena we commonly experience. To introduce the theory we start with the basics of the perception process of a simple yet fundamental geometry (Ciftcioglu et al., 2006a). This is shown in figure 1.



(a) (b) (c)

Figure 1. The geometry of visual perception from a top (a); $f_x(x)$ is the probability density function of perception for the distance between observer and plane (b); $f_z(z)$ is the probability density function of the perception along the z direction (c).

In the figure an observer is facing and viewing a vertical plane from the point denoted by P (a). By viewing the observer pays visual attention to all directions equally in the first instance. That is, the observer visually experiences all locations on the plane without any preference for one region over another. This is the axiom of the theory. It is based on the simple fact that we cannot assume that an observer has a preference for any particular direction in view before having information about the environment. In other words, a possible preference for objects or events in the environment can only be exercised when the environment is perceived already. The axiom entails that the attention is the same for each single differential visual resolution angle $d\theta$ of the view.

The angle θ is a *random variable* in the terminology of the probability theory. In mathematical terms, the axiom stated above translates into the following: the probability density function (pdf), which belongs to the angle θ is uniformly distributed. Since θ is trigonometrically related with each point on the plane, the distances x or z, which are indicated in figure 1, are also random variables. The next step is to compute the density functions of these random variables. In other words, we model the *visual attention* for the environment. For this purpose we apply a theorem of the probability theory, which is known as the *theorem of the function of a random variable* (Papoulis, 1969). The pdf $f_x(x)$ and $f_z(z)$, which model the visual attention, are computed (Ciftcioglu et al., 2006a) and are shown in figure 1(a) and 1(b).

Integration of the visual attention pdf within a finite interval is defined as *perception*. This means perception is the intensity of attention. Perception is real and physical. Important conclusion is that it is given by a probability. Namely, *perception is the probability of consciously realizing properties of the environment*. In other words, *perception is seeing with uncertainty.* The important massage for architects is that perception depends on the geometry of the environment and it can be computed. It is given by probability, which means it is a probabilistic event. When the experiment about this event is over the event takes a definitive form, so that probability does not prevail any longer. This conclusive or definitive form of perception is “seeing”, which corresponds to perception with the probability of *1*.

From visual perception to visual openness perception

Any cognitive interpretation of visual information in our environment requires perception as an initial, fundamental step. Since perception is mathematically defined and quantified in the probabilistic perception theory described above, cognitive derivatives of perception can be also defined and computed. One of such derivatives is *visual openness* perception, which is the focus in this paper. We define visual openness perception verbally as the visual perception of far distances. It is derived from the perceived distances between observer and environment. The association between perceived distance and openness is represented in this work by means of a sigmoid function. The variation of the sigmoid with the independent variable x, which represents a perceived distance, is shown in figure 2.

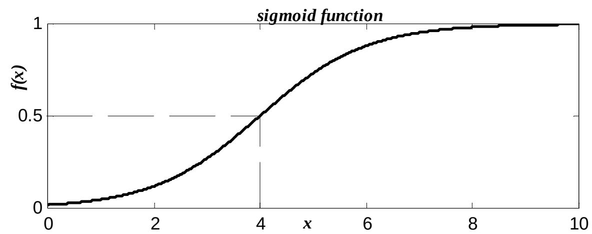


Figure 2. The Sigmoid function, $f(x)=1/[1+exp\{-(x-x_o)\}]$, with $x_0=4$. In the visual openness perception determination the sigmoid is used to map the distance x between observer and environment to openness perception $f(x)$.

The characteristic behaviour of the function is its saturation at the extremities and its approximately linear behaviour in the middle range. Qualitatively, by means of the sigmoid function the perception of the visual openness at small distances is considered to be small with no significant change in this fuzzy range. A similar behaviour is observed at the other extreme, where the visual openness perception does not deviate significantly as the distance approaches to extreme values. At the middle range, the visual openness perception is highly dependent on the distance, as one should expect. These qualitative observations about the openness perception model are similar to many other biological processes of human beings and they conform to our common, everyday visual openness perception. Another interesting feature of sigmoid is that it is used to measure the perception quantitatively in the range between 0 and 1. This is a significant feature, especially since the virtual human is experiencing and evaluating the visual openness of a space as a fuzzy statement.

Implementation to virtual reality

For measurement of perception in virtual reality a stochastic sampling process is employed. This is necessary in order to cope with the geometric complexity of environments, were analytic computation of the probability density of the perception becomes unfeasible. Through the stochastic sampling process the perception measurement is conducted in real-time. This is desirable for design, were fast information provision is rather necessary. To simulate the human vision a virtual observer is employed in virtual reality as shown in figure 3.

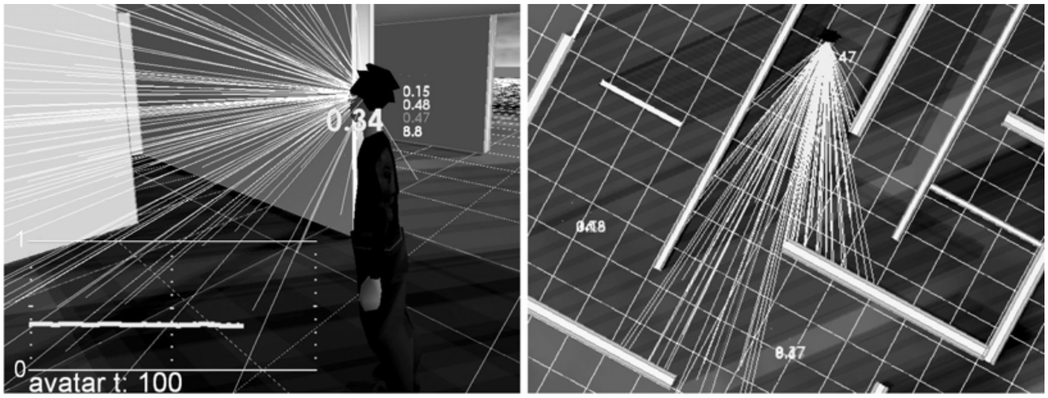


Figure 3. Virtual human viewing environment for visual openness perception determination. The visual perception has a Gaussian shaped visual attention pdf as approximation to $f_z(z)$ shown in figure 1(c).

The virtual observer senses its spatial environment by sending rays from its eyes and measuring each length as they hit shapes, which are around the observer. The rays are sent in random directions with a Gaussian pdf as an approximation to $f_z(z)$ (Ciftcioglu et al., 2006b). To model such forward oriented vision in 3D-space in conformity with the analytically computed pdf of visual perception, as it is depicted in figure 3, is explained in another work (Ciftcioglu et al., 2006c).

In the virtual reality implementation a number of rays are traced and their lengths, that is the distances between observation location and objects in the environment, are obtained. Consequently the same amount of perception data is collected. For each individual ray an elemental visual openness perception is computed via the sigmoid function. By averaging these individual mapping function outcomes, the visual openness perception, as a measurement outcome, is obtained (Bittermann and Ciftcioglu et al., 2006a). The averaging is performed on a sample-by-sample basis so that the time-dependent measurement can be obtained in real-time. This is accomplished by means exponential averaging. In exponential averaging previously obtained average information is incorporated into the computation of the current average. This way the average, which is the measurement outcome, is updated in real-time in a computationally efficient and effective way.

3. MODEL VALIDATION

Identifying a common perception model

Identification of a common visual openness perception model means to find the appropriate value for the perception model parameter, so that the modelled perception matches with the perception of a number of people. In our case, we consider the visual openness perception, so the model parameter to be identified is the x_o parameter of the sigmoid function, shown in figure 3. Goal of the determination of the appropriate x_o value is to minimize the difference between model output and human perception. For this purpose, a number of perception outcomes are computed for a selection of scenes. These scenes are also subject to perception assessment by a number of test persons, who are referred to as experimenters. The scenes are shown in figure 4.

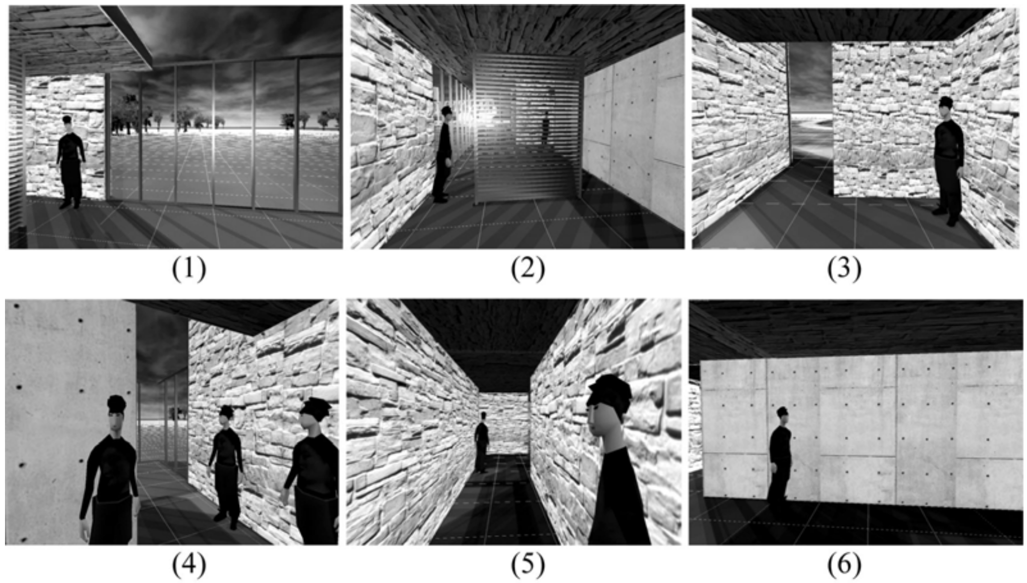


Figure 4. Screenshots of the six scenes, which are subject to visual openness assessment by the human experimenters as well as via the perception model.

In the present case one unit in the virtual reality corresponds to 1 meter in reality. Scene 1 shows a space with wide proportion and a glass façade in the front. The space is partially covered with a ceiling. The distance from the virtual camera to the façade is *3.2* units. Scene 2 shows a long room with a screen in the middle consisting of horizontal louvers. The screen partially blocks vision to deeper areas of the room. The distance from the camera to the screen is *3.0* and to the back wall *9.5* units. Scene 3 shows a small room with an opening to the exterior. The distance to the frontal wall is *2.8* units and the width of the room is *3.9* units. Scene 4 shows a hallway, which is delimited by a stone wall and a concrete wall. The distance between camera and concrete wall is *1.5* units, and the ceiling ends at the same distance. Scene 5 shows a corridor, which is *2* units wide and *7.5* units long. Scene 6 shows a space with a concrete wall, that is oriented approximately perpendicular to the view and it is positioned at 3 units distance from the camera. On the left of the wall is a passage that is 2 units wide.

In this experiment the experimenters viewed the scenes on a common 17” screen in sitting position with a horizontal field of view of 90º in the virtual reality. To enhance depth estimation a number of virtual humans are inserted in the scenes and the transitions from one scene to the next are animated in 3D. After viewing the scenes the experimenters gave their subjective assessments of the visual openness for each scene on a scale from zero to ten. In case of visual openness, ten signifies maximum and zero minimum visual openness. The experimenters assessed the scenes in random order. In total 180 statements were collected from 30 experimenters. These statements are then normalized to values between zero and one, matching the range of the sigmoid function used in the measurement model. The normalized statements are shown in figure 5(left). The variation of the statements (σ) is shown in table 1.

Table 1. Variation of the estimates per scene.

	scene 1	*scene 2*	*scene 3*	*scene 4*	*scene 5*	*scene 6*
σ	0,010	0,036	0,021	0,025	0,039	0,029

Clustering the statements

As a first step towards the identification of the appropriate openness model we first obtain a set of six statements, one for each scene, which represents most appropriately the 180 statements. This is to handle the softness of the perception derivative, where the variation among experimenters' perception statements is rather high. The representative set is determined by means of clustering of the statements. The goal is to find the cluster centre that is a virtual statement, which has the least difference from the statements of the experimenters. To reflect the statistical properties of the statements to the cluster centre we take their difference as Mahalanobis distance, where the Euclidian distance is weighted by the standard deviation of the data samples, taking into account the statistical properties of the statements for each scene, respectively. The Mahalanobis distance is

$$d(X,Y) = \sqrt{\frac{(x_1 - y_1)^2}{s^2_1} + \frac{(x_2 - y_2)^2}{s^2_2} + \ldots + \frac{(x_6 - y_6)^2}{s^2_6}} \quad (1)$$

where the vector X represents the cluster centre, Y represents one person's statement and s_1^2, s_2^2, etc. are the standard deviation of the statements for each scene respectively. The cluster centre can be obtained by means of fuzzy clustering of fuzzy logic, which is particularly suitable if multiple cluster centres ought to be used to represent the data set. In our case one cluster centre is pursued, so for this purpose, as alternative to fuzzy clustering, we employ genetic algorithm, with the Mahalanobis distance calculation in the fitness function. Genetic algorithm is a combinatoric search methodology from the domain of computational intelligence, which is particularly suitable for finding optimality in large, non-linear, and discrete search spaces. The method is inspired by natural evolution in that it provocates the emergence of optimal solutions by selectively reproducing, combining, and mutating possible solutions. The selection is probabilistic, and the probability is based on the respective fitness of the possible solutions (Goldberg, 1989). The resulting cluster centre for our data set is shown in table 2. For verification purposes the clustering process is repeated by means of fuzzy clustering, and the result is shown in table 3.

Table 2. Resulting cluster center obtained via genetic search.

scene 1	*scene 2*	*scene 3*	*scene 4*	*scene 5*	*scene 6*
0.82	0.62	0.45	0.50	0.30	0.31

Table 3. Resulting cluster center obtained via fuzzy clustering.

scene 1	*scene 2*	*scene 3*	*scene 4*	*scene 5*	*scene 6*
0.80	0.62	0.45	0.50	0.32	0.30

Model identification

The next step is to identify the appropriate model parameter x_o in the visual openness mapping function, so that the perception model output differs minimally from the statements of the experimenters. The parameters, which define the vision model, can be computed (Ciftcioglu et al., 2006c) so that the vision model becomes stationary. In the model identification, although it is not compulsory in the stationary case, for convenience genetic algorithm is used. The process of model identification by genetic algorithm in a non-stationary case is described in another work (Bittermann and Ciftcioglu, 2006b). The value of the model parameter found by genetic search is $x_o=4.16$. This value is the optimal shift in the sigmoid mapping function to represent the experimenters' visual openness perception for the present scenes.

Model validation

With the calibrated model, the visual openness of the six scenes is measured. The results are presented in table 4, where the modelled openness perception is compared with the representative statement obtained by clustering. The difference between model output and statements is shown as well.

Table 4. Comparison of representative openness statement and model output.

scene	*rep. statement*	*model output*	*error*
1	0.82	0.76	0.06
2	0.62	0.51	0.11
3	0.45	0.38	0.07
4	0.50	0.45	0.05
5	0.30	0.42	0.11
6	0.31	0.33	0.02

Figure 5 shows the statements of the experimenters (left) as well as the absolute difference between the statements and the perception model outcome (right). The absolute error between the experimenters' statements and the model output, averaged over the 30 experimenters, is shown in table 5.

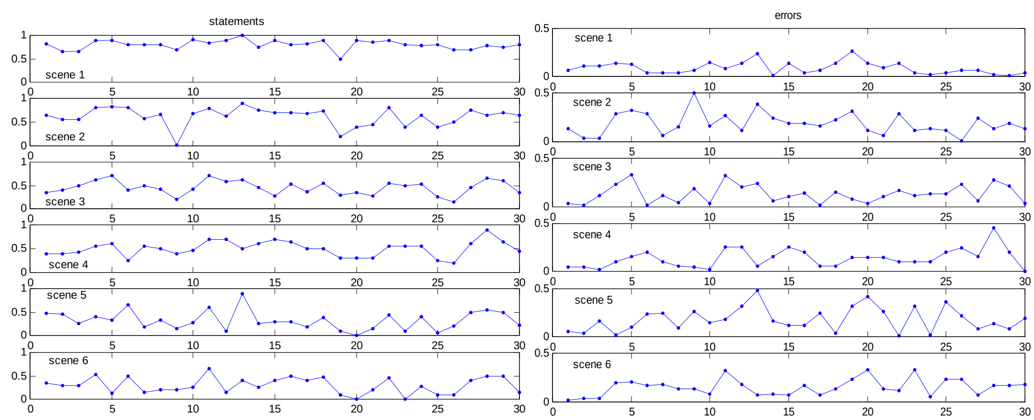


Figure 5. 180 visual openness statements obtained from 30 experimenters for the six scenes shown in figure 5 (left); the absolute difference between the statements and the perception model output is also shown (right).

Table 5. Averaged absolute difference between the statements and the model output.

	scene a	*scene b*	*scene c*	*scene d*	*scene e*	*scene f*
average error	0,089	0,186	0,133	0,136	0,181	0,150

4. CONCLUSION

The basis of this work is a novel theory of visual perception, which is named *Probabilistic Theory of Perception*. The theory introduces the concept of perception as conditional "seeing", which is subject to probability. The unique supposition above is the axiom of this theory. Perception is defined in various forms in the literature. Since it is a complex process, which includes brain processes, ample space is provided to speculate about it. What is substantial in the present work, is that all imprecision and vagueness involved in the perception process is taken care of by the theory of probability, which is a well-established theory. The newly developed *Probabilistic Perception Theory* may be seen as a unified theory, as it is unifying synergistic vision-related processes, including physiological and neurological processes of humans.

Based on the probabilistic perception theory a perception derivative, namely *visual openness perception*, is investigated. The visual openness perception model is presented and exercised by a virtual observer having human-like vision in a virtual environment. The virtual human provides quantified openness perception assessments as measurement outcomes for a number of scenes. The scenes were also subject to perception assessment by a number of human experimenters. The statements by the experimenters are used to identify a jointly valid openness perception model, which represents optimally the openness perception of the experimenters for the scenes. The results indicate that the model represents satisfactorily the visual openness perception of the experimenters for the intended architectural design purpose.

The relevance of applying the perception theory to architecture is rather evident because visual perception plays an essential role in this domain. Visual openness has direct implications on relevant design criteria such as way finding, overview and comfort.

The essential contribution of the work is that our conventional rational reasoning about perception in design is substantiated by solid mathematical reasoning, and perception is quantified. The foreseen benefits for architecture, which arise from integrating the probabilistic perception theory, are summarized as follows:

1.) Design: By modeling perception, the implications of design decisions for perception are quantitatively known, so that architects can enhance their decision making.
2.) Collaborative design: Perception aspects can be systematically and explicitly considered together with the other relevant issues of buildings. Thereby the decision-making process becomes more transparent and Pareto-optimality can be pursued.
3.) Real estate: Perception usually plays an important role in the assessment of the value of existing buildings. By modeling perception, the assessment becomes unbiased, which is an essential feature in the comparison of buildings.

It may be noteworthy to mention that computational perception is not intended to, and cannot substitute the excellence of human individuals in terms of decision making in design. Its purpose is to take this excellence to a higher level by providing insight into perception and substantiating our intuitive design decisions.

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A SIMULATION MODEL FOR ASSESSING CONSTRUCTION PROJECTS SUSTAINABILITY PERFORMANCE

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ABSTRACT

Sustainability has become a concerned issue within all built environment stakeholders. Construction projects play a major role in the sustainability of the world as any construction project should ensure that the great investment achieves good sustainability performance. It is essential to be able to assess a construction project's sustainability performance. This paper presents the development of a simulation model by using system dynamics to be used to assess construction projects' sustainability performance to integrate social, environmental, and economic factors. Whilst this development contributes significantly to the promotion of sustainable construction, it is also important that the levels of sustainability performance actually achieved can be widely understood and easily communicated within the main stakeholders.

Keywords: model, performance, simulation, sustainability, and system dynamics.

1. INTRODUCTION

Sustainability has become a concerned issue within all built environment stakeholders. Construction projects play a major role in the sustainability of the world. It is well recognised that the construction industry is one of the major contributors to the depletion of natural resources and a major cause of pollution (Augenbroe and Pearce, 1998; HKCIRC, 2001; Treloar et al, 2003). Construction projects should ensure that the great investment achieves good sustainability performance. It is essential to be able to assess a construction project's sustainability performance quantitatively and qualitatively.

In recent years, social, economic and environmental pressures to measure construction projects sustainability performance have led to an emphasis on sustainability development ability model (Shen et al 2004; Tam et al 2005). Sustainable construction addresses the responsibility of the construction industry for attaining sustainable development widely referred to as the sustainability of economic development, social development and environmental development (Ofori, 1992; WCED, 1987; UNCHS, 1996). The shortage of methods to assess sustainability performances presents the barrier of assessing whether the implementation of a project will or not contribute acceptable level of sustainability performance. Although sustainable development ability (SDA) model was developed by Shen et al in 2002 to measure the contribution of a project to the attainment of sustainable development, it was recognized by Shen et al in 2004 that a major limitation of the SDA model is that the measure did not consider the impacts of various dynamic factors. According to the general principle of sustainable development, economic, social and environmental developments are the main contributors (WCED, 1987). As social, economic, environmental and institutional processes have become increasingly interwoven (Hill et al, 1997; Kein et al, 1999), it is necessary to take integration into consideration when measuring the sustainability performance of construction projects.

To improve the scientific understanding of integrated systems, a system dynamic simulation model could explicitly shed light on the dynamics and complexity of assessing sustainable performance as it is capable of analysing the interrelationship between all the disciplines involved in the process (Hao et al 2006).Therefore, the focus of this paper is to demonstrate how a system dynamic simulation model, SDA, was developed to integrate social, economic, and environmental factors by using system dynamics to assess sustainable performance of a construction project.

2. SUSTAINABLE CONSTRUCTION

The report by the Hong Kong Construction Industry Review Committee (HKCIRC, 2001) identified the construction industry as among the worst polluters. This has been widely echoed by many researchers, for example, Tse (2001), Shen and Tam (2002), Treloar (1996), Baba (1998), Griffith (1999), CIB (1998), Sjostrom and Bakens (1999). While these findings demonstrate the significant adverse impacts of construction businesses on the environment, they also reflect the tradition of managing a construction project for focusing on controlling cost, time and quality but less attention to environmental and social performance in implementing the project. The realization of these facts has led to the growth of studies on sustainable construction solutions across a project life cycle (Hill and Bowen, 1997; Brochner et al, 1999; Heerwagen, 2000; Tam et al, 2002). Whilst safety and environmental management have been added into the context of construction management (Griffith, 2002), their effectiveness has been limited in practice. This is partly due to the profit-driven culture in the industry where the cost, quality and schedule have been the determinants ensuring maximum benefits to the construction business. It is also due to the difficulty of measuring the contribution of a construction project to environmental performance.

The existing literature also provides rich information on the application of sustainable construction, for example, the UK Building Services Research and Information Associations' Environmental Code of Practice for Buildings and their Services (Halliday, 1994). Hill and Bowen (1997) presented a framework for attaining sustainable construction. In this framework, a systematic understanding of the principles of sustainable construction is provided, which are divided into four 'pillars' of sustainability, namely, social, economic, biophysical, and technical. Wyatt (1994) proposed an approach for promoting sustainable construction by managing the service provision of a building during its lifetime from inception to eventual deconstruction, recycling resources and reducing the waste stream during the building's lifetime. A study by Tam et al (2002) examined the obstacles in promoting sustainable construction, and has found that one of the key obstacles is the lack of performance evaluation criteria. The above mentioned are not the only models. Other researchers have developed various approaches and methods for promoting sustainable construction, for example, Brochner et al (1999); Heerwagen (2000); and Griffith

(2002). A recent study (Kattz et al, 2005) more precisely looks into sustainable development implemented within the construction process. These works have contributed to the theoretical platform of sustainable construction studies. Nevertheless, none of these has provided any method for assessing the level of sustainability performance of a construction project by integrating economic, social and environmental factors through system dynamics.

3. DEVELOPMENT OF A SIMULATION MODEL

Modelling method and software

System dynamics was developed by Forrester (1957), and has achieved world-wide recognition as a well established methodology for studying and managing complex construction related systems and environmental systems (Dyson and Chang, 2005; Ford, 1995; Hao and Scott, 2001; Love et al, 2002; Rodrigues and Bowers, 1996; Sterman, 2000).

This study will employ system dynamics approach which has been widely used in analyzing systems that are complex, dynamic and has many nonlinear interactions. Several major works provide useful references in using the approach for conducting simulation, for example, Pena-More and Li (1999), and Dolol and Jaafarl (2002). To simulate a system dynamics model, there are existing computing softwares, for example, *DYNAMO, VENSIM, Stella, and Matlab*. *Stella* has been developed as an effective simulation tool by High Performance Systems, Inc (HPS) (HPS, 2005) as the mapping, modelling, and simulation capabilities of the software can transform an exercise in linear extrapolation into a powerful learning experience that captures the dynamic complexity of sustainable construction.

Structure of the simulation model

For assessing the sustainable performance of a construction project by using system dynamics approach, the measure SDA is considered as a stock, and an impact from dynamic factors to the value SDA can be considered as a flow. Therefore, an increase or decrease of the parameters *E(t), S(t)* and *En(t)* discussed above can be considered as the flows to SDA. For example, when a project brings an economic gain, namely, an increase in *E(t)*, a positive impact to the value SDA is received. This will produce an in-flow to the stock, and the volume of SDA will increase. An increase in SDA indicates that a positive contribution to the attainment of sustainable development is received. On the other hand, SDA will decrease if an out-flow occurs, indicating that a negative impact to the attainment of sustainable development is received. This may be due to that environmental pollution is induced in implementing a project. A convertor is employed to define the level of influence of each flow on the stock SDA, or the way in which the flow influences the value SDA. To simplify the analytical process, the calculation of the value SDA is proposed as a weighted value between the three dynamic attributes *E(t), S(t)* and *En(t),* which can be written as the following dynamic model:

$$\begin{cases} SDA(t) = \int_0^t W_E(t) I_E(t)dt + \int_0^t W_S(t) I_S(t)dt + \int_0^t W_{En}(t) I_{En}(t)dt \\ W_E(t) + W_S(t) + W_{En}(t) = 1 \\ I_E, I_S, I_{En} \in [-100, 100] \end{cases} \quad (4)$$

Where $I_E(t)$, $I_S(t)$ and $I_{En}(t)$ denote respectively the dynamic functions of generating economic impact, social impact and environmental impact from implementing a construction project. The values of the variables I_E, I_S and I_{En} are defined as relative measures within the interval [-100,100]. Variables W_E, W_S and W_{En} denote respectively the weights of economic impact, social impact and environmental impact to SDA. By applying these parameters to the model defined, a prototype model of SDA using system dynamics method can be developed as shown in Figure 1.

A simulation model using 'Stella' software is developed shown in Figure 1. The values of the economic sustainability (E(t)), social sustainability S(t)) and environmental sustainability (En(t)) are seen as 'flows'. When there are in-flows to the stock, the sustainability performance value will increase, indicating a positive contribution to sustainable development (for example, a new environmental protection measure). Otherwise, if out-flows occur, the sustainability performance will decrease, indicating a negative contribution to sustainable development, for example, the project pollutes the environment. The converter serves a utilitarian function, determining the relative weightings between system variables. It defines how much influence of the flow variables has on the sustainability performance. The three flows E(t), S(t) and En(t) will carry different weights in terms of their impacts on the sustainability performance value. Connectors show the connections between model elements.

To run the model, all values for various parameters need to be provided. As assumed, the weighting factors W_E, W_S and W_{En} are constants, and their values are given by decision makers. Different decision makers may allocate weighting values differently with considering the characteristics of different types of projects. For example, when the environmental impact is considered more important, the weight of environmental impact, W_{En}, will be more than 1/3. In another application, all the three weighting factors may be considered equally important and given with the same value (namely, 1/3). On the other hand, the parameters I_E, I_S, I_{En} are time functions, indicating that the implementation of a construction project will have different social, economic and environmental impacts at different stages across project life cycle. The values of I_E, I_S, I_{En} are determined respectively by economic related factors, social factors and environmental factors. Furthermore, the relationships between system elements including stock, flows, convertors and connectors need to be established in a specific application of the simulation model. These relationships can be adjusted in different applications.

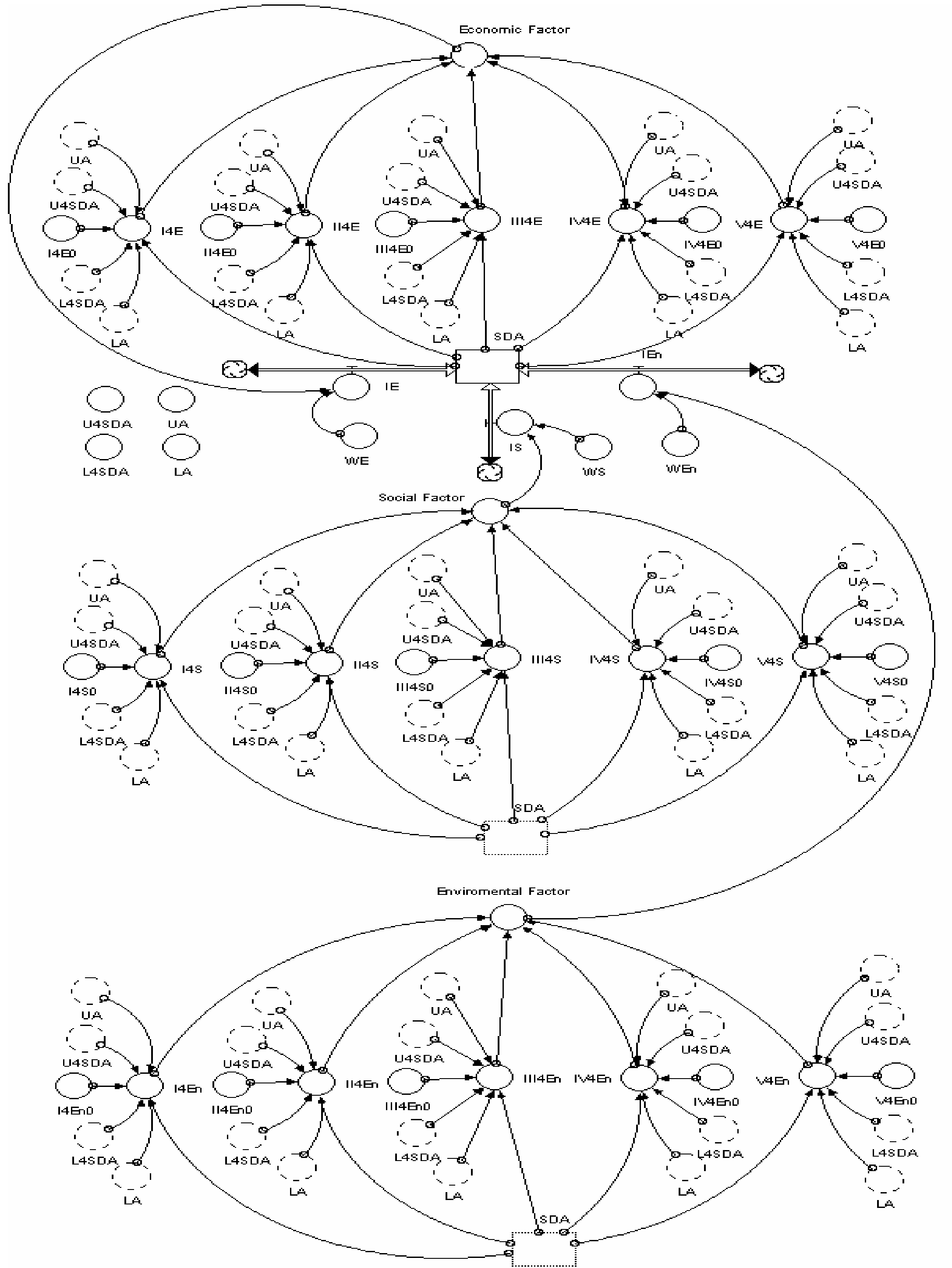

Figure 1 Structure of the simulation model

The data used to develop this simulation model are from a project feasibility study which includes economical, social and environmental assessment. The project is a renovation project located in Chongqing, China.

4. SIMULATION RESULTS

According to the project feasibility study report, the total investment of the project development is RMB 50 million. The operation of the project is expected to produce NaCN with the annual production of 4000 ton. The total land occupied by the plant is 30,000 m^2. The annual coal consumption is expected to be 13,663 ton during project operation period. In order to collect the initial values of these parameters, an interview with project client was conducted, and the results are shown in Table 1. In fact, the initial values of impact parameters are affected by many factors, and they can be revised as needed.

Table 1
The initial values of project performance indicators for FD NaCN Innovation Project

Stage	**Period (1/4y)**	**Economic (E)**	**Social (S)**	**Environmental (En)**
Inception (I)	(0, 1]	-10 (I4E0)	-60 (I4S0)	-50 (I4En0)
Construction (II)	(1, 5]	-100 (II4E0)	+50 (II4S0)	-80 (II4En0)
Commission (III)	(5, 6]	0 (III4E0)	-20 (III4S0)	0 (III4En0)
Operation (IV)	(6, 46]	+60 (IV4E0)	+30 (IV4S0)	-70 (IV4En0)
Demolish (V)	(46, 47]	+10 (V4E0)	-50 (V4S0)	-100 (V4En0)

Concerning weighting parameters (W_E, W_S, W_{En}), four scenarios are considered: (1) $W_E=W_S=W_{En}=1/3$, indicating that the economic, social and environmental impacts are considered as equally important; (2) $W_E=1/2$, $W_S=W_{En}=1/4$, considering that the economic impact is more important than social and environmental impacts; (3) $W_S=1/2$, $W_E=W_{En}=1/4$, considering that the social impact is more important than economic and environmental impacts; and (4) $W_{En}=1/2$, $W_E=W_S=1/4$, considering that the environmental impact is more important than economic and social impacts. For the control limitation, the lower limitation L4SDA=-50 and the upper limitation U4SDA=100 are adopted. The adjustment values LA=15% and UA=10% are used. To simplify the demonstration, it is assumed that the parameters L4SDA, U4SDA, LA and UA are constants across project life cycle.

Table 2 Simulation results of SDA for the Renovation Project

Year	SDA - Scenario (1)	SDA - Scenario (2)	SDA - Scenario (3)	SDA - Scenario (4)
1	0	0	0	0
2	-133.75	-182.22	-60.75	-168.03
3	-107.04	-120.06	-28.34	-193.16
4	-48.37	-19.44	21.66	-208.66
5	-21.71	60.56	71.66	-224.16
6	4.96	129.56	114.53	-239.66
7	31.63	187.56	145.53	-255.16
8	58.29	245.56	176.53	-270.66
9	84.96	303.56	207.53	-286.16
10	103.63	361.56	238.53	-301.66
11	108.96	419.56	269.53	-317.16
12	114.29	477.56	300.53	-332.66

After the parameter values are provided, simulation process can be conducted. The simulated results on the value SDA for the case project can be presented either by graphs or tables which are built in features within Stella. Concerning weighting parameters (W_E, W_S, W_{En}), four scenarios are considered. To simplify the demonstration, it is assumed that the parameters L4SDA, U4SDA, LA and UA are constants across project life cycle. Based on these conditions, Table 2 is produced to show the results with four different scenarios for the renovation project across the project's life cycle.

Scenario (1) $W_E=W_S=W_{En}=1/3$, indicating that the economic, social and environmental impacts are considered as equally important. The value of SDA is 114.29 at the end of the project life cycle. This indicates that the project is acceptable from the viewpoint of sustainability attainment through the project life cycle when decision maker gives equal weights to the economic, social and environmental impacts of the project.

Scenario (2) $W_E =1/2$, $W_S = W_{En} =1/4$, considering that the economic impact is more important than social and environmental impacts. SDA is 477.56 by the end of the project life. It indicates that the sustainability of this project is very good when the economic impacts are given higher weights than that given to social and environmental impacts. In fact, it was found from the discussion with project client that much higher weight was given to the economic impacts of the project. Therefore, this project can be considered feasible and good in contributing to the attainment of sustainable development.

Scenario (3) $W_S =1/2$, $W_E = W_{En} =1/4$, considering that the social impact is more important than economic and environmental impacts. The value SDA is 300.53, indicating that the sustainability of this project is good and acceptable when the social impacts of the project are given higher weights than that given to economic and environmental impacts.

Scenario (4) $W_{En} =1/2$, $W_E = W_S =1/4$, considering that the environmental impact is more important than economic and social impacts. For the control limitation, the lower limitation L4SDA=-50 and the upper limitation U4SDA=100 are adopted. The adjustment values LA=15% and UA=10% are used. According to Table 1, the value of SDA by the end of the project life is -332.66. It indicates that the sustainability of this project is very poor when the environmental impacts of the project are given higher weight. This project may not be acceptable in an environment where environmental protection is emphasized or in higher priority consideration.

5. CONCLUSION

In an effort to address how to assess a construction project's sustainability, the simulation model presented here is applicable to be used as an integrated means to improve understanding of the complexity involved in sustainability assessment. Such a simulation model is aimed at testing the effectiveness of various policy strategies, and estimating trade-offs among different policy options. The model can be helpful in monitoring and examining the goals and criteria set to measure sustainability.

In view of the growing complexity of attaining sustainability while constructing a project, there is a definite need for integrated approaches that assist decision makers and stakeholders in this undertaking. The purpose of this paper was to demonstrate a simulation model developed by using system dynamics methodology. The model considers that the contribution of a construction project to sustainable development can change largely due to the impacts of various dynamic variables across project life cycle. This indicates that the sustainability attainment from implementing a construction project can be improved by properly controlling various dynamic variables. System dynamics approach was found applicable in assisting in the prototype analysis. Through a simulation process, the model enables users to assess the dynamic impacts of implementing a construction project on economic development, social development and environmental development.

The integrated simulation model can be instrumental in formulating and underpinning targets for a more sustainable development of a project by balancing the economical, social and environmental factors. The procedures of applying the SDA simulation model are formulated and their effectiveness has been demonstrated by a practical example. From this demonstration example, it was found that when different weights are given among the three sustainable development contributors, namely, *E*, *S*, and *En*, the sustainability attainment from implementing a construction project will be different. This study provides valuable reference for further study on improving the sustainability attainment of a construction project.

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DEVELOPMENT OF QUALITY PERFORMANCE INDICATORS FOR QUALITY MANAGEMENT IN CONSTRUCTION PROJECTS

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ABSTRACT

The growing competitions among companies intensified by the rapid changes in business environments are forcing them to adopt a new managerial paradigm. The traditional production-oriented management focusing on higher productivity has transformed into the customer-oriented management aiming at achieving customer satisfaction. Under these circumstances, quality management is one of the critical concepts for innovating corporations and improving their competitive edge. Despite the companies' recognition of the significance of quality, most of them do not have a solid basis for quality management and substantial action programs. In the construction industry, there have been many attempts to adopt quality management as a tool for continuous improvement. They include Six-Sigma which has already been proven to be very useful for fostering quality innovation in the manufacturing industry. But these kinds of efforts are not sufficient enough to achieve organizational goals in quality management. It is essential to also take into consideration the root causes of inefficiency in the quality management.

The low level of construction quality is mainly caused by the result-oriented quality management owing to the fact that quality problems can be detected only after they occur. Also, few systems provide the quality managers with numerical objectives or tangible goals.

This study suggests a data-based quality management as a solution to the foregoing problems and discusses the methods of measuring and analyzing the performance related to quality in a construction company. It establishes the quality indicators to measure quality performance objectively. The management objectives and CSFs are defined according to the three management levels: strategic level; project level; and operational level, and then the indicators to measure and manage them are listed. The indicators are assigned to each quality management level and the level of quality is expressed with Sigma values. Through this quality performance management, managers will be able to improve the construction quality by monitoring the major indicators of construction project success and ultimately increase the competitiveness of overall construction organization.

Keywords: Performance, Performance Indicators, Quality, Quality management

1. INTRODUCTION

The shifts in business environments have intensified competition among companies, forcing them to adopt a new managerial paradigm. The production-oriented management that focuses on higher productivity is changing to a customer-oriented management focused at customer satisfaction. Under these circumstances, quality is one of the critical factors to increase their competitiveness, and quality management is one of the main issues for improving competitive edge of innovating corporations. However, most of the companies do not have a basis for quality management and substantial action programs even though they recognize the significance of quality.

Until now, quality has not been a priority factor considered in the construction project life cycle compared to other project management factors such as cost and schedule. Quality should be perceived as a critical success factor and be analyzed from a new perspective that considers the relationships with traditional key success factors in the construction industry. Recently, there have been increasing attempts to adopt quality as a tool for continuous improvement like Six-sigma which already proves its usefulness for quality innovation in manufacturing industry (Pheng 2004). The average level of quality of construction industry is comparatively lower than other industries like the textile and clothing industries and the electronics industry. The low construction quality is mainly attributed to the practice of result-oriented quality management.

This paper introduces some quality indicators for measuring quality performance objectively and with which to develop a quality performance management system to monitor the construction quality continuously. Through the quality performance management, managers will be able to improve the construction quality by monitoring the leading indicator that determines the success of a construction project and ultimately increase the competitiveness of the overall construction organization.

Quality management should be implemented in a more quantified and integrated manner to advance to higher managerial level as discussed in project management process maturity model (Kwak 2002). This paper suggests a method of measuring the quality level of project and enterprise by aggregating the quality of the respective works and materials, which is the lowest unit of quality management.

The scope to which the concept of quality can be applied in a construction company ranges from the management quality using TQM to the quality of material or labor on construction field. And quality data classified according to managerial levels should be aggregated and manipulated by those levels.

This paper limits the research scope to the quality of activity during the executing phase of the construction project. Among the quality concepts that shows diverse aspects according to project phases or customers by the delivery systems, the definition of quality is determined as "conformance to specification" in this paper. Subsequently, the degree of achieving construction quality of "conformance to specification" is defined as quality performance. The processes and results of this quality performance were analyzed with suggested indicators from the perspective of the main contractor undertaking overall field management during the construction stage.

This research was executed according to the following procedure. 1) Review the current status and problems of the quality management in construction project through literature review and establish the solution to them. 2) Analyze quality management process, and identify the problems and critical points in measuring and analyzing the quality performance. 3) Discuss the characteristics of performance indicators and systems, and develop the quality performance indicators linked to organization's strategies and quality objectives. 4) Find the data collecting method according to the established indicators, and plan the architecture for continual quality data accumulation. 5) Develop construction quality performance management process

2. QUALITY IN CONSTRUCTION

Quality management, which is a concept that had referred to simple inspections in the early 20th century, has continued to evolve to TQM, Six-sigma, and so on. Recently, quality places emphasis on the strategic direction, systematic approach, and organizational efforts.

There is a difference between a producer’s perspective and customer’s perspective with respect to quality. Quality from the producer’s perspective is the quality of conformance, making sure that a product or service conforms to the described design standards and quality specifications. Normally the design activities, the starting point of quality management, are completed before the products are manufactured, and design standards and quality objectives are set up according to the corporate strategy and customer needs. To assure that the quality is maintained throughout the whole product life cycle and not confined to a simple product quality, quality of goal achievement and quality of conformance to meet the specification can be applied for the construction project management.

According to Ledbetter (1994), quality is defined as the conformance to the established requirements and the requirements are regarded as the characteristics of product, process, or services specified by the contracts.

Quality Management Process

Prior to developing the quality performance indicators and continuous measurement system, the currently used quality management process should be analyzed as a preliminary work. Quality performance management practice, related organization, and incurred data can be reviewed during this process analysis.

Quality management process of the main contractors in a construction project is composed of four sub-processes, and they are quality planning, quality check, quality action, and quality analysis. In quality planning stage, a quality management plan that includes quality goals and organization on the project level and inspection and test plan(ITP) on the activity level are prepared. The tests and inspections for materials and finished works are executed according to the designated schedule in the quality plan during quality check stage. Items requiring additional managerial efforts are identified by the inspection results, and non-conformance reports are issued to the related sub-contractors during the quality action stage. In the quality analysis stage, the inspection results are periodically analyzed and used to evaluate the level of project quality. Non-conformance items are classified along with building types, project types, or trades, and managers assess the performance by comparing actual values to the original goals.

Quality inspections are classified into the factory inspection, material inspection on delivery, work-in-process inspection(surveillance), and final inspection, all of which have the common process of 'planning - executing - processing'. Quality action includes the measures to handle non-conforming materials or works along with the process of 'identifying - action-taking - confirmation' as shown in Figure 1.

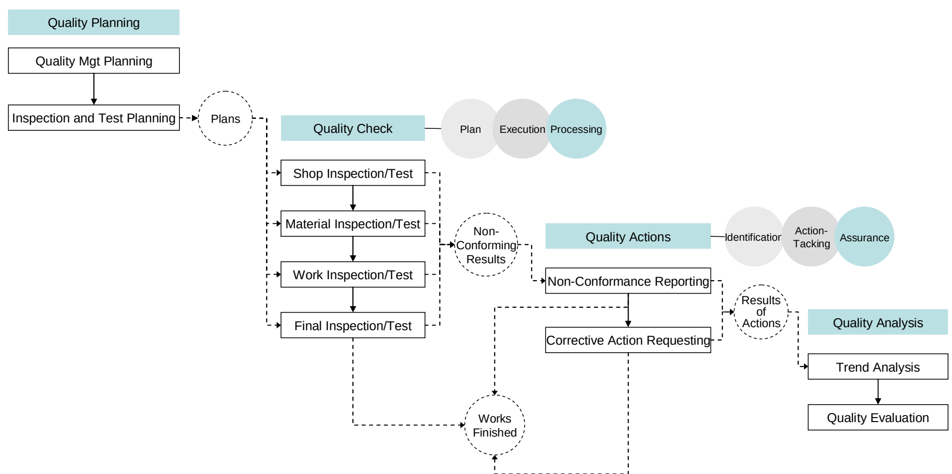

Figure 1. Process of quality management

Characteristics of Quality Management in Construction

Quality management is achieved by defining requirements based on organization's vision, and executing activities to satisfy them. The quality objects to be achieved through quality management in construction projects vary according to various factors such as types of customer, project phases, participants, construction methods, and so on. These factors are determined by the characteristics of project and influence the quality management system and contents. The quality level of the construction project tends to depend on whether proper quality control system is developed considering project characteristics and organizational capabilities. The quality performance should be evaluated continuously based on these factors.

Current quality management is focused on the results of works, and materials scheduled to be installed. Though other resources put to activities on construction site like labors or equipments affect the productivity and quality (Lee 2004), normally they are not included in the scope of quality management.

The current quality assurance system does not provide a quantitative ground for quality management. For time management and cost management, time, cost, or ratios are provided to the managers to help them perceive intuitively the managerial objectives and status. But most of the objectives in quality management have qualitative attributes and there is no method to properly assess the quality. Quality problems are intrinsically difficult in detecting before they occur and they are identified when managers confirm them (Garvin 1984). So, quality management are likely to be result-oriented without a proper preventive system that converts quality's result-oriented characteristic to predictable values.

The characteristic of the construction industry that it depends on the field production is one of the main obstacles in ensuring the performance (Kubal 1994), and CII (1994) summarizes problems of quality management in construction industry as follows.

- For end results rather than process steps; that is, most measurement processes are a non-predictive manner of measurement.
- Focused on isolated phases with minimum integration.
- Geared toward short-term improvements vs. long-term strategic goals.
- Seldom developed by the full project team (owner, engineer, and contractor).
- Not well-suited to benchmarking.

Literature Reviews on Quality Performance Management

Davis (1989) designed QPTS (Quality Performance Tracking System) and discussed the definition of quality, requirement analysis, and application to cost/schedule system. Ledbetter (1994) developed QPMS (Quality Performance Management System) for estimating quality costs based on labor costs. Love (2004) measured the quality costs with PROMQACS (Project management quality cost system) including problem types, related trades and organizations, quality cost types, and impact on schedule/cost. All these researches regard quality costs as the major indicator and discuss the measurement of quality costs and their actual proportion to project costs.

Cheung et al. (2004) developed PPMS (Project Performance Monitoring System) for monitoring quality by using the performance indicators shown in Table 1.

Table 1. Quality-related indicators (Cheung 2004)

Category	Performance indicators
Inspections	• Number of site inspections conducted
Non-Compliance Records	• Number of non-compliance records received • Number of non-compliance records closed • Total number of non-compliance records rectified • Average time to close out non-compliance records
Work Rejection	• Due to workmanship • Due to lateness
Survey (Samples) Rejection	• Due to workmanship • Due to lateness

Cheng et al. (2000) suggested the quality-related measures as shown in Table 2. Quality measures were developed to improve client confidence, increase client satisfaction, and increase construction durability, and rework is measured to reduce wasted work.

Table 2. Quality-related measures (Chung 2000)

Criterion	Measure	Measuring unit
Quality	Rejection of work Client satisfaction Quality of work	• % sample rejections • Number of claims by client • Number of claims by contractor
Construction Process	Rework	Rework MH/total MH

In UK providing and managing KPIs to measure and analyze the construction performance as a social system, quality issues are classified into three types: rejected; reworked; and compromised. The cost and time incurred to rectify quality issues are measured, and the sources of quality issues are also reported with the categories of workmanship, design/specification, defective materials, damage on site, and others.

Existing quality management systems in practice are focused on processing the quality management tasks, and provide a simple function of generating the periodical reports to monitor the quality status. To complement this shortcoming, various quality performance indicators need to be developed and settled in the performance management process. Also, the process that includes identifying the causes of quality problems, developing necessary actions to resolve them, and establishing the goals should be suggested in accordance with the general framework of performance management to overcome current systems' failure to trace the root causes in performance variation.

3. QUALITY PERFORMANCE OF CONSTRUCTION PROEJCTS

Quality Performance Management Process

Performance measurement means the process of evaluating performance relative to a defined goal, and performance metrics are defined as the analytical tools in the performance measurement process that take measurements, display results, and determine subsequent action (Rose 1995).

The performance measurement system in specific organization should have a balanced framework between cause and effect, efficiency and effectiveness, etc. In the measurement and analysis of the quality performance, it is important to identify the points needing improvement and formulating the solutions through the indicators able to analyze the process, taking into consideration that one of the drawbacks in traditional business is the result-oriented measurement (Pande 2001). As pointed out by Bassioni (2004), the feedback loops and subsequent decision-makings are required to transform measurement system into the management systems including decision-support functions.

In the construction projects, work progress is managed with process factors while the monitoring is based on the result factors. The managers on the lower level are interested in the process factors, while the upper management places more emphasis on the measures showing results. In this sense, quality performance can be regarded as the process measures, compared to the financial measures mainly demonstrating the cost status in the construction project.

In this research, the quality performance management cycle was composed with reference to the Deming cycle which comprise the plan, do, check, and action. The cycle comprises quality performance planning, quality performance measurement, quality performance review, and quality performance improvement. The management level is divided into three levels: the strategic management; project management; operational management. The tasks of each level in conducting quality performance management are listed to identify their major interests. Managers on the upper level must have data on matters such as cost or schedule as well as the quality to evaluate the quality performance of the construction companies. By synthesizing all these data from various management areas, managers can judge the quality status from a more integrated perspective.

The functions and tasks related to quality performance management for each management level are as follows:

- Strategic management level(S) : Review the quality management strategy and quality policy in the enterprise or department's perspective, and monitor the overall quality performance of the departments and sites
- Project management level(P) : Manage the quality assurance status, review the quality objectives and action plans, and monitor quality status of the site by analyzing and comparing quality data
- Operational management level(O) : Plan the inspections and tests considering the relationships with the schedule and resource allocation, determine whether to proceed to succeeding activities, and take necessary actions to handle quality problems

Figure 3 shows tasks and review items of the each management level along the quality performance management cycle.

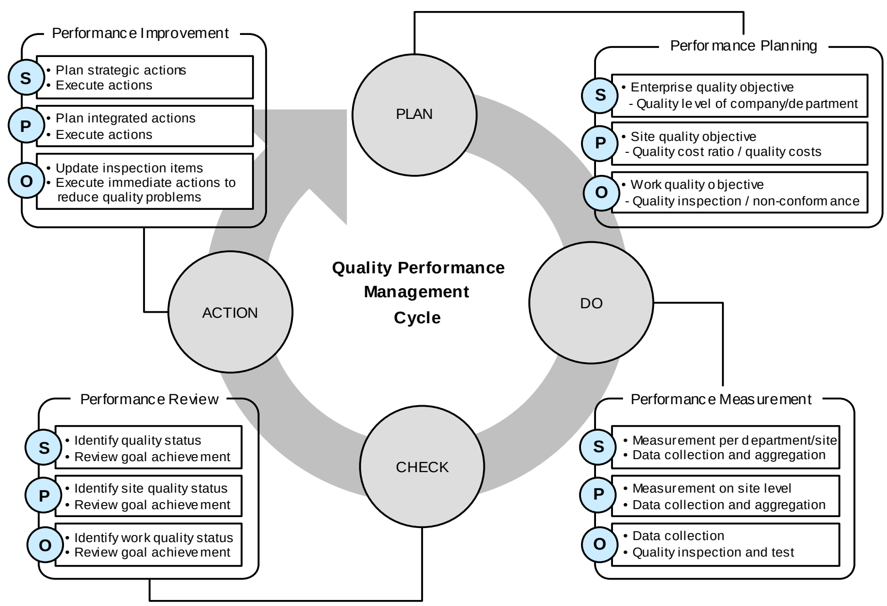

Figure 2. Quality performance management cycle

After determining the quality status, the causes for poor achievement should be traced to improve and enhance the efficiency of quality management. This research categorizes the causes of quality problems into work error, design error, defective material, damage on site, etc. Each inspection item is connected to the cause on the inspection checklist, and inspection results are input into the quality management system in a periodic manner.

Development of Quality Performance Indicators

The performance indicators are the objective standards developed based on the management policies and the critical success factors to assess the accomplishment of the policies in the companies.

Rose(1995) suggested the attributes of good metrics, and they are summarized as follows.

- Good metrics are customer centered and focus on indicators that provide value to customers.
- They measure performance across time, which shows trends rather than snapshots.
- They provide direct information at the level at which they are applied, and no further processing and analysis is required to determine meaning.
- They are linked with an organization's mission, strategies, and actions.
- They are collaboratively developed by teams of people who provide, collect, process, and use the data.

Also, the what, why, when, how, and who to measure should be defined in developing quality-related indicators (CII 1994).

In this research, the management objectives and critical success factors (CSFs) were defined for each quality management level, and the indicators to measure and manage them were developed (shown in Table 3). The basic principles in developing quality indicators by CSFs are as follows.

- Upper management identifies the quality level and performance at a glance with a single indicator. The indicators cover the larger scopes in performance as the management levels are higher, and have the characteristics of financial indicator.
- The quality indicators are classified into effectiveness measures and efficiency measures. Efficiency measures are designed to measure the productivity of the quality management process, including quality cost ratio and each category of quality costs. Effectiveness measures are calculated using the data from the inspections and tests, including work quality ratio, NCR records, and goal achievement ratio.
- The achievement ratios are calculated by comparing the actual performance to the periodical quality goal for each indicator. These ratios show the effectiveness of quality management by comparing the actual results to the achievable level.
- The newly developed quality indicators enable management to monitor the processes, and not the results, and analyze quality from various dimensions in order to improve efficiency.

Table 3. Quality objectives and CSFs

Level	Objective	CSFs
Strategic Level	• Customer satisfaction • Assuring management quality	• Integrated quality management for projects in the company • Analysis and comparison of respective project quality
Project Level	• Internal customer satisfaction • Assuring project quality	• Review of the link with cost and schedule • Setting of the quality goals of project • Identification of the quality status of project
Operational Level	• Assuring work quality • Keeping work schedule	• Identification of the quality status of work • Identification of the causes of quality errors

The indicators are developed to measure the degree of achieving the CSFs listed in Table 3, and categorized into three groups below.

Work quality indicators

To assure the work quality, data from inspection results and non-conformance records are analyzed on the operational level. Combining the inspection (test) results and the data from non-conformance processing enables manager to understand the result of quality management.

Quality cost indicators
The efficiency of the quality management is identified by measuring and analyzing quality cost on site. The Quality Cost Ratio (QCR) is calculated to check the comparative value of quality cost using interim expenditure. Among the many classification of quality cost, this research adopts the most prevalent PAF model using the classification of prevention cost, appraisal cost, and failure cost. The responsibility of quality cost incurred during construction can be varied according to the contract and delivery systems.

Quality status indicators
Quality status includes both reviewing the achievement ratio of quality goal and measuring the quality level. Sigma level is calculated by converting the yield or defects per million opportunities (DPMO) to determine quality level. In this research, the inspection items on quality checklists for work were regarded as opportunities, and DPMO and sigma values were computed using them.

In addition, quality training hours and the degree of participation can be the preceding indicators, and be analyzed in connection with other quality indicators.
As Bassioni (2004) discusses, performance management systems should be dynamic and flexible, with the ability to cope with the occurrence of relevant external and internal changes. In this context, this research adds the periodic review for measures to quality performance management process.

Table 4 shows the calculation formulas and data source for each indicator.

Table 4. Quality performance indicators for construction projects

Indicators	Management Level	Category	Calculations	Data Sources
Quality level	Strategic level	Status	Sum of company quality index multiplied by index weight	(computation inside system)
Department sigma level	Strategic level	Status	Sum of each sigma quality level of project multiplied by project weight	(computation inside system)
Quality cost ratio	Project level	Cost	Ratio of total quality cost to the periodic earned value	• Monthly project report • Payment report for sub-contractors
Quality cost	Project level	Cost	• (Prevention cost) Total cost for quality managers and trainings • (Appraisal cost) Total cost for quality inspection and test • (Failure cost) Total cost for rework and disposal	• Control budget • ERP (system) • Daily project report
Project sigma level	Project level	Status	Sum of each sigma quality level of work multiplied by work weight	• Work quality checklist
Work quality ratio	Operational level	Work	Ratio of the number of inspection passed to total number of inspection	• Inspection and test plan • Work quality checklist • Daily project

				report
No. of NCR	Operational level	Work	Numbers of NCR received and rectified in each period	• NCR(process) report
No. of CAR	Operational level	Work	Numbers of CAR received and rectified in each period	• CAR(process) report
Work sigma level	Operational level	Status	Converting defect ratio per inspection item to sigma level	• Work quality checklist
Goal achievement ratio	Every level	Status	Ratio of actual data to goal values	(computation inside system)

4. CONCLUSION

In the construction industry, there are more companies attempting to adopt quality as a tool for continuous improvement. These tools include Six-Sigma which has already been proven to be useful for quality innovation in the manufacturing industry. However, these kinds of efforts are not sufficient enough to achieve the organizational goals in quality management. The root causes of inefficiency in the quality management should be considered. The low level of construction quality is mainly caused by the result-oriented quality management due to the fact that quality problems can be detected only after they occur. Also, few systems provide the quality managers with the numerical objectives or tangible goals.

This study suggests the data-based quality management as a solution to the foregoing problems and discusses the methods of measuring and analyzing the performance related to quality in a construction company. It establishes the quality indicators to measure quality performance objectively. The management objectives and CSFs are defined according to the three management levels: strategic level; project level; and operational level, and the indicators to measure and manage them are listed subsequently. The indicators are assigned to each quality management level and the level of quality is expressed with Sigma values. Through the quality performance management, managers will be able to improve the construction quality by monitoring the major indicators of construction project success and ultimately increase the competitiveness of the overall construction organization.

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TOWARDS GREEN INDUSTRIAL BUILDING CONSTRUCTION SUSTAINABLE ENGINEERING OF BUILDINGS

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ABSTRACT

Conventional buildings are designed as static and finished products although they are almost daily subject to transformation. Increase of the dynamics of societies caused by increased mobility, economic growth, life stile changes, results into growing number of changes within the built environment. (SEV 2006) Consequently this requires even greater material and energy consumption and waste production. However developers and real estate managers warn that existing building structures are not suitable for the changing demands of the modern society.
This is why more than 60% of yearly building production in the Netherlands involves partial and total demolition of existing structures and their replacement by the new once. Resent estimations indicate that existing building account for 2/5 of the worlds annual energy use, one half of its waste stream and 40% of materials entering the global economy. The World Resource Institute projects 300% rise in material use as world population increases over 50 years. At the same time excavation of row materials is becoming difficult and more expensive. Governments introduce a tax on use of row materials. Landfill sites are filling up forcing landfill tax to increase and making the waste management exceptionally expensive.
The physical impact of increasing building mass and its frequent transformations become undeniable in 21 century and is forcing building industry to rethink its construction methods.

One can argue that existing structures and construction methods are in large part responsible for the increase of the total life cycle costs of the building, material and energy use and waste production. If building practice does not evolve towards building methods that stimulate reuse and recycling of building and its products (by high disassembly potential of its parts) the burden of demolition activities will continue to have negative impact on economic, social and environmental systems. In other words the gap between conventional construction methods and the key principles of sustainable engineering (such as; adapt to the users needs, reduce costs, conceive natural resources, save energy, reduce waste etc.) would increase considerably.
This paper will discuss a new design & construction approach that can bridge a gap between growing construction activity and efficient material use.

Keywords: Design for disassembly, sustainable engineering, flexibility

1. INTRODUCTION

The way in which building parts are put together has a great effect on whether or not a part of the building or the whole building is recycled after its service life. This is independent of whether its materials were wisely selected or not. In other words, the building process which represents the way building parts are put together, determines the potential of buildings and its components to extend their life cycle by reuse, reconfiguration and recycling. Ultimately this contributes to the reduction of waste, and energy and materials use.

Demolition in general can be defined as the process whereby the building is broken up, with little or no attempt to recover any of the constituent parts for reuse. Most buildings are designed for such end-of-life scenario. This means that different functions and materials comprising a building system are integrated in one closed and dependent structure that does not allow alterations and disassembly. The inability to remove and exchange building systems and their components results not only in significant energy consumption and increased waste production, but also in the lack of spatial adaptability and technical serviceability of the building. Such approach to building integration ignores the fact that building components and systems have different degrees of durability. While the structure of the building may have the service life of up to 75 years, the cladding of the building may only last 20 years. Similarly, services may only be adequate for 15 years, and the interior fit-out may be changed as frequently as every three years. Nevertheless, it is often the case that parts with short durability are fixed in permanently, preventing easy disassembly. Therefore, at the end of components or building service life there is usually little option but for demolition, with associated waste disposal. If we recognise the potential of disassembly, it is possible to divert the flow of materials from disposal and save bought materials and energy embodied in them by avoiding the demolition process.

2. DISASSEMBLY AS A KEY TO THE CYCLIC MATERIAL FLOW

As already discussed in the previous paragraph, material flow in the building industry has a dominant linear direction in which material systems are running down. Such material flow is often defined as a once-through linear system passing from raw materials extraction, through materials processing, assembly, use, and finally to demolition.(Figure 1) Such systems recognise one end-of-life scenario, waste disposal.

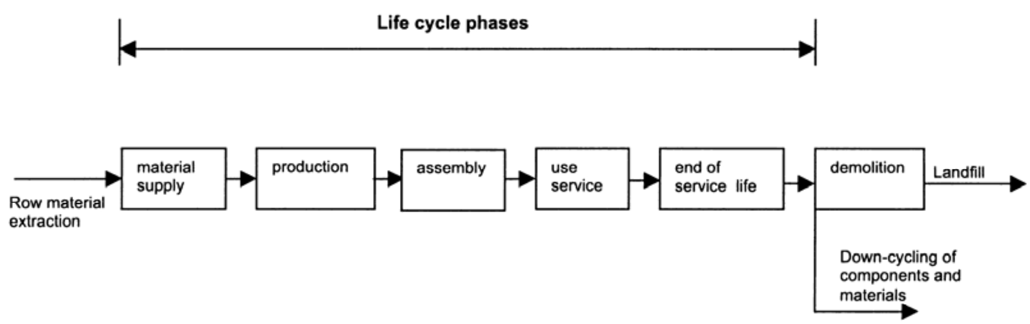


Figure1: Once-through linear system of material flow

However the ideal use of materials and resources available for processes in building industry would be one that is similar to the cyclic material flow (Figure 2). A number of examples from other industries indicate that if the act of demolition is replaced with disassembly, conventional material flow can be diverted towards reuse, reconfiguration and recycling of materials and components. This suggests a more cyclic life cycle model, one that provides transformation and adds value to materials during different stages of product life cycles. (Figure 2).

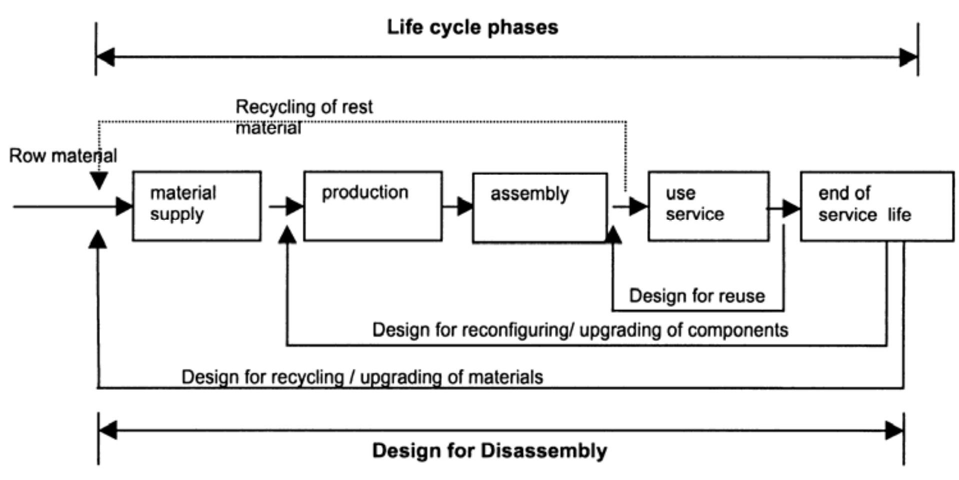


Figure 2: Cyclic material flow

This mode of operation has been recognised within product design practises as Design for Environment strategy.(Graedel 1997) These industries recognise different end-of-life cycle scenarios of the product such as: reuse, maintenance, remanufacturing, recycling. These strategies have resulted into a successful business program in companies as Kodak, IBM, Simens, Xerox etc. However the implementation of cyclic material flow to the building design & construction is still far away from happening.
Most modern buildings today are made of prefabricated components designed to be mountable. On the other hand, disassembly in the building industry usually involves a few bulldozers and some explosives. In order to increase a building's potential to be disassembled, first of all we need to change our perception of the building technical composition from being permanent and fixed to being changeable and open. Open structures would allow for modifications according to new requirements and recovery of materials and components for reuse and recycling. Finally, they allow existing and new building stock to serve as primary material sources for new construction, rather than harvesting resources from the natural environment. In order to bring construction industry closer to such end-of-life scenarios, as designers and engineers, we must consider how we can access and replace parts of existing building systems and components, and accordingly, how we can design and integrate such open building systems and components in order to be able to reconfigure or to replace them later on. Design of such transformable and material efficient structures would have environmental, economic and social benefits and can be recognised as the key to sustainable construction in the future.

Demolition prevention by design

Obviously in order to adopt such a approach our understanding of the performance of the building structure needs to be changed. We need to understand that building can not be observed as a finished product, and that the total life cycle of building and its elements would be much more environmentally and economically efficient if the options for re-placeability and recovery of building parts would be provided for during the design phase. Therefore one of the basic analyses during design is to understand when and where does disassembly takes place in the building. This is extremely difficult task since each building represents a system of planes, lines and points broken into number of material levels which again interact with each other on different physical levels, that form ultimately technical composition of the building structure. Such maximal integration of building elements results into building structures that do not support recovery of its materials because:

a) almost all elements create dependent relations with surrounding elements,(Figure 3)
b) connections between the elements are not designed for disassembly,
c) materials are often composites what complicates their recycling process.

This dependent integration of components, that is created after the assembly, can be compared with the ‘spaghetti effect’ in a building, a term that was first used in building construction by Van Randen in 1988. (Van Randen 1992) Figure 3 presents the relational diagram of building components within one conventional housing project in the Netherlands. It shows that in order to remove one part great number of relations have to be removed. This is often not possible without demolished.

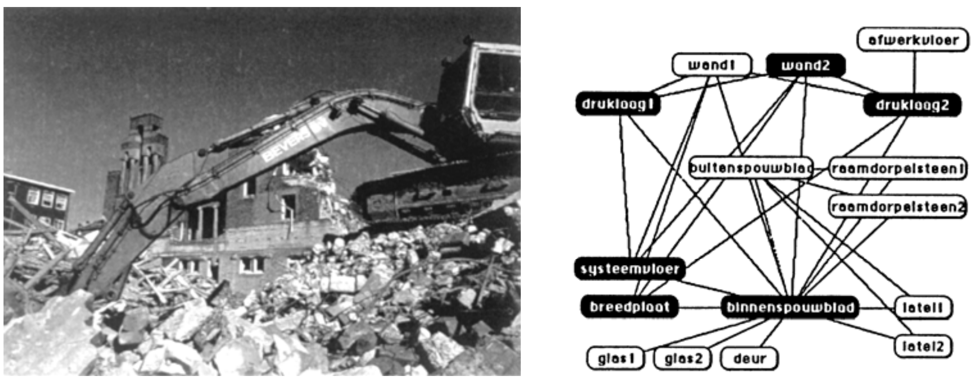
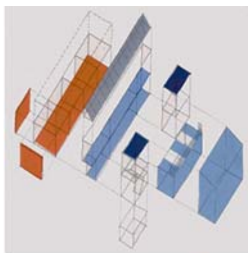


Figure 3: Relational diagram (left) shows dependencies between components within one housing project in the Netherlands.

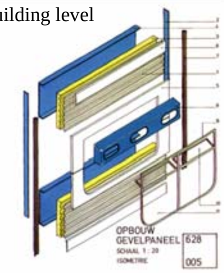
In order to resolve this effect so that building parts can be disassembled without degrading other parts, different approach to building structuring is needed. In other words a systematisation of the building is needed according to the two main criteria for disassembly: independency and exchangeability of building parts.

The question of the building systematisation aiming at improved efficiency of the built environment has been addressed in the past. A well-known approach is the one that addresses the independence and decoupling of the levels of decision making within the built environment. This approach was first recognised in the work of Professor Habraken who introduced the theory of levels of change in 1960’s in his book ‘Supports’. Habraken suggested that the built environment could be divided into three levels of decision making, namely: urban fabric or tissue, base building or support, and fit out or infill, proposing that these three elves should become independent of each other in order to provide changes on infill levels without interrupting other two levels. Later on Duffy and Brand defined 4 and 6 functional levels of a building in order to identify individual building functions with different changing rates such as: site, structure, skin, services, space plan and stuff.

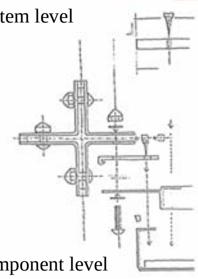
However when the issues of material recovery play a role one has to realise that besides different functional changing rates and levels of responsibility, each material has different technical changing rates as well. Thus each material within a building has embedded duality in terms of different use and technical life cycle. It is the fixed integration of functions and their materials throughout different levels of technical composition that complicates replacement of parts. Therefore Design for Disassembly has to focus primarily on systematisation of levels of technical composition in order to provide decomposition of the functional and physical building levels. Levels of technical composition are: subcomponents, components, subsystems, systems, building. As illustrated in figure 4, levels of technical composition are multidimensional and can result into X number of independent material levels.



Building level



System level



Component level

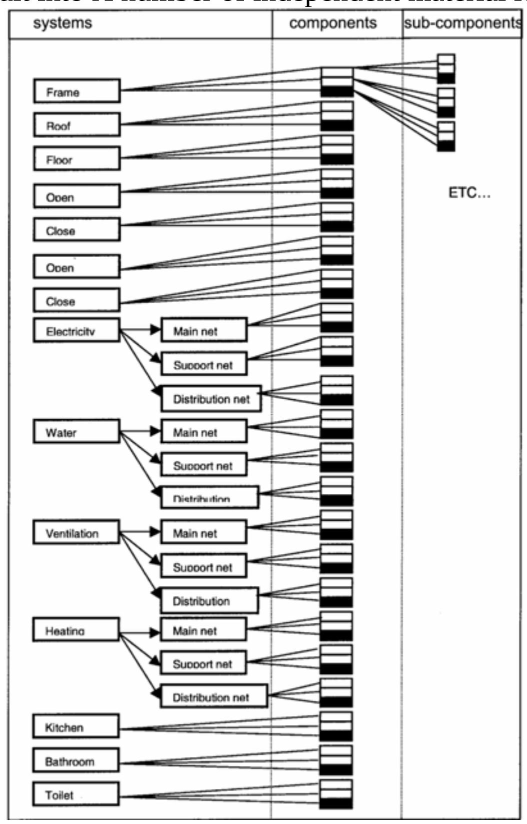


Figure 4: separation of material levels on all levels of technical composition (from systems to materials)

The concept of transformation and independent material levels is not restricted to one scale. Each level of technical composition can be further divided into sub-levels, which can be recursively composed of additional sub-levels. One can say the greater desire for transformation on building, system, and component level, for the reason of their reconfiguration, reuse and recycling, results in a greater number of independent material levels. It is obvious that if we wont to explore transformation of building and its systems by design for disassembly approach than a fixed number of changing levels become ambiguous. The number of independent material levels (as apart of independent levels of technical composition) is increased with the increase of changing user requirements and the need for separation and recovery of building materials. In that respect, design process in the future will have to focus on finding the write mach between the required use strategy for the whole life cycle of the building and number and hierarchy of material levels that will support this strategy. In other words different use scenarios required by different clients will result into different number of independent levels of technical composition as well as into different arrangement and hierarchy of material levels.

Systematisation of the building according to the criteria of independence and exchangeability of building components can be also seen as a process of emancipation of material levels, that are conventionally part of a fixed structure. To illustrate this we can take an example of typical housing construction in Holland where all building functions are integrated into one fixed material level. Most of these buildings are being demolished at the moment, because they can not be adopted to the new lifestyles and requirements. In order to extend the life cycle of such buildings the structure should become adoptable to a certain extend. For example if the long-term use scenario requires spatial flexibility number of material levels such as sanitary installation level, electricity/data level, partitioning level and fittings should be extracted out of previously mentioned, one material level (represented by fixed mass of materials that should last 75 years. (see figure 5 left) If those four levels are developed as independent subsystems that can be replaced, reused, reconfigured, recycled than these buildings could easily transform to number of different spatial typologies and its parts could be reused in different situations or reconfigured and recycled.

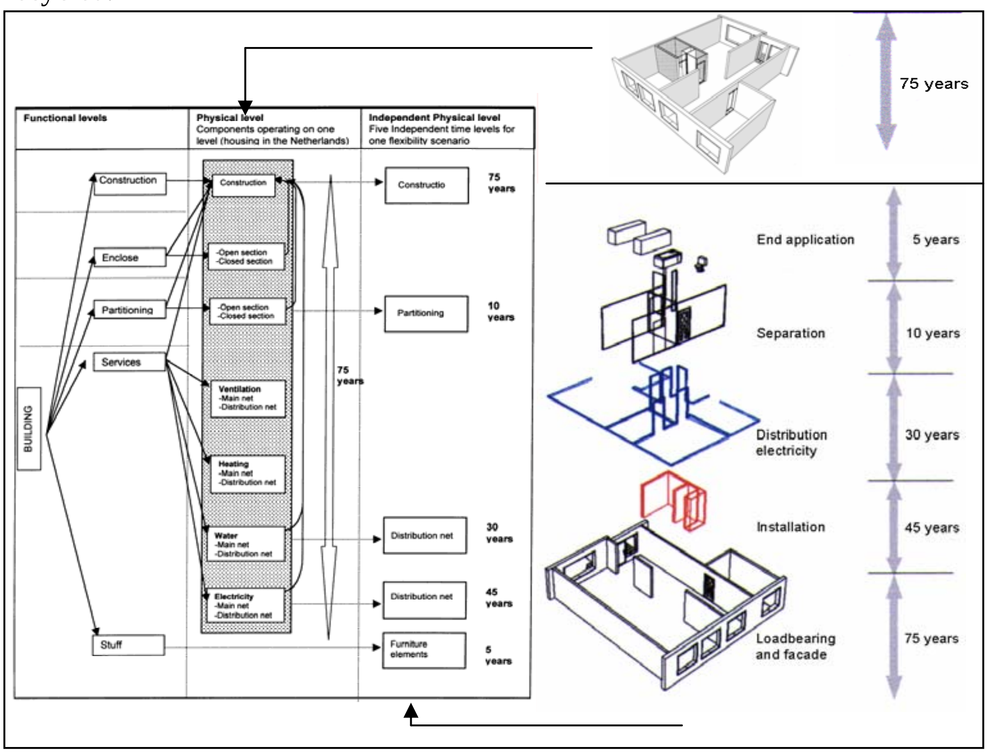


Figure 5: left, housing project in the Netherlands that freezes functional levels into one fixed material level (one material level one spatial system); right, alternative solution where four functional levels have been separated.

The project that has provided even greater number of independent material levels for the purpose of greater adaptability to the user needs is the Next 21 Project in Osaka. Independency of the façade, installations, and infill systems were a leading concept in this project. (Figure 6) The functional levels are defined by eleven independent material levels (see Figure 6 left).

This has been a result of desired use requirements such as having total spatial and functional flexibility in the dwellings. Such strategy required that users are being able to reposition windows, extend apartments, and to access all installations for their maintenance, upgrading and repositioning. The functional decomposition that was needed in order to provide these requirements has resulted into eleven material levels in a form of main systems and eighteen sublevels in a form of independent and exchangeable subsystems and components. (Figure 6 left) This has resulted in the design of an external envelope made up of movable steel frames covered with aluminium strips. The façade system can be reconfigured by moving or adding window or door openings, as well as by integrating the balcony into the dwelling space, or by creating a new balcony.(Figure 6 right)

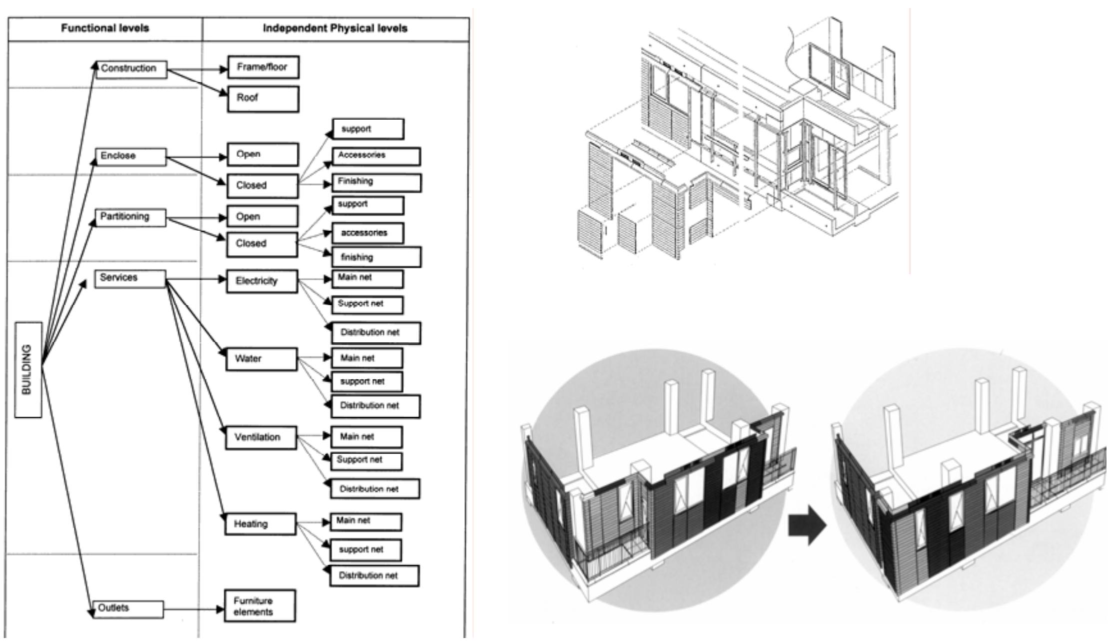


Figure 6: left, number of independent material levels within Next 21, right transformation of the external envelope (Fukao 1999)

Design for better building use performance and material efficiency

To summarize design for disassembly addresses a moment of change of the purpose of the building assemblies. It addresses the moment when the rearrangement of materials takes place.(Durmisevic 2006) A good understanding of the requirements that takes into account the long-term purpose of the artefact is crucial in the DfD approach. Scenarios for the use of building and building material in the future have to be defined at the early design stage. This requires additional efforts from bought the client and the design team. Every use scenario for a building or a system results in different technical compositions and different configuration types.

It is evident that each use scenario imposes different use life cycle on building components. Add to the fact that building components have different durability, it can be concluded that every use scenario will have different numbers and hierarchies of physical levels, and therefore a different hierarchy of technical systems. The hierarchy and material dependency between physical levels corresponds to a desired transformation strategy. Having this in mind, all building structures could be divided into three groups, such as fixed structures, partially decomposable structures, and totally decomposable structures. The process of transformation from massive to decomposable structures symbolises the process of separation of building functions, according to use strategy, from fixed to fewer dependent conditions.

Figure 7 illustrates three different configuration types that match three different long-term use scenarios. Configuration1 addresses flexibility that deals with the inner partitioning of a space, and introduces a floor and wall system that can be reconfigured and replaced. Configuration 2 addresses spatial flexibility that introduces a flexible concept for electrical installations imbedded in movable walls. Configuration 3 addresses a concept for the total flexibility, introducing systems that can be reconfigured and replaced.

Configuration 1 *Configuration 2* *Configuration 3*

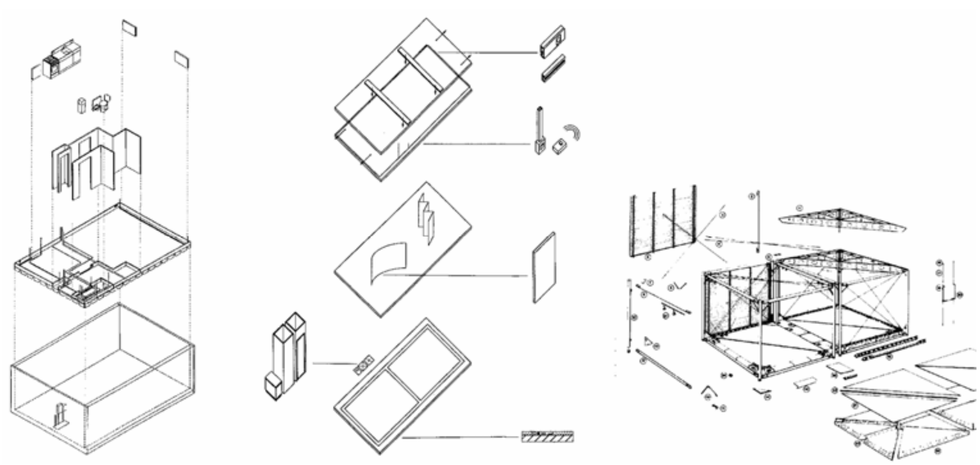


Figure 7: illustrates three different types of configurations

Taking into account all possible combinations of functions, sub-functions, sub-sub-functions on building, system, component levels it is possible to develop thousands of different configuration types with a building. Therefore the key issue in the design of transformable structures is the definition of the right match between the long-term use strategies and the type of configuration that will support these use strategies.

Design protocol

Considering the complexity of the design of transformable buildings based on design for disassembly strategy the key issue is to define the boundary conditions within which building and its systems will be developed through the number of optimisation phases.

Accordingly design for disassembly can be summarised into the following steps:

- Definition of the use performance through specification of long and short-term scenarios;
- Functional decomposition followed by the initial specification of material levels;
- Definition of a hierarchy of material levels that corresponds to the frequency of change of building components for the purpose of maintenance and functional

change. If a structure is represented by a closed hierarchical relational diagram, then re-structuring should take place. This can result in the change of material levels, or change of functionality.

• Development of a life cycle coordination matrix for the proposed solution that indicates disproportion of use and technical life cycle within chosen materials. At this point designer can optimise the matrix by reducing or extending the technical life cycle by choosing other materials, or by allocating other functions to the existing materials, which are accounted for the great life cycle disproportion.

Such optimisation of the life cycle coordination matrix is directly related to the reconfiguration of the structure or functional decomposition.

• Outline of the physical integration between parts that have different functional and technical life cycle. This stage deals with the pure physical aspects of relations between two components.

• Evaluation of a design solution by use of a knowledge model that can match design solutions with desired performance indicators; (as for example model measuring transformation capacity of the building)

3. CONCLUSIONS

Results of many research studies, regarding sustainable construction and disassembly as a key element of sustainable construction, are summarised in reports by CIB deconstruction TG 39 group (Chini 2005) and the US governmental Green Building program (EPA 2005). These indicate that designing transformable buildings with exchangeable and reconfigurable /reusable components, seen from the perspective of 21st century requirements, results in the reduction of construction and demolition (C&D) debris, conservation of landfill space, reduction of the environmental impact of producing new materials, creation of jobs, and reduction of overall building project expenses through avoided purchase/disposal costs. Furthermore, demountable buildings are easier to adapt to new requirements.

In short, such an approach to building design has the potential to accomplish benefits such as:

-Economic benefits: Reduction in operating costs, Creation, expansion, and shaping of markets for green product and services, Improvement in occupant productivity, Optimisation of life-cycle economic performance

-Social benefits: Enhancement of occupant comfort and health, Heightening of aesthetic qualities, Minimizing the strain on local infrastructure, Improvement of overall quality of life

-Environmental benefits: Reduction in waste streams, Conservation and restoration of natural resources, Enhancement and protection of biodiversity and ecosystems, Improvement of air and water quality

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MANAGING CONSTRUCTION WASTE THROUGH SYSTEM DYNAMICS MODELLING: THE CASE OF HONG KONG

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ABSTRACT:

As construction waste is the main waste generator in Hong Kong, its impact on the environment has become a serious problem to society. Although, construction waste management has received increasing attention from decision makers and researchers since the early 1980s, how to coordinate the factors involved in construction waste to minimise its impact on the environment still needs attention. This paper describes the development of a simulation model by applying system dynamics. This model provides a comprehensive view of construction waste management in Hong Kong. The model is designed to provide decision makes and associated stakeholders with a tool to evaluate construction waste management plans and to improve the environmental performance of construction waste strategies in Hong Kong, which ultimately will lead to the ways of better managing construction waste in the Pearl River Delta Region.

Keywords: construction waste, simulation model, system dynamics, and Hong Kong.

1. INTRODUCTION

Construction and demolition (C & D) waste management has become one of the major environmental problems in both developed and developing countries. It has been a pressing issue in Hong Kong since the late nineties. Tremendous amounts of C & D waste have been generated from ongoing new construction works, as well as renovation and demolition works. The C & D waste has been increased which has been resulted from the extensive building and infrastructure development projects as well as redevelopment of old districts. Figure 1 shows the quantity of construction waste from 1991 to 2004 (EPD 2005).

From the Figure1, it is found that part of C & D waste is disposed of at landfills. Although it is decreasing in its quantity, it still composes a major part of total solid waste disposed of at landfills. In this situation, not only a large amount of money is paid to handle C & D waste, but also valuable land is consumed for C & D waste disposal. It is reported that C & D waste has been costing the government more than HK$ 200 million per year for disposal and taking up valuable landfill space at a rate of about 3500 m^3 per day. Keeping with the rate, our landfills will run out around 2015. Nevertheless, it is necessary to forecast C & D waste quantities on site by using a method to be in line with the changes. The intent of this paper is to describe such a simulation model developed by using system dynamics to forecast construction waste on-site.

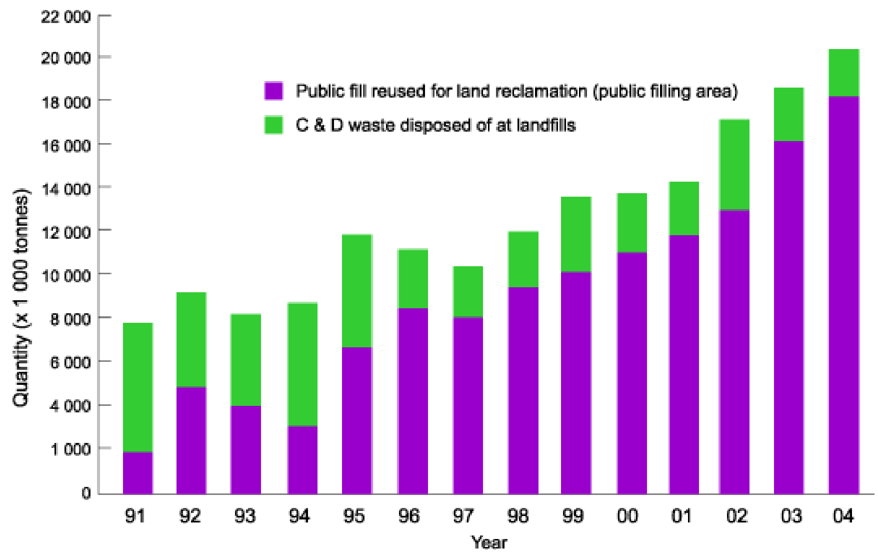

Figure 1 Quantities of Construction Waste in 1991-2004 (EPD 2005)

2. METHODOLOGY BY USING SYSTEM DYNAMICSS

A waste management mapping model has been developed based on some cases in Hong Kong to be used for guiding the waste controlling procedures (Shen, Tam, Tam, and Drew, 2004). However, wastage factors and waste handling procedures involved in C & D waste management have been viewed separately. No one has considered the inter-relationships between major decisions makers involved in C & D waste management. The whole business of waste management can essentially be viewed as one system all linked to the physical waste process because it involves different decision makers, disciplines and activities. With this in mind, waste management can be considered as a complex system, with inherent characteristics for planning, organising, and co-ordinating all activities.

System Dynamics (SD), originated by Forrester (1958), is a system analysis approach that is concerned with creating models or representations of real world systems and studying their dynamics. The modelling approach focuses upon an understanding of feedback and feed forward relationships, and the model construction requires the analyst to construct the relationships between the various stage variables and rate variables. As a result, system dynamics is often used as a methodology for improving the soundness and effectiveness of the decision-making process and, in recent times, has become a popular technique for modelling construction project management (Sterman, 1992; Rodrigues & Bowers, 1996; Li, Love and Drew, 2000; Shen, Li, Love and Mandal; Hao and Scott, 2001). It can be seen that by using the similar approach and methodology will throw some light for C & D waste management. Although system dynamics has been widely used in different fields of project management, the area of C & D waste management has not benefited enough from this modelling approach. Only a few published articles can be found.

Mashayekhi (1993) carried out a comprehensive study on the transition in New York State solid waste system, which incorporated qualitative analysis in its system dynamics model. Sudhir et al. (1997) further identified the difference of solid waste management system between developed countries and developing countries. It was suggested that both formal and informal systems operate at the same time in the developing countries. Therefore, a system dynamics model relevant to the issues in developing countries, specifically to the Indian context, was developed. Karavezyris et al. (2002) applied system dynamics to forecasting of municipal solid waste. In order to incorporate qualitative variables used for modelling exogenous elements like influences and thresholds, fuzzy logic was integrated with the system dynamics tool. To resolve the scarcity of complete historical records of solid waste, a system dynamics model based on grey dynamic model was developed for prediction of solid waste generation in a fast-growing urban area (Dyson and Chang 2005). From the view of the whole life cycle of a construction project, Hao et al. (2006) developed a simulation model based on system dynamics methodology for strategic planning of C & D waste in Hong Kong.

3. SIMULATION MODEL DESCRIPTION

C & D waste management for construction on site

One of the most effective mean is on-site sorting of C & D waste (Poon et al. 2001). C & D waste usually involves two types of material: the inert waste, which comprises mainly sand, bricks and concrete, and the non-inert waste, consisting of materials such as bamboo, plastics, glass, wood, paper, vegetation and other organic materials. By separating the inert waste from the non-inert waste, the inert waste could be used for land reclamation and only the non-inert waste will be disposed of at landfills. The strategy minimizes the amount requiring final disposal so that the life span of the landfills can be extended.

However, the strategy is not fully implemented by construction companies. The major barriers attributes to increase in management and operation costs, lack of trained staffs and expertise, lack of government legal enforcement, and so on (Shen and Tam 2002). Increase in cost may be the most concerned factors of contractors and other stakeholders. A recent survey of the Hong Kong construction industry also showed that the conception that environmental management results in many more costs than benefits is prevalent among contractors (Shen and Tam 2002). As companies always seek to maximize profits, it is natural that contractors are reluctant to adopt environmentally friendly measures of waste management.

In 2004 the Legislative Council passed a bill, The Waste Disposal (Amendment) Ordinance 2004, which is the enabling legislation for the Charging Regulation and the Designated Waste Disposal Facility (DWDF) Regulation and provided the statutory basis for the introduction of the construction waste disposal charging scheme. The Charging Regulation and the DWDF Regulation set out the details of the construction waste disposal charging scheme, including the charges for the disposal of construction waste at landfills, sorting facilities and public fill reception facilities and their calculation. The Charging Regulation sets the disposal charges at HK$125 per tonne at landfills for waste that contains less than 50% inert material, HK$100 per tonne at sorting facilities and HK$27 per tonne at public fill reception facilities in order to fully recover the capital and recurrent costs of the facilities according to the polluter pays principle (EPD 2006). The charges scheme will come into effect on 20 January 2006.

Waste generation

Generally, the quantity of generated waste varies through construction process. The quantity and composition of the waste highly depend on the building structure type and the technology used to build the structure. Specially, it is noted that the quantity of waste is highly related to that of purchased building material. Shen et al (2004) estimated that about 1-10% by weight of the purchased construction materials, depending on the type of material, leaves the site as waste.

On site sorting

As aforementioned, on-site sorting is an effective means to reduce the quantities of C & D waste to be disposed of at landfills. However, on-site sorting is not yet a common measure in construction because the prerequisites such as enough site space, skilled workers, and investment in necessary equipment have to be met to operate the on-site sorting. Furthermore, the normal construction may be disturbed by the sorting work. Thus, it is not surprising that about 70% of the contractors would not perform on-site construction waste sorting unless it is specified in the contract (Poon et al. 2001). However, the execution of the construction waste disposal charging scheme will alter the attitude of the contractors to the on-site sorting. When the charges scheme comes into effect, on-site sorting will become popular because it may decrease the total cost of waste disposal.

Model development

The most popular system dynamics software is Stella®. It is a multi-level, hierarchical environment for construction and interacting with models. The software enables users to modelling interrelationships, which constitute a process, a strategy or an issue, by user-friendly visual tools on the interface. The modelling and simulation capabilities of the software are ideally suited for capturing the operational dynamics and complexities of management issues depicting them as a flow chart or schematic.

The model depicting the C & D waste management for construction on-site is developed using the abovementioned software package. As shown in Figure 2, C & D waste is generated from building construction activities. The quantity of C & D waste is determined by the quantity of purchased building material and waste ratio. The quantity of purchase building material varies with construction schedule. It can be calculated by adding the needed materials of all activities implemented simultaneously according to project schedule.

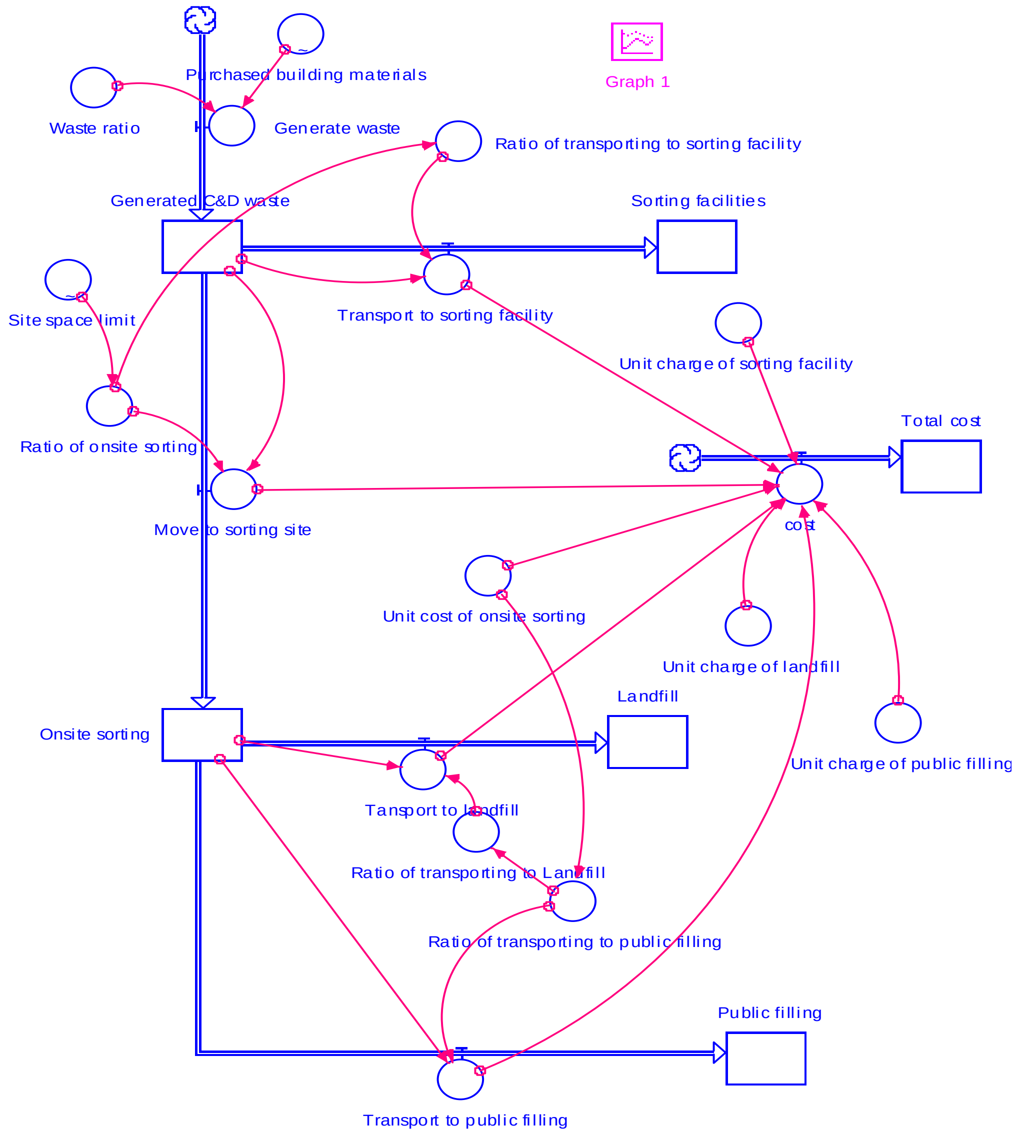

Figure 2 Simulation model for C & D waste management on-site

There are two ways to handle the generated waste. One is to transport the waste directly to sorting facilities with the charge of HK$100 per tonne. The other way is to adopt the on-site sorting before disposal at landfills or public fillings, because the landfills do not receive the waste that contains more than 50% inert material. The ratio of waste further moved to on-site sorting is in relation with the availability of site space, because the implementation of on-site sorting is restricted by the site space. For congested building sites in urban areas, it is difficult to find enough space for setting up sorting facilities and equipment. Moreover, the sorting process may interfere with normal construction activities and result in delay of completion date and increase in cost. So, the more limited the site space is, the more low the ratio of on-site sorting is.

On-site sorting involves labours and facilities such as containers, rubbish bins. Different construction waste sorting schemes need different quantity of the labors and facilities. For example, only a few of containers are setup on site for separate collection of the inert waste and non-inert waste in a simple sorting scheme. The scheme only results in a little increase in investment including the cost of containers and the fee of training frontline workers. However, the separation is usually not complete due to lack of management and guideline. To improve the separation percentage of inert waste to the total waste, manual sorting is needed to further separate the inert waste from the non-inert waste. The corresponding cost of sorting is augmented at result of increment in skilled labors. Thus, in this model the ratio of separated inert waste is determined by the unit cost of on-site sorting. After separated through on-site sorting, the inert waste is transported to public filling with the charge HK$27 per tonne. Whilst the remained non-inert waste or mixed waste that contains less than 50% inert material is delivered to landfill with charge HK$125 per tonne.

4. SIMULATION RESULTS AND DISCUSSIONS

Data input

As aforementioned, waste generation depends mostly on the performance of the construction operation and the schedule. The simulation model incorporates the construction schedule in relation to the generation of waste. The quantity of C & D waste is determined by the quantity of purchased building material according to the schedule and waste ratio. It is estimated that 10% of the materials is the waste generated from new construction projects in this research. The monthly quantity of purchased building material according to the construction schedule is shown in Figure 3. The construction duration is 12 months, and the quantity unit of the material is 1000 t per month.

Ratio of on-site sorting determined by site space limit is a number in scale of 0 to 1. If there is no space for placement of waste containers and operation of on-site sorting, the ratio of on-site sorting is 0. By contrary, the space is large enough to adopt the on-site sorting; the ratio of on-site sorting is 1. Sometimes the ratio of on-site sorting is a number between 0 and 1 because the site space is congested and only a fraction of needed space is supplied. The ratio of on-site sorting may vary with construction schedule, too. Once the ratio of on-site sorting is determined, the ratio of transporting to sorting facility is calculated as Ratio of transporting to sorting facility = 1- ratio of on-site sorting.

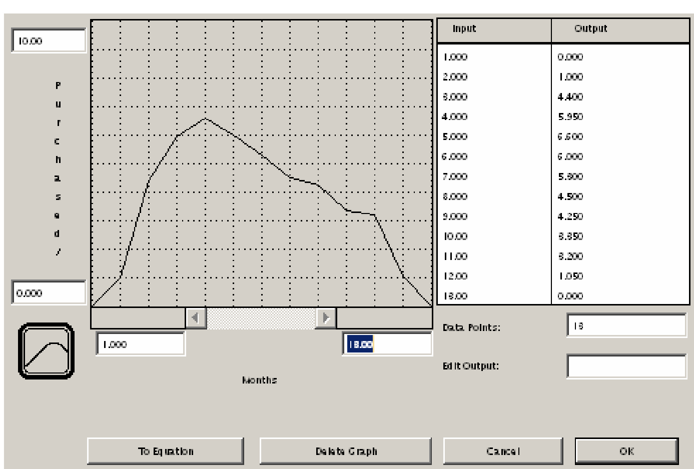

Figure 3 The monthly quantity of purchased building material

As aforementioned, unit cost of on-site sorting is different in various waste sorting schemes. More cost has to be paid for a scheme with a higher separation percentage of inert waste to the total waste (namely, ratio of transporting to public filling). In this paper, two sorting schemes are considered.

Scenario 1:
Only on-site sorting facilities and training for frontline workers are adopted. The unit cost of on-site sorting is HK$5 per tonne and ratio of transporting to public filling is a random number scale from 70% to 80%.

Scenario 2:
Apart from on-site sorting facilities, the manual sorting is also adopted. The unit cost of on-site sorting is HK$15 per tonne and ratio of transporting to public filling is a random number scale from 80% to 90%. Similarly the ratio of transporting to landfill is calculated as Ratio of transporting to landfill = 1- ratio of transporting to public filling In addition, the unit charges of sorting facility, landfill and public filling are respective HK$100, HK $125 and HK $27.

Simulation result analysis
After all the variables are determined, simulation can be performed. Figure 4 shows the variation of total cost of waste disposal depending on the ratio of on-site sorting. From the figure, it is obvious that the implementation of on-site sorting can dramatically decrease the waste disposal cost when the charge scheme takes effect. If the on-site sorting is completely adopted, the C & D waste disposal cost is only HK$ 2.36×10^5. Whilst the C & D waste disposal cost is up to HK$ 5.32×10^5, 2.25 times as the earlier, when on-site sorting is not implemented. In other point, the result reveals that the charge scheme will be effective to promote the reasonable disposal of C & D waste.

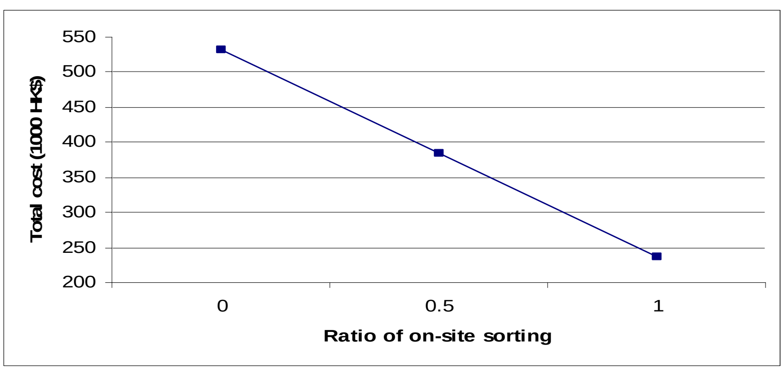

Figure 4 The total cost of disposal waste

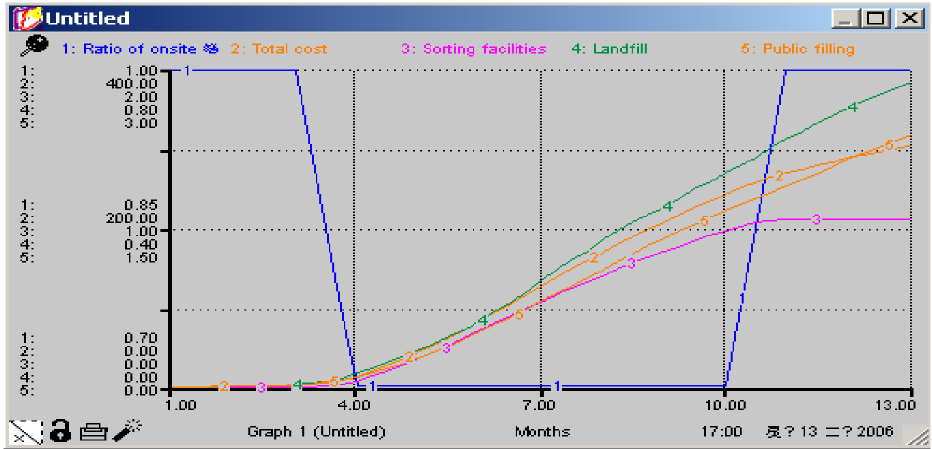

Figure 5 The simulation result on-site sorting scheme 1

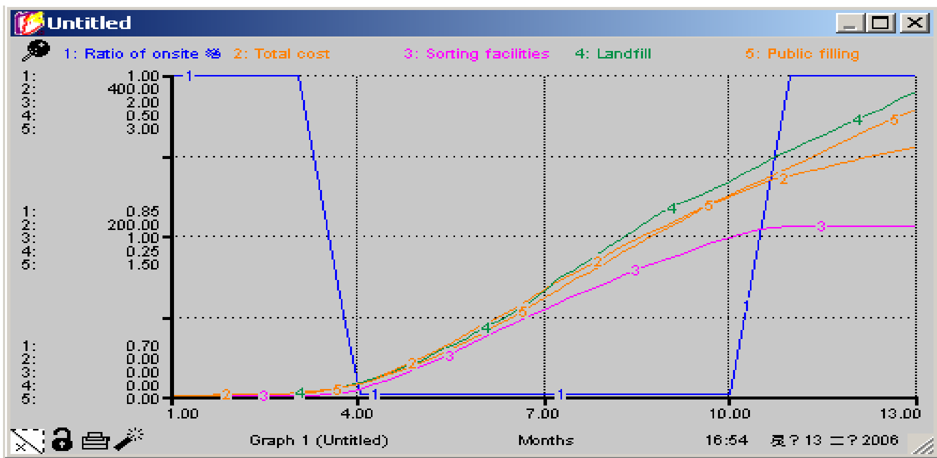

Figure 6 The simulation result of on-site sorting scenario 2

As mentioned above, the ratio of on-site sorting is limited by the limited site space. As the vacancy site space commonly varies with construction schedule, the ratio of on-site sorting is variable during construction process. To gain more practical result, the variation of the ratio is further taken into account of in the simulation. As shown in Figure 5, the ratios of on-site sorting are 1.0 in months 1-2 and 10-12, and decline to 0.7 through months 3-9 when a bulk of construction activities are implemented simultaneously and site space is congest. Accordingly, the total cost increases to HK$ 3.05 $\times 10^5$. At the same time, the monthly quantity of waste disposal at sorting facilities, landfill and public filling are generated, which give the contractors more information to arrange the waste management plan.

From the simulation shown above, the on-site sorting scheme 1 is adopted. Subsequently the on-site sorting scheme 2 will be simulated for comparison. As shown in Figure 6, the total cost is HK$ 3.10 $\times 10^5$, higher than that of scheme 1. Although the higher percentage of inert waste separation is achieved, more wages have to be paid to workers for manual sorting than the saving of disposal cost. In term of cost, the scheme 2 is better. After simulation, it is found that the implementation of on-site waste sorting is profitable for construction contractors for it decreases the total waste disposal cost dramatically. Furthermore, the on-site sorting scenario 1 is recommended because it costs less than scenario 2.

5. CONCLUSION

Study on enhancement of the waste management on site is an approach to address the problem. This paper presents a model developed by using system dynamics methodology to predict C & D waste generated on site. With the simulation model, contractors can gain deep insight into the C & D waste management system and make an optimum decision about the waste management scheme. The results from this model can be used to compare to other results. Since the model allows the users to fine-tune the input parameters, it is flexible to adjust the model to better reflect the reality according to different conditions. The model represents a relatively powerful tool for planning and policy analysis using available data. This is a well claimed advantage over other static models.

6. ACKNOWLEDGMENT

The authors would like to thank for the financial support provided by the Department of Building & Real Estate, The Hong Kong Polytechnic University.

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A SYSTEMATIC APPROACH TO PERFORMANCE IMPROVEMENT IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

This paper focuses on how established systematic analytical tools, which were developed for the manufacturing industry, have been applied to a company within the construction industry to improve performance. It goes on to describe how the company is using these tools to become more operationally efficient and customer focussed. Issues important to the customer were identified, the existing approach to resolving these issues were evaluated. Process mapping tools were used to analyse current activities and then to establish a future desired state. Finally the paper highlights the barriers and drivers identified in implementing these continuous improvement techniques and lessons learned from it.

Keywords: Construction Industry, Customer Requirements, Information Systems, Performance Measurement, Strategy Map

1. INTRODUCTION & BACKGROUND

Traditionally, the cost accounting models alone described the production processes (Kaplan 1984) and were used to control the business. Later on, new dimensions of performance such as quality, time, cost and flexibility came into the use (Slack 1983). One of the key activities that make a significant impact on continuous improvement is defining the performance indicators and modelling their relationship (Bititci and Nudurupati 2000b). Hence a number of academics and practitioners recognised the need to change traditional accounting measurement systems to accommodate the new philosophies and dimensions (Dixon et al 1990). However despite this recognition, the accounting systems in most of the companies included only financial information in their management reports.

The performance measurement revolution started in the late 1970s and early 1980s with the dissatisfaction of traditional backward looking accounting systems (Neely 1999, Kaplan et al 1992, Dixon et al 1990, Johnson et al 1987, Skinner 1974). These models are based on lagging indicators (financial). Since then, a number of frameworks as well as tools and techniques have been developed for designing performance measurement. In many companies, non-financial indicators such as quality, customer satisfaction, cycle time, innovation, etc. were recognised. They acted as the leading indicators for the financial performance (Bititci and Nudurupati 2002b, Suwingnjo et al, 1997, Ittner et al 1998). In order to identify the leading indicators at bottom level, which effect the lagging indicators at top level, there were models and approaches used, such as Cause and Effect Analysis, Fish Bone Diagrams, Failure Mode Effect Analysis (FMEA), etc.

Cause and Effect diagrams can be used to identify the leading indicators that affect the lagging key performance measures (Bititci and Nudurupati 2000b). This is not a new concept, it has been in practice for many years. Failure Mode and Effect Analysis (FMEA), a risk management tool commonly used in product design, process engineering and risk management providing a useful solution. FMEA allows the operational teams to prioritise the potential impact of each cause (failure mode)

Many performance measurement studies emphasise the key role played by management information system (MIS) in performance measurement activities to support data collection, analysis, interpretation and reporting processes. Nudurupati's (2005) research developed a causal relationship between MIS and performance measurement systems (PMS) and their impact on management and business. The research concluded that PMS, if appropriately designed, implemented and used with appropriate MIS would result in more dynamic and pro-active management style leading to improvements in business performance. In fact, it is now an accepted fact that businesses perform better if they are managed through formalised, balanced and integrated performance measures. However in contrast, many companies do not use formalised and integrated performance measures. Recent research reports indicate failures are common amongst performance measurement implementation projects (Skinner 1974, Hayes et al 1980, Kaplan et al 1992, Bourne et al 2000, Nudurupati et al 2005).

Although the concepts of performance measurement are developed to improve the performance of a business, it can sometimes mislead management. If it is not appropriately designed and implemented for any business, it can be of no use and sometimes become a threat for the business (Skinner 1974, Hayes et al 1980, Kaplan et al 1992). This can be more significant in the businesses operating in construction sector as they operate with complex supply chains with different clients achieving their own goals (Love et al 2000, Beatham et al 2004, Chan et al 2004). Appropriate measures are required to control these complex relationships. However, performance measurement remains un-explored in construction sector.

Many companies in the construction industry tend to focus internally on themselves with little focus on the customer (Rostad et al 2005). According to Atkins (1994), the main weaknesses of the construction sector are the logistics, and the material and information flow. A lot of time is being wasted due to different actors having their own time plans, which seldom match one another. Time gains of 40-50% on projects are possible by making simple changes (Persson et al 1994). 50% of the time spent on site is non-productive and 80% of the purchase orders raised for a contract are rush orders (Rostad et al 2005). A lot of companies in the construction industry waste their resources in their projects. This is due to complex supply chains with different actors wanting to achieve their own goals. Its environment is dynamic with increasing uncertainty in technology, budget and processes operating under combination of many actors, events and interactions (Chan et al 2004). According to Beatham et al (2004), the construction industry has been recognised as having problems in its structure particularly with fragmentation that has inhibited performance. Many companies in construction industry to-date rely on traditional performance measures such as Profitability, Return on Investment (ROI), Utilisation, etc. (Love et al 2000).

A lot of companies in this sector strive to focus on themselves with little focus on the customer (Love et al 2000, Rostad et al 2005). According to Atkins (1994), the main weakness of the construction sector is the logistics, the material and information flow. A lot of time being wasted due to different actors with their own time plans, which seldom match with one another. Time gains of 40-50% are possible by making simple changes (Persson et al 1994). 50% of the time spent on site is non-productive and 80% of the purchase orders raised for a contract are rush orders (Rostad et al 2005). The Construction Best Practice Programme (CBPP) launched 12 headline KPIs as shown in Table 1. These headline KPIs were further broken down into KPIs at operational and diagnostic levels. Operational KPIs are to measure specific activities enabling the management to identify and focus on specific areas of improvement. Diagnostic KPIs provide information on why certain changes may have occurred in the headline or operational KPIs and used in analysing areas of improvement.

Table 1: CBPP Headline KPIs

defects	customer satisfaction – product	construction cost
safety	customer satisfaction – service	construction time
productivity	predictability of construction cost	predictability of design
profitability.	predictability of construction time	cost of design

Beatham et al (2004) criticises that the headline KPIs developed by CBPP are lagging indicators and do not provide opportunity for change and do not predict future performance. Many companies in construction industry develop various measures and call them KPIs. According to Beatham et al (2004) there are three specific types of measures, which can be used in construction industry which are, KPIs, KPOs (Key performance Outcomes) and perception measures. KPIs are measures that indicate the performance of processes. They should be used as leading indicators, which gives opportunity to change and to take appropriate corrective action before the situation has gone out of control. KPIs should only be indicatives of future performance. Cause and effect diagrams, FMEA (failure mode effect analysis) could be used to identify the KPIs. KPOs are results of a completed action or process. They do not offer opportunity to change as they are lagging indicators. They can also be used to measure the results of processes and sub-processes, whose results cannot be altered. Most of the headline KPIs developed by CBPP will fall under this category. On the other hand perception measures can be either leading or lagging indicators, for instance customer satisfaction can be measured after the contract, which makes it a lagging indicator. It can also be measured during the contract, which makes it a leading indicator. Perception measures are usually measured on the perception (feedback) of people on the performance.

A lot of literature developed and cases reported on performance measurement are from non-construction industrial sector (Love et al 2000). Does the performance measurement systems (PMS) developed in general literature work in construction environment? Do we find the same issues (problems) in implementing PMS in construction environment? Do PMS bring the same impact as other organisations in different industrial sectors? Does the culture in construction environment have a different impact on implementing PMS?

From the existing literature, the authors believe that the construction sector is facing the same problems that the manufacturing sector facing in 1980s. The research developed in general has to be adapted, transferred and tested on the businesses operating in construction sector. Hence the objective of the paper is to study the impact of introducing and implementing performance measurement in a business operating in construction sector. To begin with, a literature review is presented on performance measurement in general and performance measurement within construction industry. It follows by presenting a methodology used in doing this research (project). An action case is then presented on how the performance measurement concepts reviewed in the general literature were introduced in a construction environment. Finally the paper includes a discussion on the impact of performance measurement on the business.

2. METHODOLOGY

A Knowledge Transfer Partnership (KTP) programme is being used to change the culture in Company A. It is a graduate programme that partners the company with Strathclyde University in Glasgow. The project is part sponsored by the DTI (Department Of Trade and Industry) and the Scottish Executive. The overall aim of the project which lasted two years in implementing appropriate IT systems and Active Monitoring techniques (Turner et al 2005) to improve business performance. The researchers (associates) worked full time in the company and are personally involved in implementing the project. They have control of project activities and their implementation, hence action research was used as the research methodology and personal observation was used to collect data necessary to disseminate the results. Action research involves practical problem solving, which has theoretical relevance (Mumford 2001, Coughlan et al 2002, Gill et al 1991). Associate 1 worked at the customer interface and gathered data from the clients to identify problem areas while the Associate 2 is working on internal systems. These two projects together have been used to provide Company A's customer focus in all areas of the business. Associate 2 used IDEF0 methodology (Maull et al, 1994) to develop an As-Is map of the company processes. Then the projects were linked together and the customer satisfaction analysis together with FMEA Analysis was used to populate a strategy map and to establish a To-Be process map to describe the future state of the company with improved systems and controls. A performance measurement system was developed from the strategy map to allow performance to be monitored over time.

3. PROJECT IMPLEMENTATION (ACTION RESEARCH)

Company background

Company A has the largest fleet of MCWP (Mast Climbing Work Platforms) equipment in the world, covering standard, medium and heavy-duty machine types. It delivers a comprehensive package of equipment, installation of equipment, safe certification of its condition and also trains users on site to operate the equipment efficiently and safely. It provides solutions throughout the UK and Ireland with its branches located in Glasgow, Manchester and London. The access from the MCWP provides for different work types such as brick laying, over cladding, window replacements, etc. The company used many lagging indicators to measure performance, this always presented information after the event. The company were failing to perform consistently in some key areas and so decided to improve their systems to become more consistent. Company A based their operations activity on assumptions. They assumed what the service levels should be without consulting the customer, they then developed systems based on these assumptions. Company A aims to grow their market share and become exceptionally operationally efficient, leading the way for the MCWP industry and becoming a role model for the construction industry in general.

AS-IS Process Map

The activities within the business were identified by working across all the departments. The identified activities were mapped using IDEF0 methodology, An AS-IS process map was created. Each activity was thoroughly examined in the light of the value it brings for the business and the activities, which do not add value, were highlighted for attention. Value stream maps were used wherever necessary to identify the non-value adding activities. Although Value Stream mapping is theoretically strong in the manufacturing industry, the authors felt it was impractical, especially in the construction industry, hence it was decided to use the mapping at very basic level (virtual) to identify activities that were duplicated, consuming larger amounts of people time, redundant activities, etc.

Customer interviews

Customer interviews were conducted with a number of Company A's 'key accounts' to determine the client's perception of the level of service they have received. More importantly it was an opportunity to ask directly what elements of service are most important to them. Company A then had an opportunity to use this information to tailor their service to meet the desired needs of the clients therefore measurably improving the levels of service and improving chances of repeat and referral business. Interviews were conducted in major cities in the UK where contractual work involving Company A had taken place in the last year, or where work on the contract was approaching completion. The main findings from the customer interviews were documented as shown in Table 2.

Table 2: Main Findings of Customer Interviews

Issues raised through customer interviews:	
• Poor response to general queries	• Lack of clarity in pre start meetings
• Salesmen selling jobs beyond our operational capability	• Poor communication between fitters and site
• Information lost during handover process (Sales and Operations)	• Inability to cope with multi trade requirement
• Lack of information on product capabilities	• Poor response to complaints
• Poor attention to detail at installation	• Poor response to breakdowns
• Lack of customer focus and client courtesy	• Poor planning of jobs
• Poor performance with complicated jobs	• Cables constantly breaking

Failure Mode and Effects Analysis (FMEA)

FMEA was used to prioritise the improvement areas identified from customer interviews as well as the AS-IS models and determined which had the most negative impact on the customer. The results are shown in Table 3. Priority numbers 1 and 2 will be discussed later in the paper. Through the customer interviews a number of customers expressed concern that information they had passed on to the salesman did not appear to be passed on to the operations team when they carried out the job. After analysing the reason for this it became clear that little emphasis was placed on the information handover between sales and operations, resulting in information being lost between the two departments. The answer was to create a defined process, a communication document, to stimulate the handover of information and discussion on job specific detail. This is now called the ‘Pre Planning Summary Agreement’. This document is focussed on the internal handover of information before the pre contract meeting that takes place with the client and includes a representative from the commercial department. Hence priority 3 was successfully addressed.

Table 3: Top 6 Improvement areas identified from FMEA analysis

Priority	Improvement Area	Risk Priority Number (RPN)
1	Lack of customer focus and client courtesy	576
2	Poor response to complaints	512
3	Lack of clarity on pre start meetings	512
4	Inability to cope with multi trade environment	441
5	Poor communication between installers and site	384
6	Poor attention to detail at installation	216

Priority number 4 is a common view held by the clients that were interviewed. Problems occur in this area when the contractor is under pressure and more than one trade requires use of the platform at the same time. This is not possible but the issue can be avoided through working with the client to develop a greater understanding of how the product works. Programming is critical particularly when using MCWPs in a multi trade environment. It is therefore a responsibility on behalf of all staff members to educate the client on the effective use of the product so that projected benefits can be achieved. Priority number 5 and 6 has been attributed to a lack of information being passed down to the installer teams. This may have been a result of missing information resulting from poor communication between sales and operations. The next level of communications needs to be enhanced, once sales and operations are effectively and efficiently passing information then it is the responsibility of the Contract Supervisor to extract the relevant information and pass it onto the installer teams and then provide sound tool box talks in order to communicate that information to them.

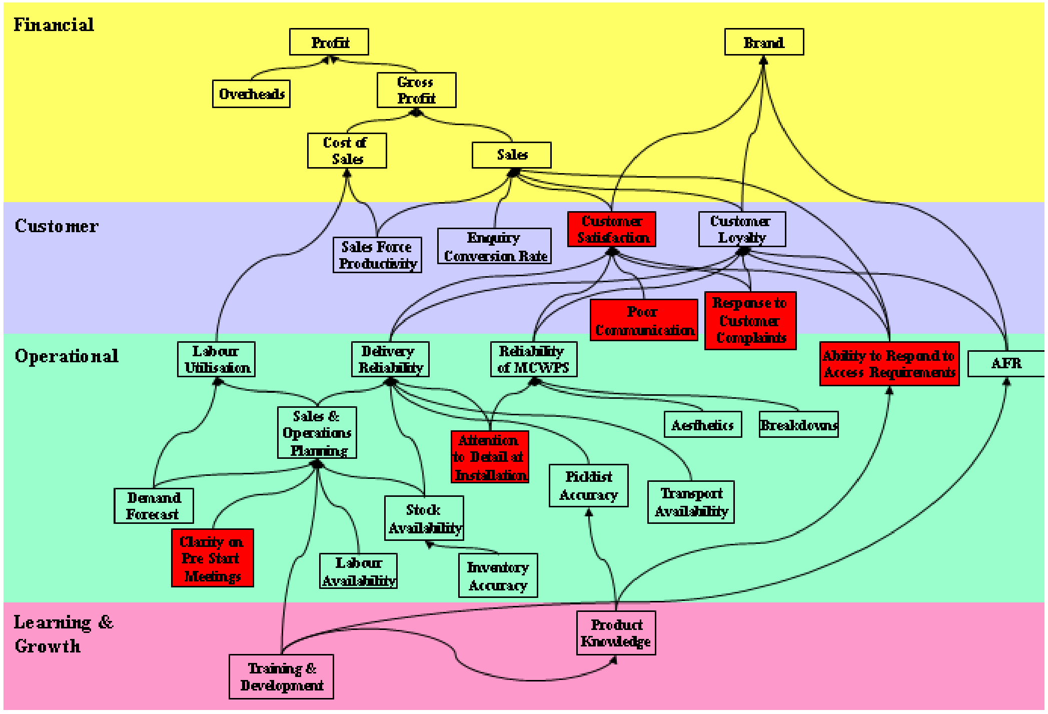

Figure 1: Strategy Map – Improvement Areas

Strategy Map & Key Performance Indicators (KPIs)

The Strategy Map was developed as shown in Figure 1. A brain storming analysis was done to identify all the factors at bottom line, which were impacting top-line performance and a cause and effect relationship diagram was developed. The objective of developing the Strategy Map was to realign the improvement activities with the Company's strategy and objectives. Associate 1 has done many interviews to identify customer requirements. Based on the interview findings as well as Quality Review Questionnaire findings, Associate 2 identified that the bottom line factors (Critical Input Variables) have a major influence on top-line factors (Critical Output Variables) in terms of all stakeholders. In order to monitor each of the factors, KPIs are defined and stored in a database as shown in Table 4. These measures are now used and monitored within the business.

Table 4: Key Performance Indicators (KPIs) for Company A

Absenteeism	Order Book - Six Months Forward
Accident Frequency Ratio	Profit (before interest and tax)
Customer Complaints	Return on Assets
Customer Retention / Loyalty	Return on Sales
Customer Satisfaction	Sales Force Productivity
Delivery Reliability (Delivery On Time In Full)	Sales Turnover / Revenue
Demand Forecast (1 Month Forward - Fleet)	Setup / Dismantle Time
Time to Resolve Customer Complaints	Gross Profit
Labour Utilisation	Utilisation - On Hire
Order Book - One Month Forward	Utilisation - On Site

Address Customer Complaints & Improve Customer Focus (Priority 1 & 2)
As the business was growing rapidly, there had been a significant increase in the number of issues with customers. In several instances, customers withheld payment until these issues were resolved. The main issues reported from quality review questionnaires (QRQs) were:

- Platform installation not completed on time. (This causes delays in other plans)
- Poor response from operations to technical and service related queries
- Handling of accident queries
- Failure to meet specific access requirements
- Poor aesthetics of mast climbing work platforms

When the business was small, all the issues were kept in mind and resolved appropriately. However as the business grew, it was proving very difficult to keep everything in mind and resolve them quickly. The issues and complaints were not logged in properly and hence people never got an opportunity to systematically solve them with in a reasonable timescale.

Designing & Implementing Customer Complaints Database & Procedures
The authors created a customer complaint procedure to enable customers to express their problems and frustration with the service. Once complaints are received, they are directly logged on to the customer complaint database on the server. These complaints are allocated to a responsible person and communicated through telephone or e-mail to an administrator. The aim is to resolve a complaint as soon as possible. Hence someone in the business responds within three hours of any complaint being lodged. One of the members of staff contacts the customer with the details on how it is expected to address their concerns:

To-Be Process Map
The activities within the business have changed over the period of this project implementation with several changes being made in the business. In addition to these changes, the business was taken over by the Group, which brought in some more changes. The new identified activities were mapped using IDEF0 methodology (To-Be). Although AS-IS process map was developed in functional approach. To-Be process map was developed using a process approach.

4. DISCUSSION

After developing As-Is Process Map, the Implementation team tried to implement Value Stream Analysis. However it proved very difficult to apply Value Stream analysis in this business in the way it is applied in Manufacturing Industry. Unlike manufacturing, the construction industry has different projects with several activities. Each activity differs in each contract depending on the complexity of the job. Hence the researchers decided to use the concepts rather than the detailed analysis to identify non-value adding activities. The other major activity on which people spend most of their time in identifying where they were overspending money on a contract. The researchers implemented Sage Job Costing to address this problem. Although it was easy enough for the researchers to configure and implement the Sage Job Costing, the difficulty was getting people to buy into it. Initially administrators were not posting all the costs. The designated people were not updating the budgets on each job. Hence the monthly reports were showing many discrepancies. This failure was due to lack of understanding from the administrators who were updating the system on a day to day basis. The researchers spent almost 3 or 4 times training each person to make them understand the system. Finally the system was completely rolled out and full control was transferred from the researchers to commercial managers. It is now generating valid reports, which are used by all relevant people in the branch meetings.

The researchers decided to develop a Strategy Map (Cause & Effect relationship) to visualise improvement efforts to align to the stakeholder requirements. The information is gathered both from the external customers as well as internal people who interact with customers. FMEA analysis was conducted with different people with in the business to identify the improvement areas which need immediate attention. KPI’s were developed from the Strategy Map and implemented as Headline KPIs (mainly Critical Output Variables) and Operation KPIs (both Critical Output and Input Variables). However only people at senior management level used these KPIs initially and it was not properly deployed at lower levels. Plans are now in place to deploy KPI’s to lower levels. The culture observed at this Company was similar to that observed in any typical UK manufacturing industry, with people having blame culture (pointing fingers at each other) and showed resistance to implementing some of the systems. However, as the senior management stressed the importance and benefits of the systems repeatedly, the resistance was over come to a greater extent. Many people at this company lack basic computing skills, which also made them resistant to use the systems implemented. The researchers had to train the users repeatedly up to five times on one-to-one basis to make the users comfortable on the systems. The implementation of KPIs had not only improved the business performance but also began to change the culture of the people from intuitive to fact-based decision-making.

As the company did not have many written procedures and at the same time were growing quickly, there were many issues (operations and commercial), which went out of control. This affected customer service, which delayed payments and increased debtor days. On a couple of occasions the customers even asked the business to pay compensation money in turn for not providing the appropriate service, and adversely affecting their plans. In order to address this issue, the researchers introduced the customer complaint procedure and implemented a customer complaint database to collect customer complaints and resolve them systematically. At the same time the company has also developed written procedures for several activities and processes. The introduction of the database has improved the customer service and reduced commercial issues, which eventually improved our debtor days.

Overall, the benefits of this project (research) may be summarised as follows. The PMS implemented at Company A resulted in significant benefits by:

- Making the business focus on all stakeholder requirements (internal and external)
- Creating an understanding of the cause and effect relationship between the business measures and operational measures
- Creating awareness of issues and focus on critical problems
- Making performance information more transparent and visible
- Bringing the cultural change (intuitive to fact based decision making, reactive to proactive approach)

Like every other project, the researchers have to justify the cost-benefit analysis of implementing the PMS. Although it was fairly easy to establish the implementation costs, it proved difficult to establish the operational costs or saving of such systems (i.e. the marginal cost or saving of operating maintaining, updating and using such a system). As the PMS became an inextricable part of the Company's processes and structures, it became increasingly difficult to separate the impact of PMS from other assets and activities (Bititci et al 2002a). Even though the paper demonstrated that there are overall benefits of PMS, it failed to address whether the benefits are worth the PMS investment. However, the management team's (Company A) opinion was that the business benefits enjoyed were largely attributable to the PMS and that it far outweighed its costs.

5. CONCLUSION

The authors opinion is that a lot of literature already developed in performance measurement (especially manufacturing industry) can also be adapted to businesses operating in construction industry. This paper provided empirical evidence that appropriately designed performance measurement systems developed from different stakeholders, if appropriately implemented will improve visibility, communications and other cultural changes such as more proactive management style. However, this conclusion is based on a single case study. The authors are confident that the benefits enjoyed by Company A are replicable in other organisations provided that the environmental conditions are similar. However, the literature requires more of these studies to generalise that the concepts work in construction industry if they are appropriately implemented.

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DESIGNMAP: CAPTURING DESIGN KNOWLEDGE IN ARCHITECTURAL PRACTICE

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ABSTRACT

Within the conceptual phase of design, architects (and designers in general) collect and look at design documents. These design documents are sources of knowledge and inspiration for designers. In order to support knowledge representation and information organization in an integrated manner during the conceptual design phase, an information model named Architectural Information Map (ArcIMap) has been developed. Four prototype applications of this model have been developed and tested; three in architectural education and one in architectural practice. This paper presents the ArcIMap model, its application in architectural practice, the evaluation of this application, and its final version. The paper is concluded with a discussion of the results and future work.
Keywords: architectural design, conceptual design phase, design correspondence information modeling, knowledge representation

1. INTRODUCTION

In the conceptual phase of design, architects develop one or more concepts that must prove to be valid throughout the lifecycle of the project (Heylighen and Neuckermans 2000). In order to do so, they gather information and study relevant precedents (Akin 2002, Oxman 1994). This information is usually represented as design documents and can be of any format, i.e., drawings, diagrams, pictures, texts, movies, etc., and they convey a specific aspect and viewpoint. Furthermore, architects often work in teams, also in the conceptual phase of design. Correspondence among the team members, and with members of other disciplines involved in this phase, is crucial, because in design, designers learn from and with each other (Schön 1985). Correspondence in this context conveys communication with the aim of reaching an agreement. Finally, the knowledge created within any community, for instance an architectural office, needs to be captured and reused for future projects and new team members.

Design information has many inter-relationships and dependencies. Organizing this information is a complex task. A computational environment that supports the recording and reuse of knowledge, and the organization of information, is essential. A computational environment for a collection of design documents has a number of purposes: to create a design document library that can be searched and browsed, and the organization of the knowledge that resides in these documents that can be searched and browsed. This environment must be robust, but also flexible, extensible, and easy to use.

Many electronic design document libraries have been developed, most of them as image archives. These traditionally organize documents according to categories such as year, style, architect, etc. Others are also targeted at supporting cognitive processes of designers at the early stages of design, as well as providing organized precedent libraries (e.g., Akin *et al.*, 1997; Heylighen and Neuckermans, 2000). Some target the cataloging, adaptation and reuse of knowledge embedded in 'cases' (e.g., Flemming, *et al.*, 1997; Oxman and Oxman, 1993). However, a system that can cognitively support designers in the conceptual phase of design through the recording of design knowledge and design ideas that at the same time serves as an information organization environment is interesting from many viewpoints.

In order to support knowledge representation and information organization in an integrated manner during the conceptual design phase, an information model has been developed. This model, named Architectural Information Map (ArcIMap), consists of a semantic structure and a document structure. Four prototype applications of parts of this model have been designed, developed, tested and evaluated; three in architectural education and one in architectural practice. In this paper, ArcIMap model is briefly presented. The application of this model in architectural practice, named DesignMap, its use at Mecanoo Architects, Delft, The Netherlands, its evaluation, and its final version have been described. The paper is concluded with a discussion of the results and future work.

2. THE ARCIMAP MODEL

The goal of the ArcIMap model is to define a framework for creating digital applications for designers to use in the conceptual phase of design. In this way, extensible libraries of design documents can be created, and knowledge structures of designers can be recorded. This framework can be used for educational as well as professional contexts. The process and requirements differ in a practical and educational environment. Novice designers can use the model to learn about design solutions and expand their knowledge structure in a targeted way. Experienced designers can use the model for organizing and storing visual material in a personal way. Project managers can use the model for archiving collective material using a common information organization scheme. In this model, two distinct activities are investigated: information gathering and organization in the context of conceptual design, and knowledge representation and reuse in the context of conceptual design. This model acts as a framework for the definition and implementation of computational systems, and applied in specific contexts. The ArcIMap model creates a methodology for the separation of the organizational structure and the document structure. ArchIMap has two main components (Figure 1):

Semantic structure: A semantic structure to model *concepts* and *conceptual relationships* (knowledge), conceptually derived from concept maps (Novak and Gowin 1984), representationally using aspects from semantic networks (Quillian 1968, Sowa 1991), conceptual graphs (Sowa 1984), and XML topic maps (Pepper 2002). The semantic structure acts as a backbone for the organization, decomposition and indexing of documents. Document metadata is also incorporated into the semantic structure. This network can be defined by a user or a group, can be project or institution specific, and defines a common language among users. It can also be imported. The concepts and conceptual relationships in the semantic structure are typed, respectively through the concept type hierarchy and the relationship type hierarchy.

Document structure: This structure contains a collection of multi-media design documents to be used in the information gathering phase of conceptual design. These documents are named components in the model. The document structure allows for the definition of document components for ease of indexing by content. These document components are created by dividing documents into smaller components. Components can be related to other components in other ways than component relationships: referential relationships can be defined among components. Occurrences relate components to members in the semantic structure. Occurrences are typed.

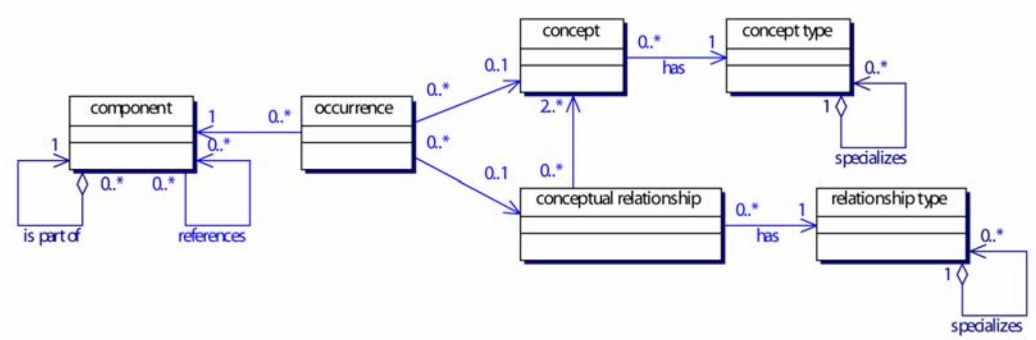

Figure 1: The ArcIMap model as a class diagram represented in UML.

3. DESIGNMAP: A PROTOTYPE APPLICATION OF ARCIMAP IN AN ARCHITECTURAL OFFICE

A prototype application of ArcIMap, named DesignMap, was developed in order to test the validity and applicability of the model in a practical context. DesignMap implements parts of the ArcIMap model in a flexible and extensible web-based collaborative environment, intended to be used at the early stages of design. It targets middle and small-size architectural offices. DesignMap was applied in an architectural office, Mecanoo (http://www.mecanoo.com/) located in Delft, The Netherlands. Mecanoo has about 65 employees, consisting mostly of architects and engineers.

Because of the recent advances in Information, Communication and Knowledge Technologies (ICKT), architectural offices are going through a process of digitalization. It is becoming increasingly common practice for architectural offices to digitally archive their project documents and to set up intranet sites. In this respect, offices are looking for organizational structures for their documents that are suitable in order to support an easy and fast, but also effective retrieval. This was also the case in Mecanoo.

In this particular office, a lot of aspects from previous designs are reused; this is an office policy. Images and documents are stored on servers, but there is very little recorded information available about the design rationale and the crucial concepts. Furthermore, there is a single rigid classification system that does not allow designers to use subjective terms. Additionally, designers at Mecanoo look at magazines, and use search engines such as Google to find relevant information for the project at hand. They organize documents on a server according to a naming system used in the whole office. However, when people need to use an image, they tend to copy it to the hard disk of the computer they are using, which causes problems of too little hard disk space.

The DesignMap application has three main goals: To enable a design team organize their information that they gather during the conceptual design phase in a personal, flexible and extensible manner; to enable a design team build up a common language of design concepts and relationship in order to improve their communication; and to enable the recording and reuse of design knowledge generated by a design team in other projects and other design teams. Keeping these goals in mind, the main motivating points for the development of the DesignMap tool are that such a record of the creative thought process makes it possible to accelerate and improve the quality of the design process of a given design team. It also enables the comparison between the methods different design teams use to design a given product. Recording the thought process of the design team enables the team to contribute to the design, and interact with each other's ideas, independently of any space or time constraints. This makes it possible to accelerate the lengthy and time consuming creative thought processes needed at the beginning of every design process, by building on the knowledge accumulated during the design of previous projects. This also supports the concept of precedent-based learning, where a design team adopts their successful solutions to problems similar to the ones they had to cope with in the past.

A prototype application

The input to the prototype implementation of Design Map is a concepts network and a number of design documents. An initial concepts hierarchy has been created by the project manager from Mecanoo Architects. This list contains physical concepts as well as abstract concepts such as 'inspirations'. Still, one can tell that the main line of thought behind this classification is the archiving of documents rather than a dynamic communication and organizational structure made up of concepts and relationships.

The main interface of DesignMap (Figure 2) contains functionality to upload documents, browse documents by concept, and search by concept. Additionally users can modify and delete documents and their properties. The bottom part initially shows all documents in the system by displaying their thumbnails. Below each thumbnail is a list of the associated concepts as hyperlinks. Clicking on a concept displays the documents associated with that concept. This allows for fast browsing of concepts and documents. The bottom part also displays the currently selected concept(s). One can drag and drop thumbnails into the two areas above to view them in bigger size. The 'search by category' option allows one or multiple concepts to be selected, and this brings up the associated documents in the main interface. Documents of all formats can be uploaded to DesignMap. Once a document is uploaded, it is visible to everyone using the system.

Figure 2. The main interface of the DesignMap prototype.

Evaluation of the prototype application

In general, highly positive reactions from the participants at Mecanoo have been received about the use of this environment in their office. They especially appreciated the fact that the organizational structure can be modified and extended without affecting the already stored documents in the environment. This experiment ran for approximately 3 months. Because of the heavy work load of the designers, project deadline constraints and financial considerations, it was treated as a pilot project and was used by two individuals in the office: the general project manager who tested the system and prepared the concept hierarchy, and a designer who input documents.

In order to evaluate the prototype and its use, a 4.5 hour workshop at Mecanoo was conducted. The participants in this workshop were four members from the design and development team of DesignMap, and the project manager and five designer architects from Mecanoo. The participants from Mecanoo had received the planned schedule of the workshop beforehand and had prepared for it. Among other preparations, the five designers had gotten themselves familiar with the application before the workshop, but they had not actually used it in their design process.

The workshop started with a presentation of DesignMap, its functionality, intended use, and goals, and included a presentation of the general design process flow at Mecanoo, consisting of three main stages: idea development, design, and execution. The workshop continued with a brainstorming session on how DesignMap can be implemented in a running project at Mecanoo. Participants used notes on the wall to present ideas and relate them. Later, these notes were grouped together, themes were derived, and these were discussed. The main conclusion of this brainstorming session was that DesignMap can and should be applied in two different ways: as a structured database, and as a means to communicate ideas. Two ideas for improvement concentrated on initially filling the system in the least cumbersome way with precedent based information for allowing immediate browsing and searching at the beginning of a project, and the ease of use of the user interface. In order to fulfill the use of DesignMap both as an archive environment and as a communication tool, two types of concept structures are needed: one specific to each project and/or design team, and a filtering and mapping mechanism that filters all the networks and fits them into a mediated archival classification system.

Designers had a lot more interest for DesignMap when they realized its potential as a design correspondence tool. Designers were initially introduced to the concept hierarchy that their manager had constructed, and they thought that this was a fixed structure that they needed to abide by in their design process. This was not very interesting for them and they did not see the added value of this in the design process. On the contrary, they very much liked the idea of a concept network that they design collectively and reflects their thought processes in the conceptual phase of design.

The final prototype

In this context, a new implementation of DesignMap was started. In this environment (Figure 3) a number of DesignMap clients connect to each other using a local area network (LAN), allowing these clients to communicate and share a common design environment. The data generated and stored by these clients are collected in a database. The communication between the clients and the database takes place over the Internet, through an HTTP interface and using the XML language. A web server processes the requests issued by the DesignMap clients and forwards them to the MySQL server which, in turn, responds to them as appropriate based on the information in the database.

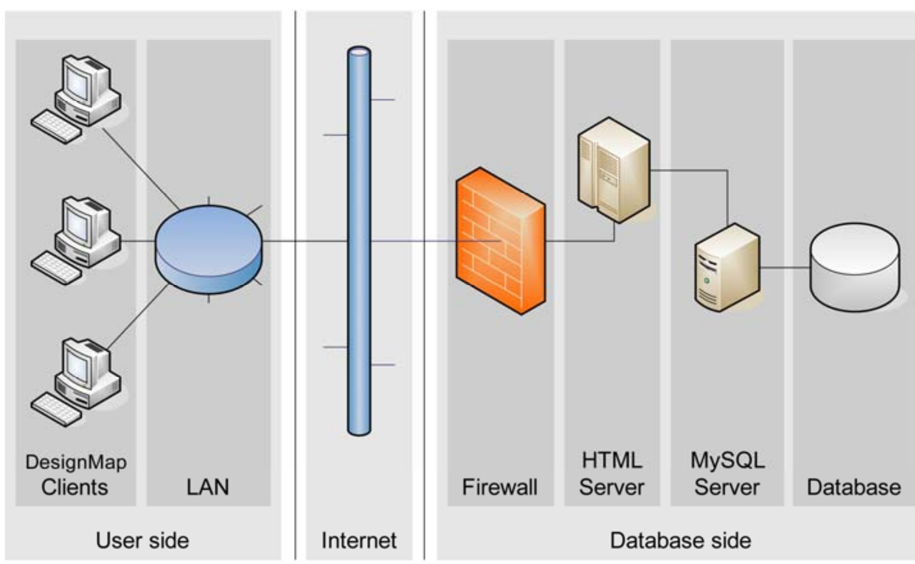

Figure 3. Illustration of the DesignMap software environment.

Figure 4 shows the user interface of DesignMap, implemented in the Java language. Besides the menu bar and the status bar, the tool has three main panels: the tree browser, the TouchGraph browser (www.touchgraph.com) and the thumbnail browser. The first two browsers present in two different ways the information stored by the designers in relation to the design process. The tree browser represents the design process in the form of a clickable tree, and allows the navigation of the design space in an explorer-like fashion. The TouchGraph browser lets the user navigate around this same design space in the form of a traceable network. These browsers describe a number of keywords the designers consider to be relevant to the way they carry out the design. Each keyword is, in turn, connected to a number of other relevant keywords, which creates a network of keywords that represent the thought process of the designers. In addition, each keyword is associated with a number of corresponding documents (text, image, simulations, etc.) that details the way the keyword contributes to the design. Each time a keyword is highlighted in the tree browser or the TouchGraph browser, the representations of the corresponding documents are shown in the thumbnail panel in DesignMap. Clicking on the thumbnail of a document opens up a popup window that shows that document.

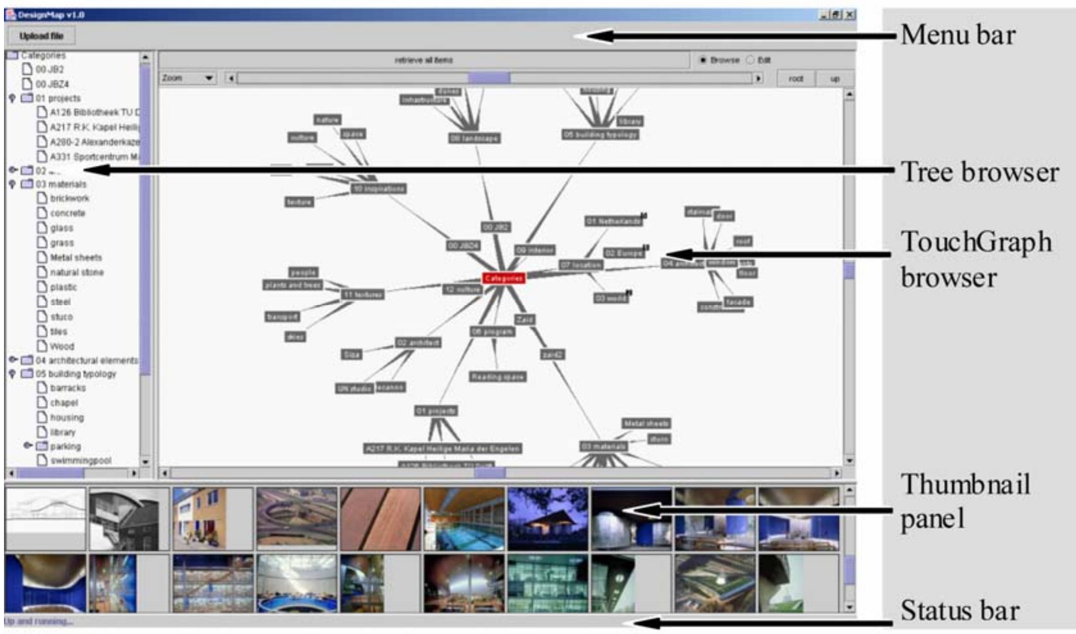

Figure 4. Main window of the DesignMap, where the different components are shown.

Structure of the final prototype

The UML model of DesignMap employs a hierarchical approach that involves a number of layers. The top layer specifies five classes, each of which contains a number of internal layered classes. The DesignMap class is the main class of the tool that initializes all other classes in the DesignMap tool. The GUI is the graphical user interface class that contains all other components of the DesignMap, and allows easy interaction between the user and the tool. In addition to the toolbar and the status bar, the GUI features the two main ways the tool employs to represent the design process: the KeywordTree component models the tree browser in the tool, and the TouchGraph component models the TouchGraph browser. The thumbnail panel is part of the GUI class itself. The fifth and final top-level class is the DesignMapData class, which is where an internal representation is stored of the data structure related to the design process. The data stored by the DesignMapData class represents a copy of the design data present in the database side of the application. This data is present in all active DesignMap clients connected to the network. Therefore, it is very important for these data structures in each client to stay up-to-date with the changes that take place in the database, and in other clients. Figure 5 shows the internal structure of the

DesignMapData class, containing 8 classes, divided into the following two main groups: data storage classes, and data communication classes.

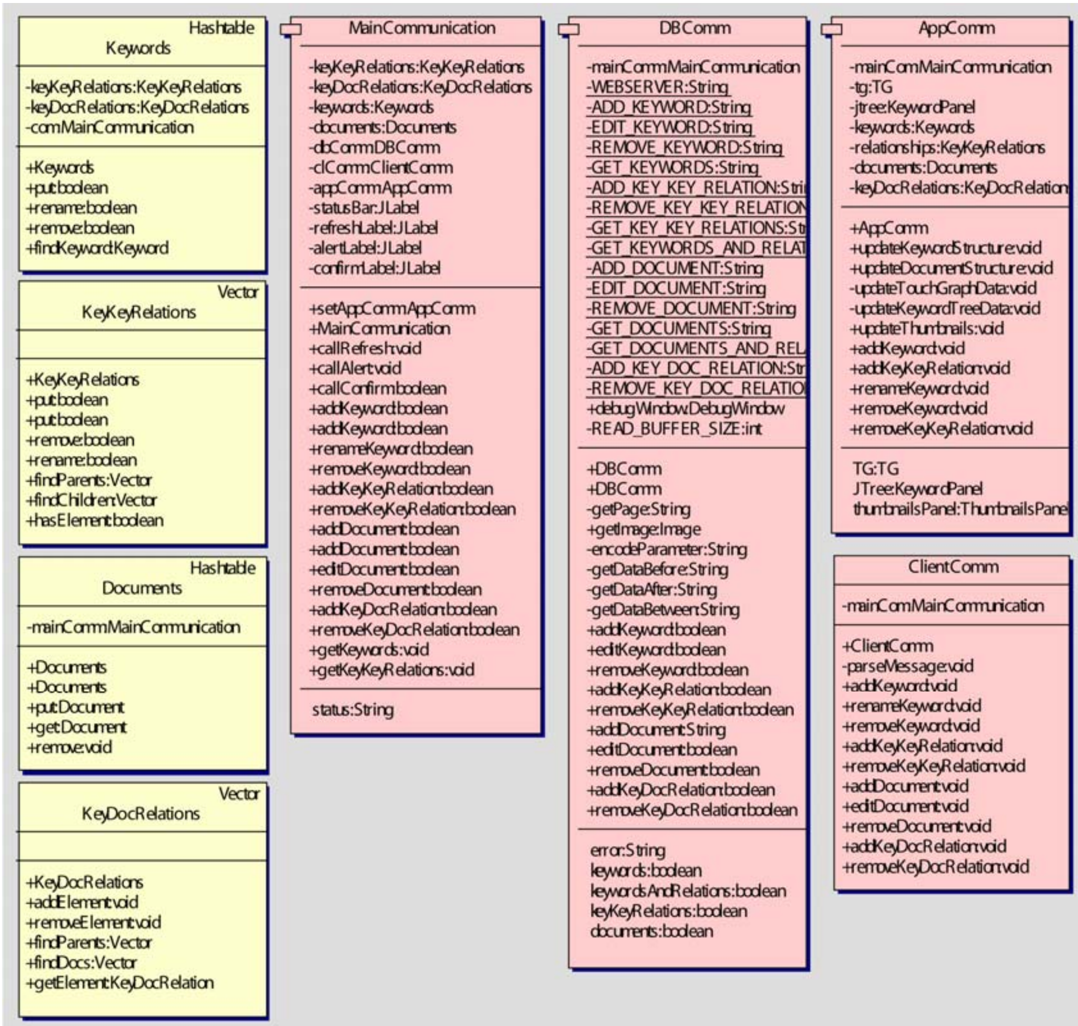

Figure 5. The internal UML model of the DesignMapData class shown in Figure 5.

Four data storage classes contain the actual DesignMap data as represented in the database. The Keywords class is coded as a hash table of the keywords the designers use to describe their ideas. These keywords are related to other keywords by relationships described in the KeyKeyRelations vector class. A similar class representation is used to store the documents data: the Documents class contains the actual documents stored by the designers, while the KeyDocRelations class contains the relationships each document has with the keywords.

Four data communication classes are responsible for keeping the data within each client synchronized with the data represented in the GUI component of the application, in other clients, as well as in the database. MainCommunication is the central class that regulates the different updating activities that need to take place, depending on the origin of the modification issued to the application. AppComm is the class that regulates the modifications that take place in the application itself as shown in the tree browser, the TouchGraph browser and the thumbnail panel. Any modifications made by the user through the GUI are propagated by AppComm to DesignMapData, to the database, and to all other clients. In the same way, any modifications made by other users to the database are signaled by MainCommunication, and propagated by AppComm to the GUI of each other client. DBComm is the class responsible of updating the database with the changes, while ClientComm is the class responsible of updating all other clients of the changes taking place locally.

4. CONCLUSIONS AND FUTURE WORK

The applications of ArcIMap are intended for use by a relatively small group of cooperating designers. Applications of this model can be conceived and developed in educational and practical contexts. In order for the use of the application to be successful, an analysis of the organizational and process aspects of the context in which the implementation is foreseen needs to be done, and the outcomes that result from this analysis need to be included in the implementation design. The implemented system needs to be rooted in the context that its users operate in. By defining designers as active organizers of the knowledge and inspirations in a design context, the focus shifts from a pre-structured use of design precedents to an environment that facilitates and encourages the designer in creating her own structured body of design knowledge.

It is a challenge to apply the results of this research in practice, where the "time is money" syndrome is widespread, and where immediate profit is generally expected from the use of such a system. There is an enormous time and financial pressure on the designers working in architectural offices. The uptake and use of such systems require an investment from the designers, as well as from the managers. Designers and managers need to be convinced of the advantages of the use in the longer term.

Such a system can be used for two purposes in an office: in order to create a common knowledge structure for use in the whole office, and in order to aid the design process of small project teams by having them cooperate through temporary project-based knowledge structures. Project managers are generally highly interested in the first use, and designers in the second. In order to transfer knowledge and information from these temporary structures to the main knowledge structure, ArcIMap foresees translation and mapping mechanisms.

However, a number of improvements would increase the chance of success of an application of ArcIMap, especially in the context of an architectural office. One important requirement for an information system to be used in practice is that it should have as little impact on daily work as possible. This concerns the user interface; it needs to be as user friendly as possible, and the user interaction needs to be very smooth. Additionally, the main problem of attempts to capture and make available knowledge during design is the additional workload that is generated by the capture process and how one can justify this to designers and managers. In order to decrease this workload, a number of tools must be developed and implemented. These tools can be used, for example, for the inputting and indexing of documents, for automatic initial taxonomy generation, and for inferring new knowledge from a knowledge structure. This latter one can be achieved by using inference mechanisms that are widely used in the knowledge representation field.

5. ACKNOWLEDGMENTS

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LIFE-CYCLE MAINTENANCE MANAGEMENT STRATEGIES FOR BRIDGES IN HONG KONG

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ABSTRACT

It is becoming increasingly important to systematize the maintenance of bridges in Hong Kong because of their advancing age, increasing traffic volumes, heavier weight of road vehicles, limited resources and various modes of structural aging and deterioration. Thus, it is necessary to develop appropriate bridge maintenance strategies and tools not only to meet serviceability criteria but also for the life cycle cost optimization of new bridges. Based on a review of the existing bridge management systems in some selected countries and comparing them with current bridge management practices in Hong Kong, this paper develops a proposed preliminary framework for the maintenance management strategies of medium and short span bridges in Hong Kong, which aims to optimize the life cycle costs with a 'value for money' focus, while taking into account the safety, serviceability and sustainability during the lifetime of the existing structures.

Keywords: Bridge maintenance; Bridge management system; Life cycle value-cost optimization; Safety; Serviceability.

1. INTRODUCTION

Hong Kong (HK)'s roads with about 900 road bridges throughout the territory carry a very high traffic volume. They play an important role in improving mobility and convenience, and to provide strategic linkages within HK (HyD 2005). As the governmental executive of highway management, the Highways Department (HyD) of The Hong Kong Special Administration Region (HKSAR) is responsible for planning, design, construction and maintenance of the public road system.

Although the bridge stock in HK is relatively new when compared with the stock of structures in Europe and North America, it is important for HK that its bridge assets are managed effectively. Those structures convey large volumes of traffic critical to the economy, with little opportunity for diversionary routes through densely populated areas. "Many structures are difficult to access, aesthetics and environment are of political importance, and the marine environment has the potential to influence a high proportion of structures" (Wong et al. 2001). Furthermore, resources for repair and maintenance are limited as in most regions.

Maintenance management of these bridges is therefore critical in order to provide an acceptable level of safety and serviceability during operation, over the entire life cycle. Well-structured strategies and procedures for periodic maintenance are important. Table 1 profiles the relevant structures needing HyD attention in HK.

Table 1 - Structures maintained by HyD (HyD 2006)

	Number	Length (m)	Area (m^2)
Bridge	885	150,937	2,104,113
Underpass	61	4,340	61,440
Footbridge	652	76,507	302,309

For simplicity, bridges in HK can be classified into two categories. The first category comprises long span (LS) bridges (Tsing Ma, Kap Shui Mun, Ting Kau, etc.), which are either cable-stayed or suspension bridges. They are relatively new with modern bridge monitoring systems. The second category comprises medium and short span (MSS) road bridges, the bulk of which are prestressed concrete structures of various forms. Some of the older ones are simply supported reinforced concrete bridges, including those built over 30 years ago. The proposed preliminary framework for the maintenance management strategies developed in this paper focuses on MSS bridges in HK, since the higher profile LS bridges have usually attracted special attention leading to tailor-made specific maintenance strategies and systems.

2. PILOT REVIEW OF A CROSS-SECTION OF EXISTING BRIDGE MANAGEMENT SYSTEMS (BMS's)

Methodology

In order to review the condition of the existing BMS's, an investigation was undertaken on existing BMS's in some selected countries. This review was based on a questionnaire. Most questions were based on those in the 1999 Questionnaire developed for deliverable D4 under the 'BRIME' project in Europe (FEHRL 1999). The main areas addressed by the Questionnaire are: (1) description of the BMS; (2) information on database; (3) condition of bridges; (4) other information recorded on BMS; (5) prediction (of future conditions); (6) information on costs; (7) decision on maintenance and repair; (8) prioritization (e.g. of maintenance strategies); (9) quality control; and (10) administrative organization.

The Questionnaire was initially sent to 28 bridge administration departments/units in various countries and states/regions within some countries in Asia, Europe, North America and Oceania. Seven responses were received by the initial deadline. In fulfilling the undertaking to keep specific information confidential, 'A, B, C…' is used to represent various respondents below, except for HK.

Analysis of the Survey Responses

The following response analysis focuses on the general maintenance information of BMS's. Tables 2, 3 and 4 compare summaries of the general features of the BMS's, their main functions/components and maintenance-related information from seven countries/regions/states.

Table 2 - General information on BMS's

Country / State / Region:	A	B	C	D	E	F	HK
Bridge category (MSS/LS)?	MSS	All	All	All	All	All	MSS
Computerized BMS?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of years in use?	6	9	>10	15	19	>15	5
Linked to a road management system?	No	Yes	Yes	No	No	Yes	Yes
Number of bridges in BMS?	9,000 (including large culverts)	3,000	12,000	4,600	about 30,000	3,000	896 (under ISIS)
Special documentation for the BMS?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Life Cycle Cost Analysis?	Yes	Yes	No	Yes	Yes	Yes	Nd

Table 3 - Main functions/components of BMS's in seven countries/states/regions

A	Recording the inventory of the structure stock. Recording capacity and condition of the stock. Planning and prioritizing maintenance works. Scheduling inspections. Recording of defects.
B	Inventory of: location, type of structure, geometry. Data on: condition, next inspection. Capture of cost data. Storage of reports, correspondence. Prioritization of periodic and rehabilitation works.
C	Inspection module. Programming module. Preservation module. Results module. Gateway module (to import & export data between BMS and other systems). Configuration module (to customize software).
D	Bridge inventory database, including condition state and rehabilitation measures; inspection organization; prototype for maintenance planning and prioritization.
E	Overall strategy. Activities. Structure databases. Knowledge databases. Processing modules.
F	Inventory. Inspection organization. Evaluation - under development. Maintenance planning – to some extent.
HK(MSS)	Inventory database.

Many of the respondents have used BMS's for over 10 years. A BMS has been used in country A since 1984 but the latest version was launched in 2000. All the respondents operate a computerized BMS with special support documentation for operations. For most countries, a BMS is used for all bridges on their National Highway Networks. Five organizations carry out Life Cycle Cost Analysis (LCCA), among which only E carries out LCCA through the BMS itself. Except for the BMS of HK(MSS), which presently focuses on an inventory database, most of the BMS's include management functions such as inspection organization, evaluation, maintenance planning, and prioritization. It should be noted that HK(LS) BMS's cover some such functions though, so direct comparison with HK(MSS) alone is merely indicative, and for this exercise only, as it conveys only part of the HK profile.

Table 4 - Maintenance-related information from BMS's

	A	B	C	D	E	F	HK(MSS)
Does the BMS use a specific tool or criterion to decide whether to repair, strengthen or replace elements of a damaged bridge?	No	Yes	Yes	Yes	Yes	No	No
Are there any methods to decide when to carry out maintenance work except for professional judgment?	Yes	Yes	Yes	Yes	Yes	Yes	No
Are there any methods to decide the best maintenance option apart from professional judgment?	Yes	Yes	Yes	No	Yes	Yes	No
Are there any recommended maintenance options linked to each rating range based on the condition ratings of the bridges?	No	Yes	Yes	No	No	No	Nd
Does the BMS generate an optimal (minimum cost) maintenance strategy subject to certain constraints such as a lowest acceptable condition level?	No	No	Nd	Yes	Yes	No	No
Does the BMS produce a prioritized maintenance strategy for the bridge stock when the maintenance budget is insufficient?	No	Yes	Yes	Yes	Yes	No	No

Most respondents use their BMS to make decisions on maintenance and repair. For B, decisions are based on the conditions of various elements. C makes decisions based on available funding, as well as the value and condition of the bridge elements. E uses present value cost calculation in connection with the inspections.

Most respondents have methods/tools to decide when maintenance work is needed. A decides on the basis of recorded defects. B makes decisions based on the condition of the element and a risk appraisal. For C, decisions are based on 'General Condition Ratings'. D makes decisions using an IT-tool, which will be completely developed for maintenance planning and prioritization by about early 2007. For E, the decision is supported by the result of an 'object planning' module. This uses functional classification of the damages in condition classes, given by the bridge inspector, together with deterioration models, to develop an optimal strategy for the bridge concerned. F makes decisions on the basis of maintenance programming.

To decide on the best maintenance option, A makes decisions by value management using risk analysis. B depends on both experience and the 'Strengthening Guidelines Manual'. For C, the BMS recommends the most beneficial treatment based on available funds along with engineering judgement. E makes decisions on the basis of the lowest present value cost of different options. F uses site visits, engineering judgment and life cycle costing to choose the best maintenance option. Most countries/states/regions have recommended maintenance options linked to each rating range based on the condition ratings of the bridges. In B, the inspector can recommend a treatment referring to their guidelines. For C, specific maintenance needs are identified in the structure inspection reports. The bridge managers review these reports and consider the recommended maintenance actions in their plan.

Many of the reported BMS's cannot generate an optimal (value for money (VFM)) maintenance strategy subject to certain constraints such as a lowest acceptable condition level. However, five of the BMS's can produce a prioritized maintenance strategy for the bridge stock when the maintenance budget is insufficient. For B, prioritization is based on a number of factors including traffic volumes, importance of freight route, risk etc. For C, the BMS recommends the most beneficial action within a given budget.

Review of Current MSS Bridge Maintenance Management Practice in HK

In HK, there are 896 MSS bridges that are managed under the HyD's Integrated Structures Information System (ISIS). This computerized BMS for the MSS bridges has been put into operation since 2000/2001. It serves as a simple database inventory for all the completed structures maintained by the Regional Offices of HyD.

Periodic inspections, as well as 'problem-shooting' (trouble-shooting) approaches are used in the BMS for MSS bridges. Inspectorate staff inspect every six months, engineers ever 24 months and special inspections are made when deemed necessary. Repair/maintenance work is carried once defects/damages on structures are noticed. Also, more proactive and/or comprehensive strategies are in place for many LS bridges, e.g. including weekly site inspections. Of course, preventive work, such as application of protective coatings is adopted where appropriate for MSS bridges as well. Professional judgment is generally used to decide when maintenance work is needed and the best maintenance option to be used. At present, there is no prioritized maintenance strategy for the MSS bridge stock. The maintenance budget is based on expenses in the previous year and the proposed repairs/improvements needs based on detailed/general inspections.

Interim Observations

Based on the review of the existing BMS's in some selected countries/ states/ regions, and comparing them with current MSS bridge maintenance management practice in HK, one could propose three functions of bridge maintenance management that could be considered for development in the BMS for MSS bridges in HK as follows:

1. Maintenance planning;
2. Maintenance optimization; and
3. Maintenance decision support.

3. PROPOSED PRELIMINARY FRAMEWORK FOR THE MAINTENANCE MANAGEMENT STRATEGIES OF MSS BRIDGES IN HK

Numerical methods have recently been developed for bridge maintenance optimization with multiobjective consideration. The basic principle of these methods is to minimize the life-cycle cost without compromising the performance of the structures, e.g. Itoh and Liu (1999) used the method of genetic algorithms to deal with the rehabilitation plan of bridge decks by minimizing the rehabilitation cost and deterioration degree simultaneously, Liu and Frangopol (2004) proposed the best possible tradeoff in maintenance planning with respect to three objective functions, namely, condition index, safety index, and cumulative life-cycle maintenance cost, and the maintenance renewal strategy proposed by Inagaki et al. (2005) takes into accounts bridge health indices, social values and renewal costs. The preliminary framework for the maintenance management strategies of MSS bridges in Hong Kong is proposed based on this principle, which aims to optimize the life cycle costs with a 'value for money (VFM)' focus, while taking into account the safety, serviceability and sustainability during the lifetime of the existing structures.

Prime Objectives of Bridge Management in HK

The four objectives of bridge management are proposed as follows: (Wong et al. 2001)

1. Performance - to maintain the structures in service with minimum disruption, and to the standards required by the local society;
2. Prediction - to understand and monitor the stock of structures in sufficient detail to enable effective planning;
3. Funding - to ensure that funds provided by society produce maximum value;
4. Social - to take account of wider social responsibilities, such as safety and sustainability.

In order to address the above four prime objectives, while supplementing the three proposed functions of bridge maintenance management for HK MSS bridges, namely, Maintenance planning, Maintenance optimization and Maintenance decision support, it is necessary to first formulate appropriate life-cycle maintenance management strategies. The expected bridge maintenance management strategies should also take into account the multiple constraints, including not only technical and economical considerations, but also the sustainable development imperatives. Technical considerations aim to assure the safety and serviceability of the relevant structures and the aesthetic appearance of the bridges. Economic constraints if taken by themselves could suggest a minimization of the present value of total life-cycle costs including maintenance. However, 'value for money' objectives would suggest that a balance be achieved between such life-cycle costs and desired quality, performance, utility and service levels. Furthermore, environmental, social and economical impacts, can impose constraints on sustainable development, and so should also be appraised in formulating maintenance management strategies.

Multiple Constraints Imposed on Maintenance Management Strategies

Technology - Serviceability and Safety

The ultimate goal of maintenance is to ensure both safety and serviceability of deteriorating bridges. Liu and Frangopol (2004) used a 'condition index' and a 'safety index' to assess the performance of the deteriorating bridges. The condition index takes discrete values of 0, 1, 2, and 3 representing visual inspection based condition states of no chloride contamination, onset of corrosion, onset of cracking, and loose concrete or significant delamination, respectively. A larger condition index value signifies a worse condition. The safety index is defined as the ratio of available to required live load capacity, describing approximately the reliability level of a deteriorating bridge component. A larger safety index value indicates a safer level.

Economy - Present Value of Cumulative Life-Cycle Maintenance Cost
The cumulative life-cycle maintenance cost is the sum of costs of all maintenance interventions applied during the designated service life that are respectively discounted to the present value at a reference time zero, i.e.,

$$C_{PV} = \sum_{i=1}^{N} \frac{C_{t_i}}{(1+v)^{t_i}}$$

where: C_{PV} = present value of the cumulative (life-cycle) cost due to all maintenance interventions; N = number of maintenance interventions; C_{t_i} = cost of maintenance interventions applied at time t_i; and v = discount rate. (Liu and Frangopol 2004)

The optimal maintenance planning problem deals with cost-effective allocation of maintenance efforts so that a preferred balance among condition, safety, and life-cycle maintenance cost objectives can be obtained. This problem can be concisely stated as follows (Liu and Frangopol 2004):
To obtain a set of optimized tradeoff maintenance solutions while
1. minimizing the largest (i.e. worst) condition index during the service life;
2. maximizing the smallest (i.e. worst) safety index during the service life, and;
3. minimizing the present value of cumulative life-cycle maintenance cost.

Sustainability - Environmental, Social and Economic Impact
There are three internationally accepted dimensions of sustainability: environment, economy and society. The establishment of the link between environment and development is fundamental to the concept of sustainability (WCED 1987). Key Performance Indicators (KPIs) being developed under various initiatives e.g. by Ugwu et al. (2006) can be used to appraise the environmental, social and economical impact of bridge maintenance strategies.

Life Cycle Value-Cost Optimization
Life cycle value-cost optimization is targeted through ‘value for money’ (VFM) considerations. Akhlaghi (1996) indicated that the definition of VFM is expected to revolve around the three E’s: economy – doing things for low cost; efficiency– doing things right; effectiveness – doing the right things. The life cycle value-cost of bridge maintenance strategies is optimized by balancing these 'three Es' criteria of VFM as follows:

- Economy – minimising the cost of resources for bridge maintenance management;
- Efficiency – increasing the ratio of the useful output (quality, performance and service values) to the total input (life cycle cost) in bridge maintenance management system;
- Effectiveness – increasing the utility value, which has been defined as: ‘the welfare a given investor assigns to an investment with a particular return and risk’ (SFD 2005).

Alternative Basic Bridge Maintenance Strategies

The previously discussed four prime objectives of bridge management and three functions of desired maintenance management strategies need to be addressed in terms of both general and specific constraints. In terms of the third desirable function of decision support, it may be noted that there are several short and long-term maintenance strategies and related options that can be applied to a deteriorated or substandard bridge structure and each has different consequences (Ryall 2001):

- Do nothing.
- Regular maintenance work.
- Preventative maintenance work.
- Repair work.
- Strengthening/rehabilitation.
- Replacement.

Proposed Preliminary Framework

The development of Life-cycle Maintenance Management Strategies for MSS bridges in HK involves three main steps, as shown in Figure 1 and summarized below:

1. Maintenance planning – Developing general maintenance management strategy scenarios which include alternative bridge maintenance strategies appropriate for HK in general, also to identify general constraints in HK;
2. Maintenance optimization – The resulting suite of maintenance management strategies is accessed, and an appropriate strategy is chosen and optimized for a given case/bridge scenario by balancing the various objectives and constraints in that particular case/bridge scenario with a 'value for money' focus; and
3. Maintenance decision support – The final maintenance solution is based on the above maintenance optimization, while taking into account the current MSS bridge maintenance management objectives, practices and constraints in HK, including those specific to the particular bridge under consideration.

4. CONCLUSIONS

In this paper, a proposed preliminary framework is developed for formulating appropriate maintenance management strategies for MSS bridges in HK, based on desirable objectives, functions and amidst multiple constraints. The expected maintenance management strategies are not just intended to minimize the life-cycle maintenance cost alone, but also to satisfy the multiple objectives and constraints relating to whole life bridge performance. The final bridge-specific maintenance management strategy would be optimized by catering to multiple general constraints, while taking into account local and current bridge maintenance management objectives, practices and constraints relating to that particular bridge. This proposed preliminary framework offers functions and indicates constraints in meeting identified objectives of bridge management. Further research on maintenance management strategies for MSS bridges in HK will be carried out based on this proposed preliminary framework.

5. ACKNOWLEDGMENTS

The authors are grateful to the responses obtained from the following Transportation and/or Highways Organizations: Highways Department of HKSAR, Highways Agency of UK, VicRoads (Australia), DOT (Department of Transportation) of Virginia (USA), Office Fédéral des Routes (Switzerland), Swedish National Road Administration, Main Roads of Western Australia, for their contributions of useful information. Grant HKU7138/05E from the Hong Kong Research Grants Council is gratefully acknowledged for assisting in the research and its reporting.

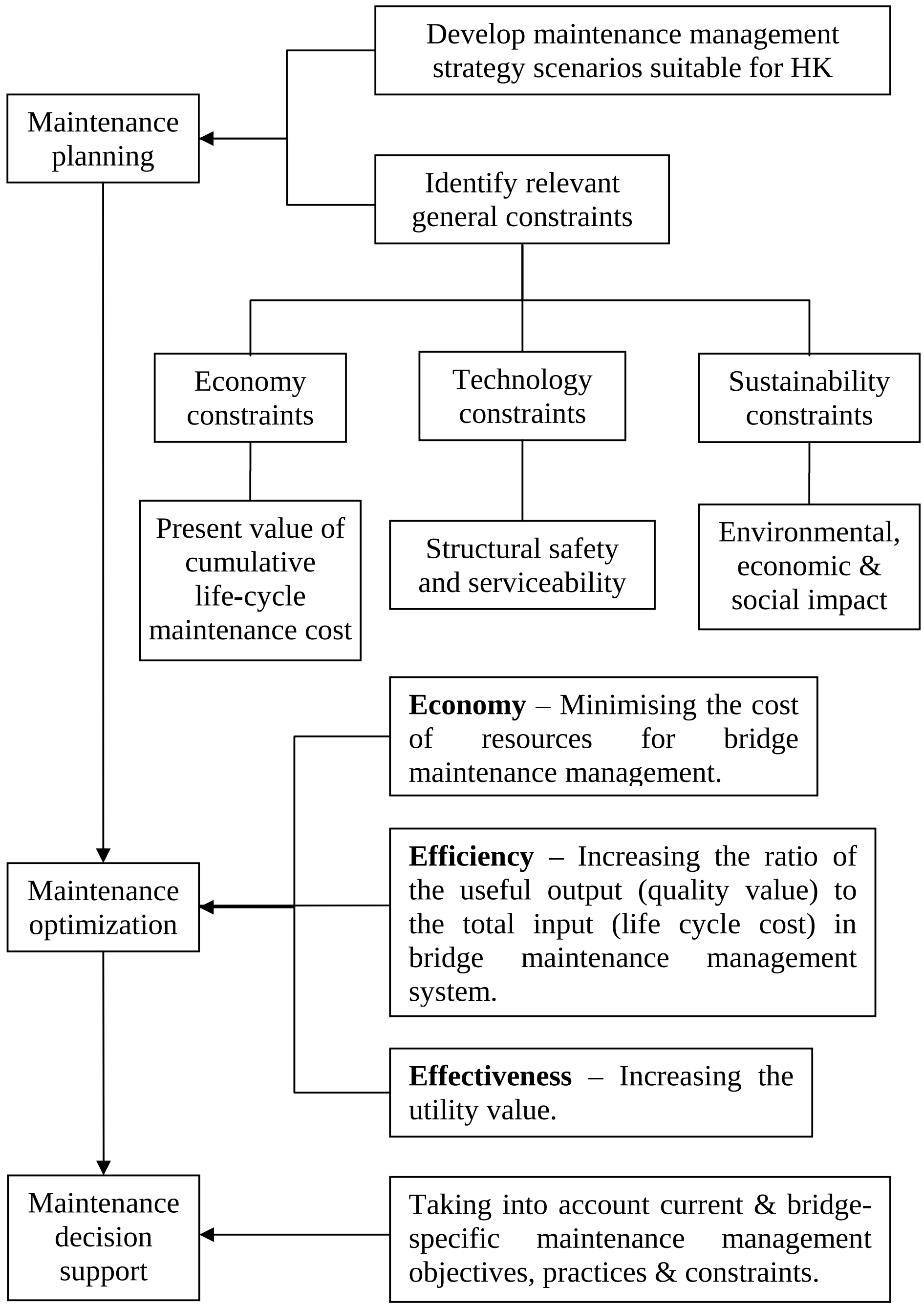

Figure 1 - Proposed preliminary framework for MSS Bridge Maintenance Management Strategies in HK

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7. ABBREVIATIONS

BMS	Bridge Management System
BRIME	Bridge Management in Europe
DOT	Department of Transportation
HK	Hong Kong
HKSAR	The Hong Kong Special Administration Region
HKU	The University of Hong Kong
HyD	Highways Department of HKSAR
ISIS	Integrated Structure Information System
KPI	Key performance indicator
LCCA	Life Cycle Cost Analysis

LS	Long Span
MSS	Medium and Short Span
Nd	No data
VFM	Value for money

BUILDING DESIGN PROCESS MAPPING & IMPROVEMENT

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ABSTRACT

This paper is based on the research work that is concerned with improvement of the process of design for construction. It is generally accepted that the quality and hence the value of a project is largely decided during the design, particularly at the early design stages. Management of this most important aspect of construction has not received due attention yet, particularly in the developing economies. It is in this context, the authors have worked on devising an improved design process map for day to day use in organisations dealing with building design projects.

The current design processes in selected Small and Medium Enterprises (SMEs) engaged in building consultancy in the Middle East and India were explored in this study and the design processes adopted by the organisations were mapped. A generalised current process map was then prepared. A number of areas could be identified in the early stages of design development, which could lead to downstream problems.

Based on the findings from the study, the authors have developed an improved Building Design Process Map (BDPM) with an associated Schematic Design Model (SDM). The new process map is easily implemented by designers without the need for rigorous training in the methodologies employed.
Key words: Process Mapping, FAST, QFD, Fuzzy Logic, Knowledge Archive

1. INTRODUCTION

The construction industry has traditionally been one of the largest in many developing nations. While other industries have greatly improved their levels of quality and performance, the majority of construction work is still based on antiquated techniques with high defect rates resulting in wasted labour and materials. In this age of globalisation and extreme competition, no economy can afford wastage of valuable resources caused by construction errors. The most effective means of reducing wastage in construction is known to be through the implementation of a well organised design effort for construction. An efficient design process map is a prerequisite to achieve this. Through a detailed questionnaire survey and interviews with senior professionals in building consultancy SMEs (which form majority of such enterprises) operating in the Middle East and in India, the need for and the essential features for such an improved design process map was established.

Lean Construction

The conventional approach to managing production processes focuses on managing the conversion of an input to an output. Lean production is an approach to managing a production process, which emphasises attainment of value efficiently. Lean production combines managing the conversion of the input to output with maximising the value of the output in the most efficient way possible (Ballard 2000).

Over the years, manufacturing industries have greatly improved their competitiveness through the use of lean methods. More recently, the efforts to apply principles of lean thinking to construction, known as 'lean construction' has started gaining momentum, more so in the developed nations. Most of the developing nations however, are yet to make much headway in this respect. With increasing demands from clients and mounting competition, construction has to break free from the antiquated styles of operation and adopt new ways. Construction wastage is an even bigger issue in the developing nations and hence warrants special attention in such economies
.

Lean Construction through Design

The Design Phase for construction proposals is responsible for providing value for the customer (client) by meeting client's requirements. It is in this phase that the designer (the design team/ firm) needs to meet the required quality standards through drawings and technical specifications (Ballard 2000, ICE 1996).

The importance given to managing design quality has a tremendous influence on the overall success of a project. Quality has the greatest influence on a construction project, if implemented in the early stages. As time passes, expenses start to rise, growing fastest during the construction stage. Ironically, the influence of project team on the quality decreases at an even greater pace (Mallon & Mulligan 1993). The need for an efficient process map to achieve the required design quality cannot thus be over emphasised.

Process and Process Maps

A **Process** can be defined as a structured, measured set of activities designed to produce a specified output for a particular customer or market. All organisations and sectors of industry use 'Processes' to deliver their business. More and more organisations are trying to develop and improve their processes in order to perform more effectively.

Removing defects, improving staff morale, improving customer satisfaction and reduced product delivery time are common core objectives of nearly all organisations. The key to achieving these objectives lies in first understanding and then changing the underlying processes that introduce the inefficiencies, defects, low satisfaction or slow production timescales in the first place (Michael 2003).

The **Process map** as applied to construction can be defined as a way in which the various processes involved in the designing and construction of a project are arranged so as to efficiently convert the various construction related inputs into the completed project.

2. RESEARCH METHODOLOGY

The research is essentially based on in depth interviews and detailed questionnaire surveys that were addressed at senior construction professionals working in the relevant market, supported by an extensive literature survey. The interviews were semi- structured and qualitative in nature to extract maximum possible information from the interviewees. Only minimal statistical techniques are used to analyse the data and to arrive at inferences. Opinions expressed by interviewees are used to establish and test the propositions put forth by this research.

Profile of participants

The respondents consisted of thirty senior construction professionals selected from fifteen consulting engineering firms from the Middle East and India. Twenty of the respondents were architects and the remaining were engineers by profession. Though architects were found to be acting as project leaders at most building design consultants, engineers were included in the survey to get a more balanced view of the problems related to construction design. Five out of the fifteen firms were international consultants, with offices in different parts of the globe. All the consultants were generally dealing with both building and civil engineering design works. Ten out of the fifteen were also doing building services related designs on their own, the remaining five were subcontracting these specific services.

3. DISCUSSION OF THE FINDINGS

Awareness of Quality Management systems has been found to be extremely low. All international consultants were aware of the ISO 9000 systems, though they were not extensively using these systems in the local offices. Two out of the thirty individuals were aware of lean construction, as their principals in Europe are part of Lean design groups in their own countries. The design processes employed varied significantly, with most of the firms having no written down design process guidelines (about 60% of the total and 100% of these were local firms), and the remaining 40% having definite guidelines on how to progress with a design development.

Current design process map

Figures 1 and 2 show the results of the survey with regard to the type of design errors. The highest rating given by the architects is for incomplete Client's Requirements (CRs) capture and processing, which points to the need for a proper tool for this aspect of design. The highest possibility of errors on the engineering part belongs to working on incomplete architectural and services information, which calls for the requirement of involving cross functional teams in design development.

Figures 3 and 4 show the results of the general problems of current process and the proposed improvements, respectively. These results again emphasise the need for a better tool for the CR capture, processing and implementation of well co-ordinated early design phases.

Proposed revised Building Design Process Map (BDPM)

Figure given in appendix shows the proposed, revised process map which is aimed at improving the overall quality and efficiency of building design organisations.

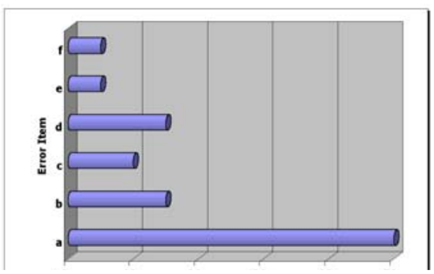
The proposal is to involve cross functional teams, in the context of process improvement, by assigning responsibility of different stages of the processes to the staff that perform them, in addition to supplying the necessary management guidance and support to enable those processes to be performed well, and to be improved continually. This follows from a fundamental aspect of lean design which is the replacement of hierarchical decisions with team decisions.

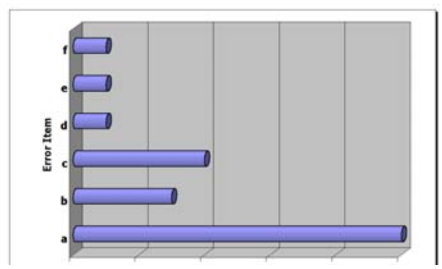
4. DESCRIPTION OF THE NEW PROCESS MAP

The fundamental change that will be brought about by the new process lies in the way it deals with the early design development. The Client's Requirements captured and processed into the development of the schematic design using workshop sessions participated by the client's team and the Cross Functional Team (CFT) of senior professionals from the design organisation.

ID	Item	% Rating
a	Incomplete Client's requirements capture	50
b	Working on incomplete/wrong site data	15
c	Lack of co-ordination of plans with sections/details/specs	10
d	Working without adequate consideration of E&S issues	15
e	Specification errors	5
f	Drafting errors	5

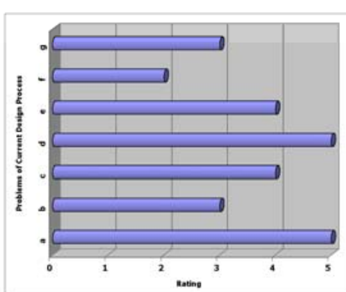
ID	Item	% Rating
a	Working on incomplete architectural & service drawings	50
b	Working on incomplete/wrong site data	15
c	Lack of co-ordination of plans with sections/details/specs	20
d	Calculation errors	5
e	Specification errors	5
f	Drafting errors	5

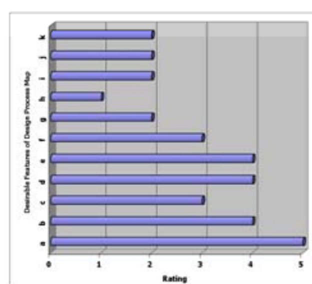




ID	Item	Rating
a	Inefficient capture and processing of client requirements	5
b	Approaching design problems with preset solutions	3
c	Designers working on incomplete / wrong data	4
d	Improper communication/co-ordination among various design disciplines	5
e	Lack of adequate check points preventing errors flowing downstream	4
f	Lack of specific client sign off points	2
g	Absence of a central QA system	3
h	Absence of knowledge archive leading to loss of valuable data from projects	3

ID	Item	Rating
a	Shall include a better tool for capturing , processing and addressing customer requirements	5
b	Shall bring out hidden CRs	4
c	Shall account for uncertainties in CRs	3
d	Shall encourage cross functional communication	4
e	Shall accelerate the design process, while providing check points for reducing the chances of errors flowing downstream	4
f	Shall include stage gates with client sign off to avoid confusion regarding the ownership of variations	3
g	There shall be a central point of QA, through which all documents have to pass before going out of the office	2
h	Shall not demand high inputs in the form of time and money	1
I	Shall be easy to implement in everyday use by professionals who have not received specific training in the management tools employed	2
j	The tool shall provide better benefits compared to cost	2
k	Use of the tool shall help building the reputation of the organisation among the potential clients	2





***Rating Scale**
5 - Extremely Important
4 - Very Important
3 - Moderatively Important
2 - Low Importance

Problems of Current Process

Figure- 4

Features of Revised Process

The first workshop will be held in two half-day sessions, in a conference room with projector facility. The first session will last for a maximum of 4 hours, attended by the Client and the Consultant's senior team. CR capture is assisted by the use of Function Analysis System Technique implemented using simple spreadsheet software. CR capture is further supported by the first House of Quality (HOQ) matrix and information from Knowledge Archive (which will be explained later). All the tools will be implemented with software support where details are projected onto a screen in the conference room and inputs entered step by step, through consensus. Appropriate design parameters to meet the CRs captured are also identified at this session. At the end of the session, the client is requested to provide his/her agreement to the CRs captured and the proposed design attributes before the team can proceed with the design development further.

The agreed design parameters are then converted into appropriate schematic design components using the second session of workshop 1 that extends for a maximum of 4 hours, attended by the same senior Cross Functional Team from the consultant. The client need not be present at this workshop. This session is supported by the HOQ 2, projected onto the screen, where schematic design components are filled in by the team through consensus, to meet the design parameters arrived at earlier.

The second workshop, to be conducted on the following working day, will involve senior designers from all concerned disciplines, including the cost consultant. This workshop extending for one full working day will be conducted in shorter sessions of one hour each, and will be led by the project architect. In the first session, the whole team will participate and decide the basic design possibilities and arrive at rough sketches of the proposed design. The team will then dissolve into individual specialities where the proposed rough schemes are developed into more details. The individual teams work with necessary interdisciplinary communication. The whole team meets again and adjusts their designs to suit overall requirements and the final scheme design is arrived at through the various sessions. The final scheme design is then approved by the team, which should be acceptable to all members. The team will include a senior engineer with good construction experience to advise on constructability issues. Ample use of the knowledge Archive is encouraged during the schematic design development stage to reduce the possibility of design errors passing downstream.

Once the schematic design is approved by the client, the rest of the process largely remains the same as the best of the current processes identified, with the following differences: the definite client sign off points, the use of a central QA team, explicit use of the knowledge Archive, the use of intermediate decision gates, better communication through the involvement of cross functional teams and in general, a more streamlined design development. In order to achieve an efficient design process flow, a specific project team is formed early in the design process and the team is provided with necessary design data at appropriate stages of design development.

Client briefing using FAST

The briefing process is critical to the successful delivery of construction projects. Client briefing is still a largely vague area in the design development process, eventhough a number of briefing guides have been developed to date. A framework based on Function Analysis System Technique (FAST) belonging to Value Management (VM) can be used to systematically identify, clarify and clearly represent CRs in the briefing process (Shen et. al 2004). The FAST methodology, developed by Charles Bytheway (Kaufman, 1998) is essentially based on the intuitive logic of HOW–WHY relationships of functions and displaying them in a diagram form.

Function analysis (Lawrence D Miles, 1972) is an essential element of the VM methodology through which CRs are expressed as functions of the project being designed. It also acts as a common language among all participants of the project, so that they can work together harmoniously to identify the opportunities available for project development and to highlight potential problems. A function is a specific purpose or intended use of a project that makes the project sell, produce revenue or meet requirements. Using the functional approach in the briefing process enables a thorough analysis of the functional requirements of the users, bringing out even the requirements that are not explicitly expressed by the Client thus making the briefs more complete and precise.

The CRs will be normally broken down from primary to secondary and then to the tertiary level. The output of the FAST process in the form of tertiary level CRs will be fed as input to the first House of Quality (HOQ1) in the new Schematic Design Model (SDM).

An overview of QFD

QFD (Quality Function Deployment) is a method for structured product planning and development (Lou Cohen 1995). The basic rationale of QFD is to systematically take the customers' desires down to the level of detailed production operations. The two QFD processes, the American Supplier Institute's (ASI) Four-Phase approach and the GOAL/QPC Matrix of Matrices approach, are widely accepted as effective processes to implement it. The ASI's Four-Phase approach that translates the customers' needs into technical requirements, and subsequently component characteristics, process steps and finally to operational steps will be used in the present case. Each of the translations uses a matrix, called the House of Quality (HOQ).

House of Quality

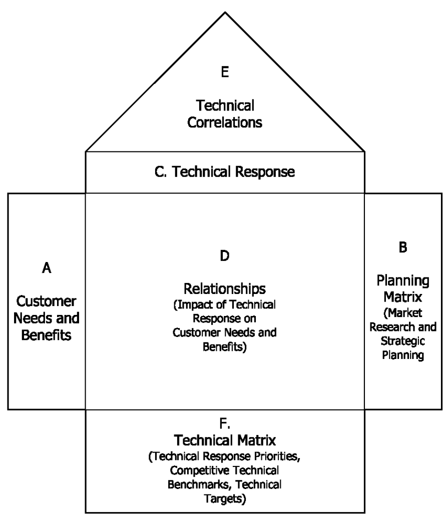


Figure-5
House of Quality (Lou Cohen 1995)

The primary tool of QFD is the House of Quality (HOQ). The HOQ is a useful tool for arranging facts so that important issues, relationships among these issues, the significance of each, and their measures of success can be readily displayed (Hauser and Clausing 1988; Lou Cohen 1995). The HOQ uses a matrix to present what the customers require i.e., the WHAT side against how those requirements would be met i.e., the HOW side. When fully developed, the matrix resembles a house, as in fig.5.

QFD in construction

QFD, which is now popular in the manufacturing industry, is slowly becoming known to the construction industry. Examples of its use in construction can be found in publications such as in the hypothetical renovation of a computer room facility (Mallon et. al. 1993), the design of low cost housing, the processing of clients requirements (Abdul Rehman et.al, 1999), the design/build contract environment (Low et.al, 2001), the integrated design of multi-storey timber frame house (L. Stehn et. al , 2002), Pilot study of QFD in construction projects (Neil Edlin, et. al 2003), Application of QFD in capital project planning (SM Ahmed , et. al 2003) the fuzzy QFD system for buildable design decision making(Yi Qing Yang et.al 2003).
A sequence of four HOQ matrices following ASI's approach is frequently used in manufacturing applications, to complete the product development cycle from the planning phase to actual production. In parallel with this, construction will have four sequential matrices as shown . As our emphasis is the early design development due to reasons mentioned before, only the first two HOQs will be considered for use in the current Schematic Design Model. (ref fig 6). The first HOQ (HOQ 1) will convert the Client Requirements (CRs) into Design Attributes (DAs) and the second HOQ (HOQ 2) will convert the DAs into schematic design components.

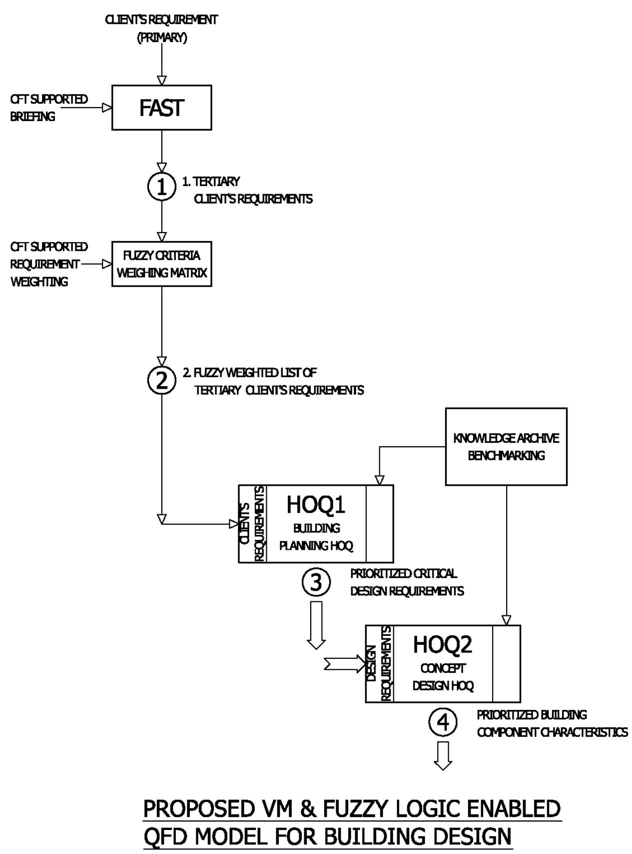


Figure -6 Proposed Schematic Design Model (SDM) for building

Fuzzy logic

The fuzzy set theory was introduced by Zadeh (1965), to solve real life problems that are subjective, vague and imprecise in nature. Using objective, definite and precise numbers to represent linguistic assessment are, although widely adopted, not very reasonable (LK Chan et. al 2005). Hence, in the present work, Symmetric Triangular Fuzzy Numbers (STFN) which can capture the vagueness in people's assessment of the relationship between HOWs and WHATs of the HOQ matrices will be used in place of the conventional crisp number ratings. The rating system will generally be based on the 9-point scale system as proposed by L KChan et.al (2005).

Use of a Central QA team

Before any documents are sent out from the company, these shall be personally checked and stamped by a central QA team. This will ensure that all documents that go out meet the quality standards that are set out by the company. The central QA team should consist of senior professionals from all concerned disciplines with relevant experience, who are conversant with the organisation's quality standards. The composition of the central QA team can be varied to suit specific projects, while retaining the important permanent members to ensure consistency.

Creation and use of a Knowledge Archive

In order to archive the professional experiences gained by any organisation, a well organised , PC based Knowledge Archive is employed. It is proposed that the updating and use of this information base during the all relevant stages of construction development is made mandatory.

The Knowledge Archive would essentially consist of the following:

A. General section

General site conditions in the region and related design guidance, statutory requirements, authority approval forms, information on codes and standards available, design options, contract types, possible problems, current market rates for construction items, new trends in construction methods, record of buildability problems.

B. Specific sections

1) Architectural

- General, specifications, drawings
- Sections on important design aspects of different categories of buildings viz. residential, commercial, institutional etc.
- Current trends in layout design, finishing materials, other construction elements (Supported by slides, material samples etc)

2) Engineering & Services

- General, specifications, drawings
- Various design options available
- Materials
- Current trends

3) Interface issues

Includes extensive information on common problems & errors for items listed under various headings as above. Experience record from actual projects and example drawings will form the most important aspect of the Knowledge archive.

5. MAJOR ADVANTAGES OF THE PROPOSED BDPM

It is envisaged that the proposed BDPM will result in the following advantages:

i) Better value generation

Explicit use of value generation methodologies and exploration of all possible design solutions with open mind will lead to better value generation. Moreover, the designers work in cross functional teams at early design development, which will lead to better balanced designs. Designers are forced to think beyond pre-set solutions are forced to work with a solution neutral format in trying to meet the CRs.

ii) Accelerated design development

The workshop approach involving CFTs help to accelerate the whole design process as basic schemes are agreed in a much shorter time than in normal situations. Reduced design development time and reduced chances of rework will speed up the whole design process and consequently improve the profitability of the organisation.

iii) Use of Stage Gates

The model includes stage gates and specific client sign off points whereby chances of confusion regarding variations can be minimised. There are lesser chances of design errors flowing downstream, considerably reducing the possibility of expensive reworks and consequent wastage.

iv) Creation and use of a Knowledge Archive

Explicit Creation and use of a company specific knowledge archive will permit the company to mature its design processes. Unlike the normal situation in which valuable knowledge gained through experience is under utilised /unutilised / lost.

v) The ease of implementation of the model

The current tool only requires very minimal additional knowledge on the part of the users and implementation is mostly based on the use of a standard PC.

6. FURTHER WORK

A simple application software package based on the popular spreadsheet program, Microsoft Excel, is being developed. The process map will then be implemented in real life projects in selected design organisations and refined with the experience gained from such applications. The Clients requirements processing procedure can be enhanced by including cost considerations in the QFD supported early design development.

7. CONCLUSIONS

Existing design processes were mapped, major problems located, major improvements identified and a new building design process map was developed. As the next step, simple application software is being prepared. Further to this, the improved process map will be implemented in real life projects in selected design organisations and refined with the experience gained from such applications.

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Building Design Process Map (BDPM)

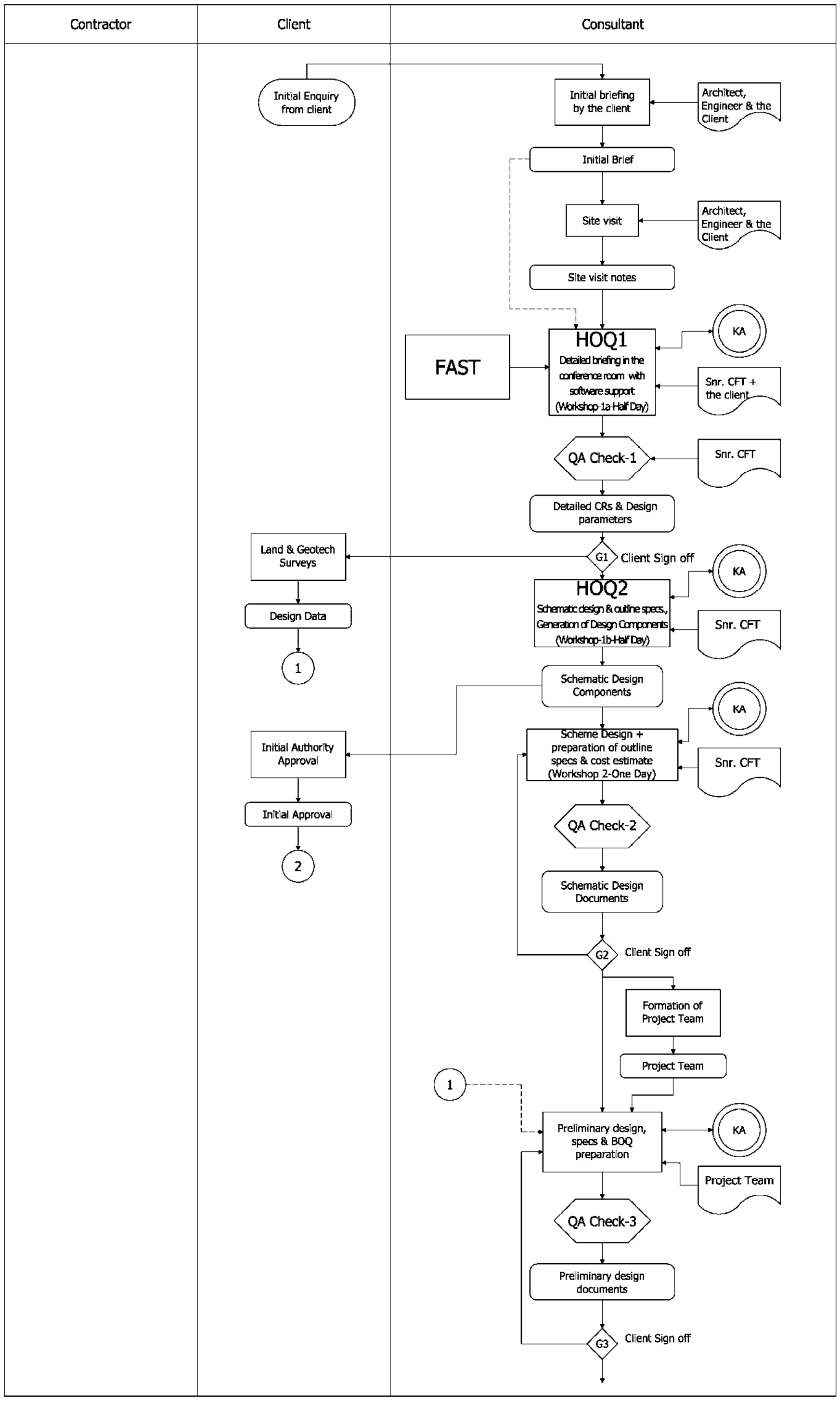

Figure 8

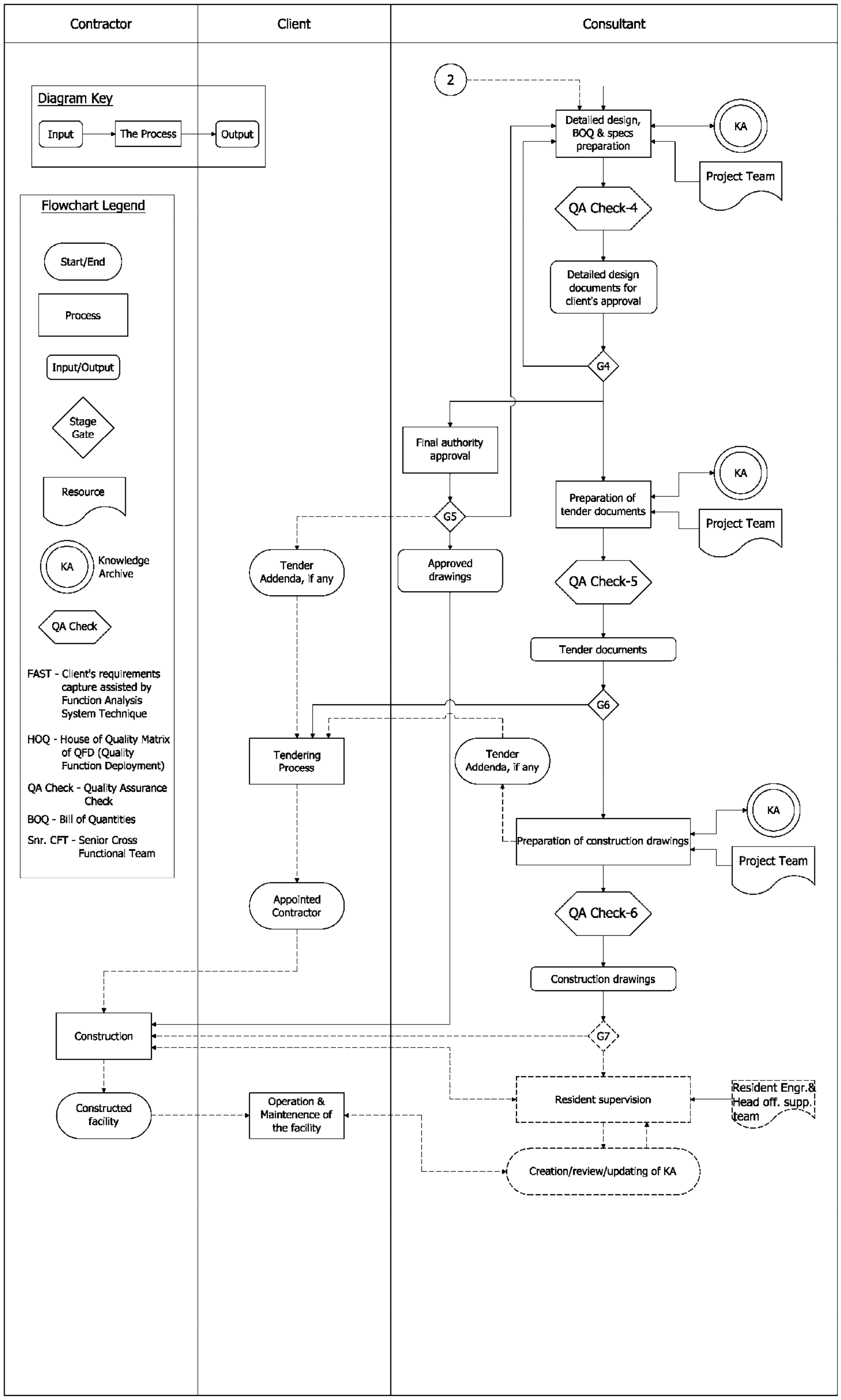

Figure 8 (Contd.)

THE APPLICATION OF INFRARED THERMOGRAPHY FOR ENERGY CONSERVATION IN BUILDINGS

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ABSTRACT

Improving the efficiency of energy use is an effective strategy to achieve both energy savings and environmental ambitions. In the United Kingdom heating is the main consumer of energy in buildings. This paper reports on the application of infrared technology to study the thermal performance of buildings in Nottingham City. The paper investigates the capability of aerial and ground thermography to examine heat losses in buildings. The results found indicate that measuring the exact temperatures of buildings is a difficult task. The presented case studies indicate that ground thermography could be more accurate in identifying heat losses in buildings when implemented as a comparative measurement technique.

Keywords: Infrared thermography, buildings, insulation, heat loss.

1. INTRODUCTION

Energy conservation in buildings is one of the major areas to reduce energy consumption, pollution and green house effect. In the UK, the Home Energy Conservation Act 1995 puts a duty on local authorities to develop strategies to improve energy efficiency in all public and private sector housing in order to tackle fuel poverty and reduce carbon dioxide emissions. Fuel poverty occurs when a household cannot afford to keep adequately warm at reasonable cost and is linked to increased mortality, ill health and lower quality of life. The factors that cause fuel poverty include household income, fuel costs and energy efficiency of the home (Department of Trade and Industry, 2001). Energy efficiency is the most suitable way to reduce carbon dioxide emissions in the short term. The average household could save around 2 tonnes of carbon dioxide (and £200) a year by taking energy efficiency measures (EST, 2003). Insulating buildings to reduce heat loss through the building fabric is becoming increasingly important. Space heating accounts for 26% of final energy consumption in the UK (DTI, 2003). In 2003 the percentage of households with no insulation was only 11% however a mere 14% had full insulation and loft insulation was less than 100mm thick in 40% of households (Shorrock and Utley, 2003). Installing 250mm of loft insulation can save up to 25% of household heating costs (EST, 2003).

A most immediate and direct environmental benefit of improving the efficiency of energy consumption is a reduction in the use of resources and in the emission of many air pollutants. From the financial point of view, one of the first priorities towards addressing the energy problem is energy conservation. According to Goldemberg et al (1988), it is usually cheaper, at common energy prices, to save an extra unit of energy than to generate it. The main three sectors that could reduce their energy consumption significantly are: energy-intensive industries, road transport and electricity/ heating in buildings. The residential sector consumes a significant percentage of the total energy use, and space conditioning and heating amount to approximately 60.4% of the total energy end-use for the countries of Organization for Economic Cooperation and Development (OECD, 1991). In most countries including UK, construction activity ranges from 1 to 3% of existing number of buildings per annum, efficiency gains in new buildings only marginally reduce future energy consumption. It is, therefore, existing buildings that offer greatest potential for energy efficiency in the UK. According to OECD 1991, modification of existing homes could reduce energy consumption by an average of 25%.

This paper reports on several case studies using aerial and ground infrared thermography to evaluate the heat loss in the built environment in order to improve energy saving.

2. INFRARED THERMOGRAPHY

Objects transfer heat by three means: conduction, convection and radiation. Conduction is the transfer of heat through solid objects. Convection is the transfer of heat through the movement of a fluid such as air and radiation is the transfer of heat energy via electromagnetic radiation emitted by the object. The radiation emitted by the object includes the infrared radiation which can be detected by an infrared camera. Infrared radiation is emitted by every object above absolute zero. The amount of infrared emitted by the object is partly a function of the temperature of the object as described by Steffan-Boltzmann law. Infrared radiation is electromagnetic waves of a length between 0.7µm and 1000 µm. However, the available un-cooled infrared cameras in the market normally work between 3 µm and 14 µm.

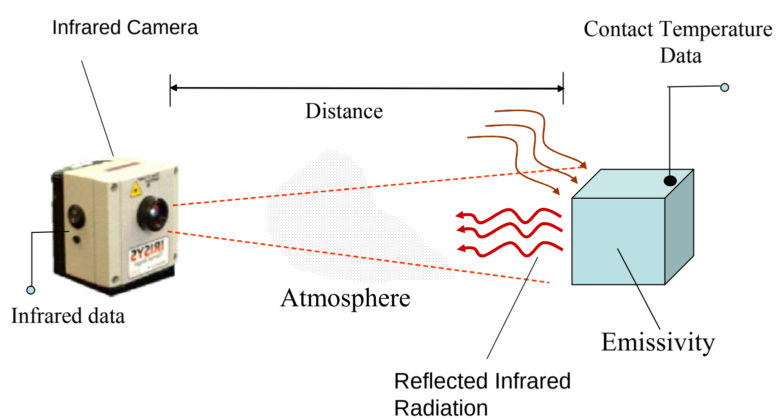

Figure 1: Quantitative measurement of temperature using infrared radiation is influenced by many factors.

For the calibration of thermal imagers a black body is used as a reference. A black body is defined as being a perfect absorber as well as a perfect emitter. Also, a black body does not reflect infrared radiation from other objects in the surrounding area and its temperature is proportional to its infrared radiation. However, actual objects in real life, such as buildings, do not always behave as a black body. In order to describe the capability of a surface to emit energy compared with a blackbody, Emissivity value (ε) is used, defined as the ratio of the thermal radiation emitted by a surface at a given temperature to that of the black body for the same spectral and directional conditions.

Examining the temperature of buildings using infrared thermography could be a complicated task as shown in Figure 1. In order to calibrate the infrared data to measure actual temperature of an object, it is important to use contact temperature sensor and to construct the relationship between the two types of data given that all other parameters are fixed. This includes the emissivity of the object, atmosphere characteristic, distance, background radiation, etc. Therefore, without knowing all factors that influence the infrared radiation measured by the infrared camera, it is significantly difficult to obtain a calibrated temperatures.

3. AERIAL THERMOGRAPHY

When compared with ground thermography, aerial thermography can mainly be applied to building's roof. The Nottingham aerial survey was conducted in February between 2030hrs and 2300hrs using a thermal infrared linescanner mounted in a fixed wing aircraft at 760m above the ground. Ground resolution was better than 1m. The survey was started over 4½ hours after sunset. The average air temperature was at 4.5°C. Mean wind speed was 4.7 knots (2.4m/s) reducing convective and ventilation heat loss effects. Clear skies prevented unpredictable variations in sky temperature. The relative humidity was high at 93.3%. Water vapour in the atmosphere attenuates the signal and dew deposition on roof surfaces will affect their emissivity and heat will be lost by evaporation. These effects are difficult to quantify. Infrared data by line scanning produces distorted images due to aircraft movement, scanning geometry and ground topography. Considerable effort has been spent in correcting the data to building polygons taken from digital Ordnance Survey maps producing a single image mosaic from the overlapping flight lines suitable for analysis in GIS software (Marsh and Ager, 2003). The sensor output is an 8-bit digital number between 0 and 255 for each pixel in the thermal image. An example of the final infrared image is shown in Figure 2.

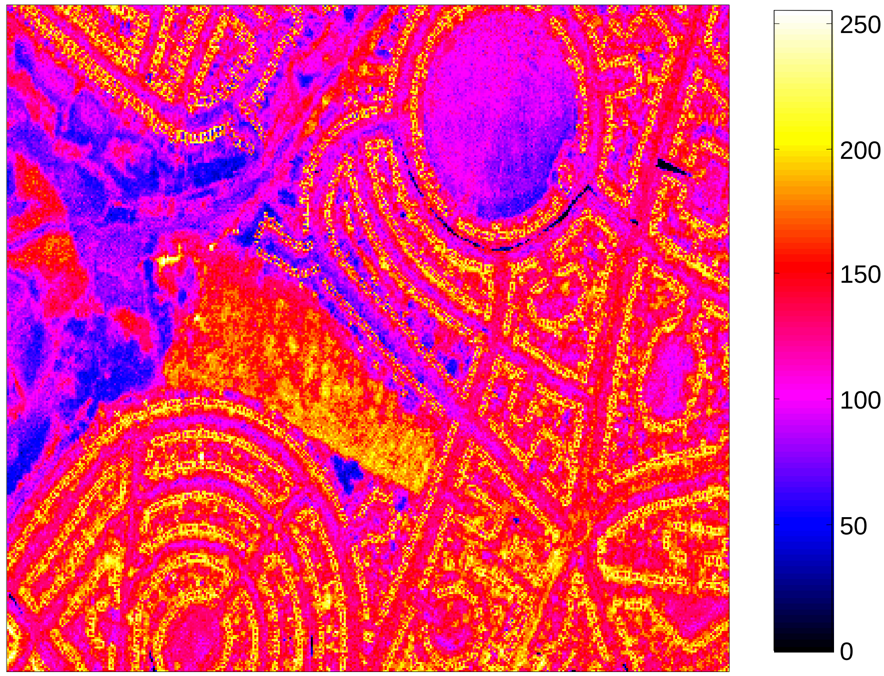

Figure 2: Thermal image with building polygons

The infrared system is assumed to be an ideal sensor operating in the 8-14μm wavelength range with an apparent temperature range of 20°C. The results were back calibrated against known insulation levels and the calibration assumed constant over the image. As discussed before, quantitative analysis of the infrared data is a complex task. The infrared radiation reaching the sensor, L, is from a number of sources as shown in Figure 3.

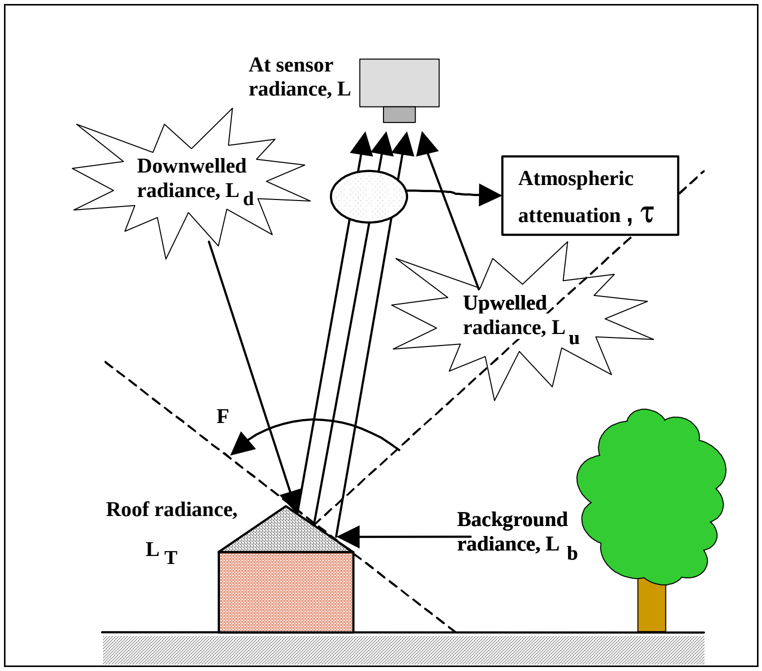

Figure 3: Sources of thermal radiation reaching the infrared sensor

In order to quantify the infrared image, the thermal radiation emitted by a building roof as a function of its temperature (L_T) should be calculated. Thermal radiation emitted by the sky (downwelled, L_d) and the surrounding background (L_b) is reflected from the roof. The column of air between the roof and the sensor emits thermal radiation (upwelled, L_u) and, through absorption and scattering, attenuates radiation in the sensor path (τ). In addition to the above, roof surfaces are not perfect black bodies and the fraction of the total radiation they emit is described by the emissivity (ε). The fraction of infrared radiation the roof reflects is therefore (1-ε). The fraction of the reflected radiation that is from the sky is described by the sky view factor (*F*) and the fraction of the reflected infrared radiation from the background is (1-*F*).

Therefore, the radiance reaching the sensor can be presented by Equation 1 after Schott (1997).

$$L = \{\, \varepsilon L_T + (1-\varepsilon)(FL_d + (1-F)L_b)\}\tau + L_u \qquad (1)$$

Where L, L_T, L_d and L_u are the effective radiances in the bandpass (8-14μm) and ε and τ are average values over the bandpass. In order to calculate roof surface temperature each of the above unknowns must be quantified.

The radiance reaching the sensor, L, is taken from the infrared image. For each building in the survey, the pixel values within the building polygon were averaged using GIS software. This average value was then converted to radiance using the assumed calibration. The Emissivity (ε) of buildings' roof is a property of the material and is affected by the angle between the roof normal and the infrared camera line of sight. Based on look-up tables it is assumed to be 0.83 for slate roofs and 0.9 for tiles. A function defining the variation in emissivity with angle is defined based on Snyder and Schott (1994). The angle is calculated by geometry based on roof pitch, building orientation and the horizontal distance between the building and the flight path. Sky view factor is calculated from the roof pitch assuming surrounding buildings were of the same height. It is 0.83 for a 20 degree roof and 0.65 for a 45 degree roof. Atmospheric attenuation and upwelled radiation are calculated using a simple atmospheric model after Anderson and Wilson (1984) and incorporating the change in path length with scan angle. Downwelled radiation is calculated assuming a spectral sky temperature of -40°C. Background radiation is calculated assuming an average background temperature of 0°C. Equation 1 is used to give the thermal radiation emitted by the roof and temperature calculated by a numerical solution of Planck's law across the bandpass (8-14μm).

It has been found that it is difficult to quantify the infrared data to measure the actual temperatures of buildings. Houses with similar type of insulation and style appear to be at significantly different temperatures. From ground survey the buildings appear to be at similar temperatures. The results found indicated that what appear to be a 'worm' roof does not necessarily indicate a poorly insulated house. It may have a higher emissivity value or a lower sky view factor. From the performed experimental work, it has been found difficult to quantify loft insulation in a house. This is due to the influence of the emissivity, view angle, and other background effect.

4. GROUND THERMOGRAPHY

The ground thermography has indicated that it is very difficult to obtain a calibrated measurement of buildings temperature. Consider for example Figure 4 which shows the visual and infrared images of a building in a sunny day at an ambient temperature of 2^{o}C. Area number 1 has an average temperature of 8 ^{o}C while area number 2 has a temperature of about 4^{o}C. However, both areas are part of a wall at constant temperature. The difference in temperature in the infrared image is mainly due to the difference in colour of the stones and surface angle. Area number 5 appears to be at 12 ^{o}C which is much warmer than area 6 which has a temperature value of 7 ^{o}C. This could be as a result of the sun light heating area 5 more than area 6 which is in the shadow. However, the difference in temperature could also be due to the reflection of the infrared radiation from sun light over the building that causes the significant change in the measured infrared radiation level, *L*.

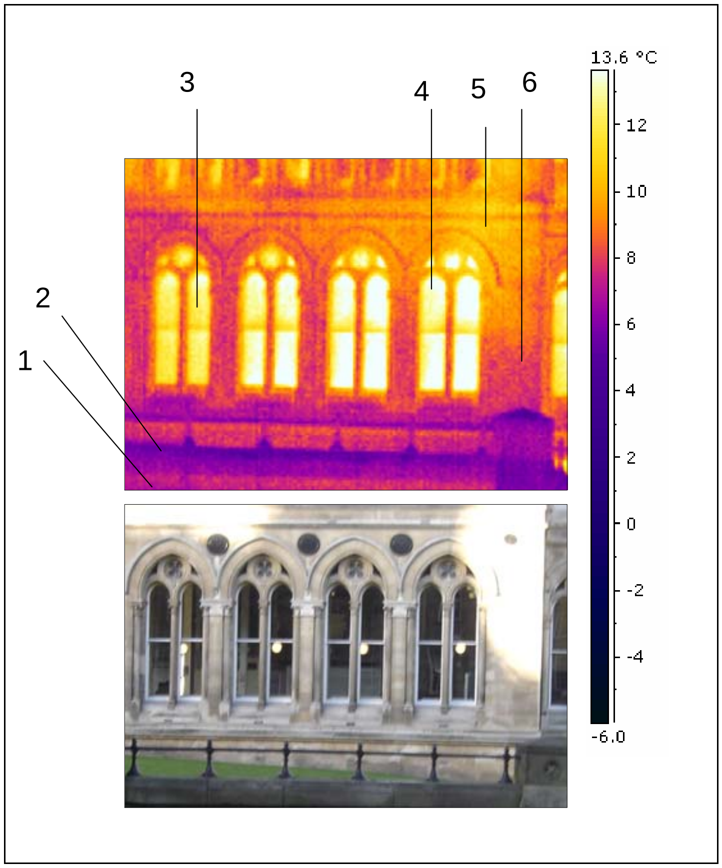

Figure 4: Infrared and visual image of a building in Nottingham.

The windows also appear to have different temperatures. Consider area 3 which appears to be at lower temperature than area 4. Given that the two windows are part of the same room with equal temperature, the difference in the infrared radiation is due to the infrared reflection from buildings on the opposite side of the road. From the above discussion, it could be concluded that infrared cameras do not actually measure temperature. They only measure infrared radiation and many aspects could influence the results of the readings such as humidity, distance from object, emissivity of the object and reflection of infrared radiation from other sources. From the authors' experimental studies, it has been found that the most suitable time for conducting surveys is when there is at least 10 degrees difference between the internal temperature of a building and the external temperature and the survey should be conducted in absence of direct sunlight in most cases to avoid direct reflection of infrared radiation. Quantitative infrared measurement, as discussed in previous sections, is difficult to obtain in real life because of all the variables mentioned above. However, in most cases comparative or relative temperatures should be sufficient to achieve the same objectives. In this study, measured temperatures are used for comparative analysis and not for actual measurement of temperature values.

Old Buildings

In most cases old buildings in the UK are built with a solid wall or cavity wall and no insulation. Roofs are also constructed with no insulation which leads to significant loss of heat. Windows normally have wooden frames and a single layer of glass. In recent years, modern insulation methods such as cavity insulation and double glazing have been introduced to improve efficiency of old buildings. Figure 5 presents an old building with double glazed windows. Notice that there are significant heat losses to the external side of the wall (area 1) as a result of having the heating system radiator adjacent to a solid wall of poor insulation. Area 2 presents an air leakage and heat losses at the junction of the wall and the roof. Area 3 presents heat losses from the chimney structure.

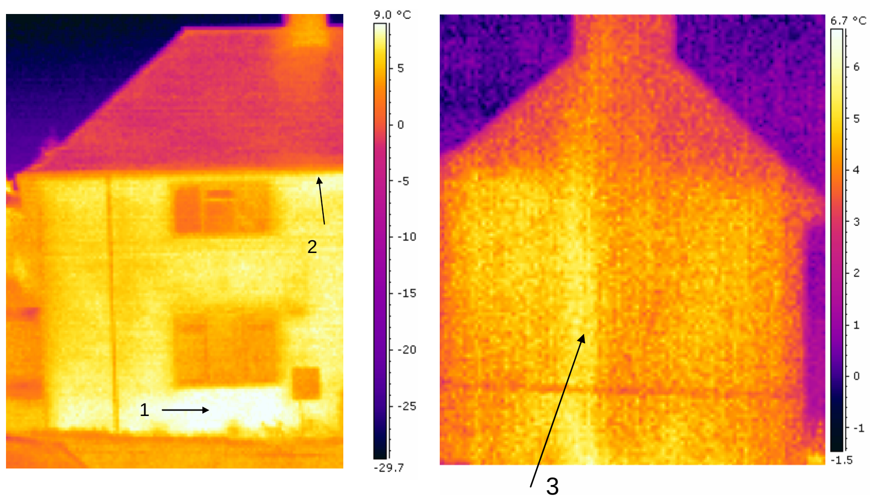

Figure 5: An old building with double glazing and solid walls.

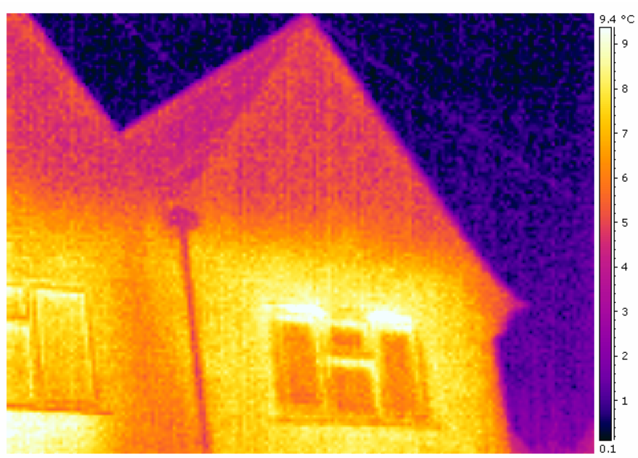

Figure 6: Examples of heat losses in old buildings

Figure 6 presents an example of typical heat losses in a building with solid walls and an insulated roof. There are significant heat losses from the frame of the double glazed windows. Also there are significant heat losses through the walls. The insulated roof has significantly less heat losses when compared with the walls around the windows. Figure 6 proves that roof insulation could significantly save energy.

New Buildings

New commercial buildings in the UK are built using modern materials and glazing to improve thermal insulation and allow natural light to the building to reduce the need for artificial light and improve natural heating from sun light. Figure 7 presents a well insulated glass roof in a modern commercial building. However, the arrow indicates a heat losses from the frames. This could be either caused by inefficient design or poor fitting. Similarly Figure 8, shows a residential house with significant heat losses from window frames.

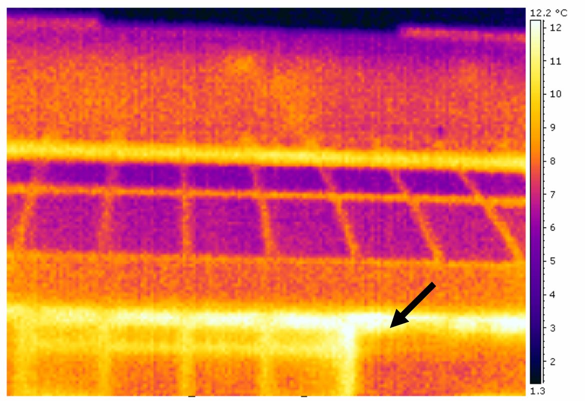

Figure 7: Infrared image of a modern building with a double glazed glass roof

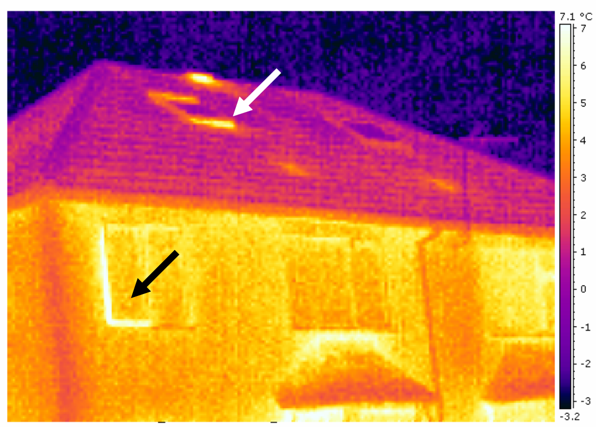

Figure 8: Frames of modern windows are one of the problems in heat insulation.

5. DISCUSSION

Infrared technology as a non-contact methods has an advantage over contact temperature measurement in reducing measurement time and covering a wider area. However, the calibration or interpretation of the infrared images require significant experience and complex calculations. Aerial thermography can reduce the surveying time, but from the performed experimental work, it has been found difficult to quantify loft insulation in houses. This is due to the influence of the emissivity, view angle, and other background effect. The ground thermography has been found easier to interpret due to the resolution and clearer details. However, it is difficult to obtain a calibrated measurement of buildings temperature due to change in emissivity and view angle. Old buildings is found to have many causes of heat losses including solid walls and chimney structure. Double glazing is found to have a significant effort on reducing heat losses in buildings.

6. CONCLUSION

Infrared thermography is an efficient method for investigating thermal performance of buildings. However, interpretation of the infrared images require significant experience and complex calculations. Aerial thermography can reduce the surveying time, but it has been found to include many sources of error. The ground thermography has been found easier to interpret due to the resolution and clearer details. In both techniques relative temperature measurement could be more effective and more practical than trying to measure the exact temperature values. From the case studies presented it has been found that heat losses from old buildings could be reduced through improved insulation of walls and roofs. Chimney structures in old building could contribute significantly to heat losses. Modern buildings utilise better materials. However, it has been found that in some cases there could be heat losses from modern frames which could be caused by design problems or installation techniques.

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ENVIRONMENTAL ASSESSMENT BY POWER SPECTRUM

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ABSTRACT

Environmental Performance Assessment (EPA) is a critical tool of the EMS in checking, reviewing, monitoring and evaluating environmental performance of organizations. This paper identifies the most important EPA criterion in a set of criteria developed by Tam *et al* [1, 2] using novel spectral methods. From that, effective ways on improving environmental performance and preventing further damage to the environment can be devised for organizations in the construction industry. In particular, the correlation of the most dominant criterion can be found which further enhances environmental performance of organizations. This paper also shows that not only improvement on environmental performance of organisations can be achieved by identifying the most dominant criterion, but also their efficiency, productivity and customer satisfaction. The power spectral method has been widely used in the field of signal processing for many decades and it is believed that these have never been employed in the field of environmental management. This paper shows the effectiveness and validity of these methods in the field of environmental management.

Keywords: Environmental Management, Environmental Performance Assessment, Criteria, Power Spectra, Bispectra

1. INTRODUCTION

With the growing awareness of environmental issues and increased concern over the deterioration of our environment, studies on impacts of construction activities to the environment have become popular in the last decade [3-6]. Previous studies have identified ten major sources of pollution generated by construction activities: energy consumption; dust and gas emission; noise distribution; waste generated; water discharge; water usage; unnecessary building consumption; pollution by building materials; land usage; and the use of natural resources [7-9]. Out of these, waste generated from the actual building and demolition of construction projects amounts to a large proportion of environmental waste [10]. Indeed, construction processes and their resultant waste have caused concern over the public heath and the environment.

The Hong Kong Government launched the Green Manager Scheme in 1995, requiring every government department to appoint a Green Manager in managing the environmental performance of individual organizations to ensure the environmental performance reached the required standard [11]. As a re-echo to the scheme, all sectors including construction have started committing to environmental issues. Since then, Environmental Performance Assessment (EPA) has become more important to construction contractors. Since EPA is a new concept for the construction industry in

Hong Kong and there has not been a commonly accepted standard assessment tool for measuring environmental performance, an attempt is made to identify such tool.

There have been a number of methods reported in the literature. Tam *et al* [1, 2] reported a method of estimating the relative importance index (*RII*) of all responses for all criteria, of which the higher the *RII*, the more important the criterion. The results obtained by using this method were consistent with other information sources obtained by conducting interviews with various organizations in the construction industry. However, the method did not show the most dominant criterion and the *RII*s of most surveyed criteria were quite close, i.e. the most dominant criterion was not clearly identified.

Thus, the aims of this paper are:

- To review the criteria used in EPA in the construction industry developed by Tam *et al* [1, 2];
- To propose a new power spectral method to effectively study construction management data by identifying the most important and dominant criterion in a set of surveyed criteria in EPA; and
- To compare the method of estimating *RII* values of the criteria with the proposed power spectral method and to show the effectiveness of the power spectral method.

2. ENVIRONMENTAL PERFORMANCE ASSESSMENT (EPA)

EPA is a process of measuring and analysing factors which are recognized as having direct and indirect impacts on the environment [12]. EPA helps to improve the environmental performance by providing information about achievement in environmental policies, objectives, targets, actions, and responsibilities in organizations. The EPA system can also measure, analyse and assess organizational environmental performance [13, 14]. Moreover, reports generated by using the EPA can identify ways to prevent pollution, which assists the identification and establishment of an environmental program in an organization. EPA can also provide continuous information on the implementation and operation of the program [12].

To apply the EPA system, relevant criteria are required which can be used to assess environmental performance of organizations. A set of criteria developed by Tam *et al.* [1, 2], are employed for this research under three main categories: Environmental Management Criteria (EMC), Environmental Operational Criteria (EOC) and Performance Measurement Criteria (PMC). A summary of all criteria is shown in Table 1a & b.

Table 1a: Criteria for the EPA under categories EMC, EOC and PMC [1, 2]

Categories	Criteria	Covered area
EMC	1	*Top management involvement* that sets the strategic direction and beliefs to provide resources in implementing environmental management from top managerial staff.
	2	*Middle management* involvement that sets the management culture on operational management and resources allocating.
	3	*Frontline staff* involvement that sets the blue-collar culture focusing on production or services.
	4	*Management co-operation* between different layers of management.
	5	*Workability and achievement of environmental policies* is to regular review the compliance of company environmental policy, objectives and targets over the construction period.
	6	*Training for top management* to increase the awareness on environmental issues from top managerial staff.
	7	*Training for middle management* to increase the awareness on environmental issues from middle level staff.
	8	*Training for frontline staff* to increase the awareness on environmental issues from frontline staff.
	9	*Pre-auditing planning* to provide a good preparation before auditing activities.
	10	*Frequency in auditing activities* to assess the fulfillment on implementing auditing activities on environmental issues.
	11	*Post-auditing corrective actions* to truly reflect both management staff and employees involvements in environmental management.
EOC	12	*Monitor of energy usage* to assess the reduction and control of the energy.
	13	*Quality of maintenance* to ensure the equipment provided with suitable maintenance.
	14	*Water sprays for minimizing dust airborne particles* to ensure the air pollutants emitted outside construction site by water sprays.
	15	*Mitigation measures to the generation of polluted air* to ensure the air pollutant emitted outside construction site by other means.
	16	*Time management* to control the generation of noise pollutants at restricted hours and close to adjoining noise sensitive parties.
	17	*Mitigation measures to noise levels* are necessary to control the generation of noise pollutants by other means.
	18	*Monitor of water usage* to control the water consumption in promoting water conservation.
	19	*Water reusing and recycling systems* to promote the water reuse and recycling system.
	20	*Wastewater treatment* to control the cleanliness for wastewater outside construction site.
	21	*Purchasing management* to control the right quantity of materials purchased with the most limited waste.
	22	*Waste reuse and recycling* to promote the waste reuse and recycling system.
	23	*Green construction technology* to promote the adoption on green construction technology, such as prefabrication.
	24	*Chemical waste treatment* to control the adequate procedures in preparing chemical waste.

Table 1b: Criteria for the EPA under categories EMC, EOC and PMC [1, 2]

Categories	Criteria	Covered area
PMC	25	*Non-compliance records of inspection* received to indicator the serious situation happened.
	26	*Complaints/warnings* received to indicate the minor situation happened.
	27	*Fines and penalties* received to indicate the seriousness of the non-complaisance records.
	28	*Non-conformance reports* received in auditing indicating the serious problem occurred.
	29	*Reports of marginal cases put under observations* received in auditing in indicating the minor situation occurred.
	30	*Energy consumption* to achieve reduction of energy used.
	31	*Timber consumption* to achieve reduction of timber used.
	32	*Paper consumption* to achieve reduction of paper used.
	33	*Water consumption* to achieve reduction of water used.

3. RESEARCH SURVEY

To unveil the importance of the developed criteria in the categories of EMC, EOC and PMC in the last section, questionnaires and interviews were conducted. Thirty-three criteria in Table 1a & b are under investigation in the survey. Importance levels from "1" to "7" of each criterion are asked on the questionnaire.

Questionnaires were sent to 377 practitioners on governmental departments, building developers, construction consultants, building contractors and sub-contractors in Hong Kong. The companies involved in the survey were chosen from the member list of the Hong Kong Construction Association, the list of building contractors approved by the Government of Hong Kong Special Administrative Region [15], the approved building contractors' list of the Hong Kong Housing Authority [16] and related governmental websites.

In return, 114 questionnaires were completed giving a response rate of 30.24%. However, 2 of them were found invalid, making the total of 112 valid responses for the study.

The questionnaire respondents can be classified into five main categories according to the nature and scale of their business:

- G1 − Governmental departments and developers
- G2 − Construction consultants
- G3 − Large-sized building contractors with capital exceeding fifty million Hong Kong dollars[1]
- G4 − Medium to small-sized building contractors with capital not exceeding fifty million Hong Kong dollars
- G5 − Sub-contractors

Besides, individual interviews were arranged with seven respondents of different business sectors, including one from governmental department, one from building developer, two from environmental consultants, one from large-sized building

[1] This classification is based on the grouping of Hong Kong Housing Authority's lists of building contractors.

contractor, one from small-sized building contractor and one from sub-contractor. The interviews were intended to gather further comments, elaboration and interpretation on the results obtained from the survey results.

4. RESEARCH METHODOLOGY

This section outlines a new method: power spectrum, which can be used to assess the EPA criteria. From that, the most important criterion can be identified which significantly improves environmental performance of organisations. A number of simulation programs have been written using a MATLAB package. This effectively improves ways which organizations can use to prevent damage to the environment. A brief description of the relative importance index (*RII*) [1, 2] method is also given. Performance of the *RII* and power spectral methods is discussed.

4.1 The *RII* method

The *RII* method provides a benchmark to assess the importance of EPA criteria. To determine the relative important of EPA criteria, scores were aggregated and transformed to relative importance indices based on the following formula:

$$RII = \sum \frac{w}{NA}, \tag{1}$$

where:

w is the weighting given to each factor by the respondent, ranging from 1 to 7 with ‘1’ corresponds to the least important and '7' to the most important;
A is the highest weight; in this study it is 7; and
N is the total number of samples.

As a result, *RII* values are always positive and less than unity. It is clear that the *RII* method uses the relative mean of all responses to determine the *RII* value. Although consistent results have been reported [1, 2], it is believed that the *RII* method cannot completely identify the most-dominant criterion because of the locality characteristic of the mean which will be discussed in more detail in Section 5.1.

4.2 The power spectrum

It is necessary to estimate its total power or energy, which is given by a power spectrum $P(f)$, as shown in Eq. (2).

$$P(f) = |X(f)|^2, \tag{2}$$

where $X(f)$ is the Fourier transform of the input signal.

It is evident that the power spectrum is proportional to the square magnitude of the input signal. Fourier transform as expected because the signal energy is directly related to its squared magnitude. It is important to stress that energy plays an important role in determining data characteristics, i.e. periodic, aperiodic or chaotic, detecting transitions from one state to another, i.e. a transition from periodicity to chaos or from periodicity to transient, and working out the energy weighting at different frequencies [17] which can be achieved by estimating the power spectrum of the input data. In the case of environmental management, the power spectrum is particularly useful as it can be used to reveal the energy distribution of data points obtained from various surveys. For example, consider that a survey consisting of a set of questions which have been distributed to a number of sources to fill out. A person fills out the questions in the survey at any one time, which means that the energy distribution of the person on the various questions in the survey can be estimated using the Fourier transform and the power spectrum under the assumption that the person fills out all of the questions by himself or herself.

5. RESULTS AND ANALYSIS

This section shows how the power spectrum is used to identify the most important and dominant criterion in the surveyed EPA criteria. Detailed comparisons of the *RII* and power spectral methods are also given. By using the power spectrum, it is possible to find effective ways to improve environmental performance of organizations, yielding improvement in their efficiency and productivity.

5.1 Identification of the most-dominant criterion

Normally, for most surveys, people are asked to fill out a number of questions of ranking from 1 to 7, with 1 as the weakest and 7 as the strongest. Then, the "mean" of these responses is estimated and the larger the mean, the more important the criterion is. For example, if being asked whether air pollution or water pollution is more important than human health, some weighting will be given to each of these criteria. From that the average mean of each criterion is used to determine whether it is more important to have the air not polluted or water not polluted. The method of calculating the mean of all responses has been reported in various works in the field of environmental management with some success [1, 2]. However, it should be noted that this method only locally considers the effects of responses, not globally, i.e. the mean does not completely describe the distribution value of the responses, if one response's value is very high the rest are very low, then the mean of the criterion is still lower than the highest value.

To remedy the problems in using the *RII* method, the power spectra of the data obtained by conducting the survey given in Table 1a & b are estimated using MATLAB. The peak of each power spectrum is then determined which is then used to identify the most dominant criterion. It should be noted that the poorer spectrum is obtained using Eq. (2) which is square magnitude of the input data's Fourier transform. The power spectra of periodic signals usually consist of a number of harmonic dominant peaks which can be considered as the dominant criteria in a survey. The locations of these peaks reveal the criterion number which helps organizations identify specific dominant criteria. It should also be stressed that even though the most dominant criteria can be identified using the power spectrum. The power spectra of all criteria have been estimated, and it has been observed that they are quite similar except some expected variation in the peak magnitude which represents the non-uniform energy distribution among various EPA criteria. This shows that there must exist the most-dominant criterion which can be used to improve environmental performance of organizations in the industry.

It should be noted that the data obtained in the survey are completely random, and by displaying monotonic characteristics, it can be said that the data can be in the transition to chaos. From that, ways to present pollution to the environment can be effectively implemented. Figure 1 plots the normalized power spectral peaks and normalized *RII* values [1, 2] of the data points obtained in the survey. To obtain the normalized values, all *RII* values are divided by the maximum *RII* and all power spectral peaks are divided by the maximum peak yielding the maximum normalized value of unity. From Figure 1, it is difficult to identify the most dominant criterion using the *RII* method as there is not distinctive dominance displayed in their *RII* values, whereas, criterion 10 *frequency of auditing activities* is revealed as the most dominant by using the power spectral method.

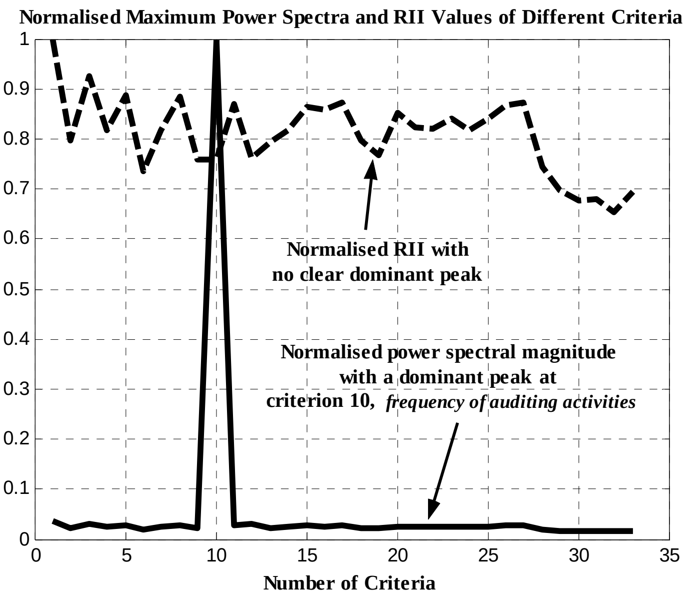

Figure 1: Normalized spectral peaks and *RII* values of 33 criteria given in Table 1a & b plotted on the same graph, from that the dominant peak of using the power spectrum method is clearly revealed, which could not be given by using the RII method.

From Figure 1, using the power spectral method, it is evident that criterion 10, *frequency in auditing activities*, dominantly possesses the strongest power spectral peak and therefore is the most important criterion out of the 33 criteria listed in the survey. The power spectral method applying to the EPA criteria shows that the more frequent the auditing activities being performed, the better the environmental performance of organizations. From Figure 1, for the *RII* method, criterion 1 *top management involvement* was considered by Tam *et al* [1, 2] even though this criterion did not possess clear dominance over the others. In fact, this result is consistent to the result obtained by using the power spectral method because *top management involvement* can be considered as a sub-criterion of *frequency of auditing activities.* The former is usually considered by most organizations as the most important criterion. However, it is *frequent* *top management involvement* practice that truly makes organizations significantly improving their environmental performance. The most crucial condition in this case is the frequency involvement of top management. The only way to achieve frequent *top management involvement* is to exercise *frequent auditing activities* which effectively makes top management of organizations more frequently involved in preparing and improving organizations' environmental performance.

In addition, according to environmental consultants during the interview discussion in this survey, auditing documents and control processes should be monitored daily to achieve the highest environmental standards. One of the interviewed project managers also argued that if organizations need to achieve satisfactory standards in auditing activities, it is necessary to be well-prepared the relevant pre-auditing documentations. At the same time, this also implies that the construction activities are working under satisfactory environmental standards both in the managerial and operational levels. It is clear that to maintain satisfactory standards, organizations experience the "pressure" of wanting to perform well during the audition period, resulting in more frequency involvement of top management to other levels of management from managers to front-line workers. This no doubt significantly improves the environmental performance of the organization under audition. Further, it is evident that, after a successful audition, the organization is left with confident and ready to perform well in the next audition which will happen shortly during the near future. Thus, higher performance can be achieved through this continuous improvement process. Clearly, this process not only greatly improves the environmental performance of the company but also its throughput, efficiency, productivity, product quality and customer satisfaction. It should be noted that all of the above processes require a substantial amount of investment which can be covered by the end results of much higher productivity and efficiency than before the audition.

Along with the most dominant criterion, other less dominant criteria also guide the company in the right direction. However, its performance is strongly dependent on the most dominant criterion of frequency of auditing. It should be noted that this criterion was not identified as the most dominant by using the RII method, which give a group of criteria which could be equivalently considered as dominant.

6. CONCLUSIONS

This paper studied the EPA criteria using new methods of employing the power spectrum to identify the most-dominant criterion. It has been shown that *frequency of auditing activities* is the most dominant criterion because of its wide and effective impacts to other sectors in an environmental organization such as improving support of top management to other levels to ensure that the organization performs well during the audition period. By having this criterion applied to organizations, it is possible to significantly improve their environmental performance as the main purpose, but also, their productivity, efficiency and customer satisfaction. The power spectrum which have been widely used in the field of signal processing have been shown to be useful in analyzing surveyed data in the field of environmental management.

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THE CULTURAL DIMENSIONS OF INFORMATION AND COMMUNICATION TECHNOLOGY SUCCESS FACTORS

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ABSTRACT

Although the widespread deployment of Information and Communication Technology (ICT) was once thought likely to address construction industry ills, it is now becoming apparent that the surrounding contextual issues hinder the successful use of ICT in a project setting. A major research project revealed the Critical Success Factors (CSFs) for ICT adoption by organisations across the construction industry supply chain, identifying a range of issues to be addressed by organisations, leading to more productive outcomes. Deeper analysis revealed that entrenched cultural assumptions prevail beneath the identified CSFs, and the rollout of ICT without recognition of them would result in suboptimal outcomes. This paper identifies and illuminates the softer cultural dimensions that influence the CSFs for ICT engagement. Data from a Delphi study of experts, and a questionnaire survey of experienced practitioners are analysed to bring an understanding of them. The paper concludes by identifying the theoretical dimensions and properties of culture that influence ICT adoption in construction projects. The metaphor of project team culture as compass or glue is an idealistic functionalist paradigm, which is unlikely to be achieved in a project environment. Rather, culture is reflected as ‘disorder’ in most project environments, and the “culture as clan” (exchange regulator) metaphor is most commonly encountered, resulting in sub optimal outcomes. An understanding of culture in a metaphoric sense, encourage identification of underlying ‘root working assumptions’ of project teams and enable effective implementation of strategies for ICT engagement in project teams.

Keywords: Culture, Cultural analysis, CSF, ICT, Metaphor

1. ICT AND THE CONSTRUCTION INDUSTRY

Critical review of the construction industry in the 90’s revealed it to be unproductive, unsafe and unwilling to change (Latham. 1994; Egan, 1998). The uptake of Information and Communication Technology (ICT) was widely anticipated to increase the effectiveness of project delivery. While it has been established that the uptake of ICT to automate business processes has, to some extent given productivity gains (Finch 2000; Love et al., 2001; Li et al., 2000; Productivity Commission, 2004) the full potential of ICT to integrate operations within a project is not widespread (Bulmer & Brewer, 2000).

Literature suggests that ICT engagement by an organisation can be at one of three progressive levels or stages, namely automation, organisation-wide process improvement, or supply chain-wide process improvement (Gajendran et. al. 2005) and development through these levels by an organisation may occur over time, as a result of the willing of that organisation to commit to ICT development. The productivity gains though ICT discussed by the Productivity Commission reports (Productivity Commission, 2004) were predominantly at the stage of automation. However to sustain productivity growth an organisation's ICT needs to evolve beyond this to a state of 'organisation-wide integration', ultimately leading to 'supply chain-wide integration'.

The challenges in engaging and expanding the use of ICT by construction organisations can emanate from many sources. The success factors/barriers that influence the success of ICT deployment may come from within the organisation, within the project or from accepted industry norms (Brewer & Gajendran 2006). Therefore, understanding the factors that critically influence the success of ICT integration is essential for better ICT management. The issue of 'Culture' has gained attention as one of the important factors, influencing both the success of, and barriers to ICT engagement. However it is problematic to determine whether to characterise 'culture as *one of the aspects'* that affect ICT uptake and integration or 'as *the overarching aspect'* that determines successful ICT uptake and integration.

The aim of this paper is to identify the Critical Success Factors for ICT engagement in project teams, and to contextualise these CSF's in a theoretically constructed cultural analysis framework, to understand the subtle cultural dimensions impacting ICT engagement in project teams.

2. 'CULTURE': AN IMPORTANT ASPECT OF LIFE

The concept of 'culture' has been extensively researched and written up in the context of anthropology, sociology and organisational management. Although there was an influx of writing in the area of organisational culture in the 80s, suggesting culture as both a 'strong prescription for success' and an 'interpretation for better understanding', this generated no clear agreement as to what culture actually was, or how it could be measured/assessed: academics and practitioners in organisational management are still continuing this discussion (Martin et al., 2004).

Although culture is considered to be a complex and inconclusive subject, generating a number of definitions and interpretations, all agree that culture is a dimension that is central to organisational life and operations (e.g. Schein, 1984, 2004; Martin et. al.2004, Alvesson 2002, Hofstede, 1998, Smircich, 1983). The view that 'culture refers to complex, inaccessible, fuzzy, holistic phenomena' (Alvesson 2002, p15) and it is too soft and complicated to be managed explicitly, cannot relegate culture to a position of insignificance in the life of an organisation.

Culture has been conceptualised in the literature in numerous ways. However, all of them can be placed on a continuum where the polar extremes are represented by culture as a '***Functional/Variable'*** (to be addressed along with other variables such as strategies, structure, etc), and culture as '***Non-Functional/metaphor'*** (an influence on all of the organisation's management activities) (Alvesson 2002, Smircich 1983). However, this paper provides a framework, slightly towards a non-functionalist paradigm of the continuum, to facilitate cultural analysis, to surface the harmony and conflicts, which may rise in ICT uptake in the construction project environment.

In the recent times the cultural dimension is highlighted in most branches of contemporary management studies including supply chain management, ICT management, customer relations management and knowledge management. Indeed some argue knowledge management is actually the management of culture (Davenport and Pruask, 1998). This position is also reflected in the construction management domain and culture in construction has been researched in the context of adversarial attitudes arising out of contractual claims (Rooke et al 2003, 2004; Phua 2003), culture in procurement (Cheng 2004), national culture (Pheng, 2002), ethics and culture (Liu, 2004) cultural change (Price et al. 2006), knowledge transfer (Brochner et al 2004), professional cultures (Ankrah et al 2005), and corporate culture (Martin et al 2006).

3. CONCEPTUALISING CULTURE: CULTURAL ANALYSIS

Due to the complex, interrelated and imprecise nature of culture a tendency exists to engage with it in the form of 'cultural analysis'. Cultural analysis gives some delimitation to the culture concept, in that it can be performed on a specific phenomenon in more focused and precise manner. Cultural analysis can be performed on how people think strategically, how they interpret and respond to the acts of a project team members and how they understand the clients. However, the literature on the methodology of cultural analysis is divisive along the lines of ontology -- culture as a variable or culture as a root metaphor.

When organisational culture is considered as a 'variable' it aligns with traditional objectivist and functionalist views of social reality, with the intention of improving organisational performance. This perspective of the organisation is accompanied by distinct cultural traits, such as values, norms, rituals, ceremonies, and verbal expressions. It is held that these cultural features can be managed to influence the behaviour of managers and employees and promote the effectiveness of an organisation.

On the other hand the 'root metaphor' view of organisational culture suggests that the organisation *is* a culture and can be seen as if it is a culture. This perspective suggests that organisations can be understood and analysed not only in economic or material terms, but as a function of their expressive, ideational, and symbolic output (Smircich, 1983, Alvesson 2002).

At its ideological extreme, culture as a root-metaphor, "means that the cultural image guides all perception and interpretation of what goes on in organisations. Seemingly 'objective' things, such as numbers of employees, turnover, physical products, customers, etc, become of interest (almost) only in terms of their cultural meanings." (Alvesson 2002, p25). It should be noted that most proponents of the root-metaphor view of culture do not hold this extreme position. However, neither do they take an overly simplistic, objectivist, variable view of culture (i.e. linking culture to performance). The principal consequence of this perspective is that nothing can be clearly relegated to a position 'outside' of the group's culture, as everything that is seen as having any meaning to a group must be seen to lie within that group's cultural context.

A substantial part of the 'cultural analysis' of an organisation falls somewhere between the 'root-metaphor' and 'variable' views of culture. This perspective accepts culture as an organising metaphor that guides thinking and analysis in a more restricted way. In a move that confirms the existence of the 'cultural continuum' Smircich (1983) has indicated that culture can be used both as a 'variable and metaphor'. This 'moderate' approach to culture, accommodates some of the 'non-cultural' aspects as these are difficult to be reduced to symbolism (e.g. external environment, competition, and performance dimensions not truly reflected by a cultural perspective) (Alvesson 2002), thus allowing researchers to combine cultural and non-cultural influences during cultural analysis. This paper formulates a cultural analysis framework that is predominantly focused on a subjective ontology that uses a metaphor-driven approach, whilst concurrently accommodating aspects of the variable-driven perspective.

4. CONSTRUCTION OF A CULTURAL ANALYSIS FRAMEWORK

This section outlines two approaches to cultural analysis, one based on Schein's (1984, 2004) functionalist model and the others, based on non-functionalist models, developed by number of authors (Alvesson 2002, Wiener 1998, Jones 1983). This framework is then used to position the CSFs for ICT mediated supply chain within cultural theory.

Cultural Interpretation: Schein's Framework
Although Schein's work on culture is generally considered to favour the 'functionalist/integration' paradigm, his symbolic and cognitive focus characterise the 'non-functionalist/differentiation' paradigm (Martin et. al. 2004). Schein (2004) defines culture as:

'*a pattern of shared basic assumptions that was learned by a group as it solved its problems of external adoption and internal integration, that has worked well enough to be considered valid and, therefore, to be thought to new members as the correct way to perceive, think, and feel in relating to those problems'* (p 17)

The authors draw on three features from this work:

1. Culture can be observed from artefacts, patters of behaviour, values and underlying assumptions. According to Schein true understanding of culture can only be gained by focusing on the ***beliefs and underlying assumptions*** of the members of a group, which are transmitted as cultural meanings -- these guide the group's thinking, feeling and acting (Schein 1984, 2004). Artefacts and behavioural norms are easy to observe but difficult to interpret, as are the underlying assumptions held by those artefacts.
2. Organisations should attempt to achieve ***internal integration*** through organisational consensus.
3. Organisations should also explore the possibility of ***external adaptation*** freeing order to reduce the likelihood of conflict in their dealings with others.

Metaphor: Exchange Regulator or Clan

Clan functions ‘as a control mechanism, in which the informal contract and the long-term rewards are regulated, aided by a common value and reference system and a corporate memory’ (Alvesson 2002, p 38). Ouchi (1980) identified the ‘clan’ (markets, and bureaucracies) as one of the three modes that can be employed to govern organisational exchanges or transactions in complex and uncertain business environments. In order to sustain it’s equity the clan adopts and builds upon the long-term memory of organisational members, by providing intellectual tools, which discourages short-term opportunistic behaviour of it’s members. The clan culture emphasises the importance of it’s members sharing common goals, generating collective interest in achieving long-term equity.

Metaphor: Compass
“Culture [as a compass] gives a sense of direction and guidelines for priorities.” (Alvesson 2002 p 38). The use of the culture as a ‘compass’ metaphor is widespread in culture literature. Most see the core of organisational culture as the direction-positioning capacity of shared value system (e.g. Wiener, 1988). The culture directs the ‘individual values’ (which guides an individuals intentions and actions) and ‘organisational values’ (which is stipulated by the organisational goals, policies, and strategies). Thus the nature of the values that prevail among the individuals and are fostered by the organisation will characterise the organisational environment and this will impact on it’s effectiveness. If the established sets of values are in harmony with the strategic direction decreed by the organisation, it’s culture will be an important asset. Conversely, the wrong sets of values can make the culture a major liability and misdirect organisations (a defective compass).

Metaphor: Social Glues
This is the second most commonly used metaphor for culture. ‘The idea here is that organisations are integrated and controlled through informal, non-structural means -- shared values, beliefs, understanding, and norms.” (Alvesson 2000, p 32). Avoidance of conflict, tension, fragmentation and other miseries are encouraged and the glues focus is on fostering an organisational life characterised by consensus, harmony and sense of community. Thus by this metaphor culture is about counteracting fragmentation, and integrating the ideas, symbols and values that are the sources of identification with the group/organisation and (Martin 2002, Schein 2004).

Metaphor: Sacred Cow
When organisational or group values/beliefs are formed from it’s collective experiences accrued during the successful solving of problems, using skills and the emotional transfigurations, a “scared cow” evolves and shapes the organisations’s culture. These values are the outcome of a historical progression, through which people gradually accept and internalise beliefs and values based on their leader’s successful ‘visions’ and problem solving processes (Schein, 1984, 2004). Thus the members of an organisation become strongly committed to a set of basic assumptions and values that point at a particular direction. Therefore the nature of the ‘sacred cow’ could also have elements of ‘compass’ or ‘social glue’.

Metaphor: Affect-regulator
As the name implies culture as an ‘affect regulator’ concentrates on the organisation’s ‘affective and expressive dimensions’: it regards organisational cultures as ‘emotional arenas’. Culture is regarded as a ‘control device’ to ‘inform, guide, and discipline the

emotions of organisational members'. It is assumed that the building, strengthening, deepening or thickening of the 'organisational culture involves the subtle (or not so subtle) control of employee emotions – or at lease those emotions expressed in the workplace' (Van Maanen and Kunda, 1989). Therefore, culture provides guidelines and scripts for emotions and affectations and how they should be expressed.

Metaphor: Disorder
According to Martin (1992) ambiguity and fragmentation are the key attributes by which an organisation or group is characterised. The disorder metaphor reflects the assumption that modern societies and organisations are in a state of constant ambiguity (e.g. uncertainty, contradiction and confusion) and can be viewed as a negative approach to culture. Cultural manifestations and their interrelationship are found to lack clarity and consistency. In this cultural environment differences in interpretation are fundamental and unavoidable, and consequently both consensus and confusion coexist (Martin 1992).

Metaphor: Contracts
Jones (1983) suggests that for the individual, the process of leaning the organisational culture involves learning the expectations of others and how to act in terms of context-specific assumptions. That is, culture is created though the contractual arrangements created to govern the social transactions within and between groups. These transactional patterns arise from the structure of property rights found in the organisation, the latter being the means used to define and structure the exchange relationships between organisational members and to allocate scare resources with in the organisation.

5. METHODOLOGY

Data for this research was gathered from two separate sources – a qualitative Delphi study (Brewer et al. 2005) and a quantitative questionnaire survey (Gajendran et al. 2005). Both the Delphi study and survey were employed to surface the CSFs for uptake and integration of ICT in construction project supply chains. Cultural analysis to identify the CSFs for ICT engagement was performed using a theoretical framework developed from related literature.

A comprehensive review of the literature, combined with the results from a Delphi study with international participants (researchers and practitioners) enabled identification of a full range of possible success criteria for ICT enabled construction project supply chains. Due to the geographical dispersion of participants, a computer mediated Delphi environment, using asynchronous discussion was used. The Delphi panel consisted of thirteen members and their discussion was initiated by responding to 7 trigger statements. Altogether three rounds of panel discussion were administered and the resulting discussion material was open coded to identify the potential success factors. Establishing the 'generic' set of CSFs for ICT mediated supply chains involved obtaining views from a significant number of experienced industry practitioners to ascertain what they considered to be the factors critical to success. Therefore, a quantitative methodology employing a questionnaire survey and appropriate statistical techniques was developed.

Two hundred and thirty survey responses (230) were included in the analysis. Although the sample contained organisations that had been in business for up to 90 years the majority of the responding organisations had been in business for 10-25 years. Employee numbers in the sample organisations ranged from 4 to 2000 and average organisational turnover ranges from $0.45m to $1bn. Around 20 % of the respondents had overseas operations while majority of the firms operated in one or two Australian states. The sample profile indicated an acceptable representation of the population in question. The sample consisted of clients (17), principal contractors (19), sub-contractors (88), architects (58), engineers (19), and quantity surveyors (29).

The development of the constructs for the questionnaire was greatly influenced by the literature, and augmented by the findings of the Delphi study. Each construct in the survey was assigned a logical measurement scale. A '0 to 100' Likert scale was used to capture the rating. This was used as it was felt to be convenient for the respondents to relate to a general 1-100 scale. Reliability analysis, a one sample t-test and factor analysis were employed as statistical tests in order to achieve the desired outputs i.e. identifying the CSFs.

The organisational and project environments in which the identified CSF's are implemented, is then, critically evaluated to uncover the potential assumptions, beliefs and values that may exist in these environments. The constructed cultural analysis formwork is then applied to analyse the beliefs, underlying assumptions and values to construct a cultural theoretical position and practical implications.

6. CSF AND CULTURAL ANALYSIS AND DISCUSSION

The Delphi study and literature review identified 21 potential success factors for successful ICT engagement (Brewer et al. 2005, Gajendran et al. 2005). Reliability analysis suggested that all statements listed in the instruments as potential success factors were reliable. Thereafter a one sample t-test was performed on all 21 items and this test rejected four factors as not being critical to the success of ICT mediated supply chains. The remaining seventeen items were subjected factor analysis and five factors were identified. These factors were organisational commitment, support and assurance, rights and duties, organisational attitude, investment drive, and communication structure. The sub factors constituting these major factors are listed in Table 1.

Table 1: ICT critical success factors and its cultural context

No.	Critical Success Factor	Cultural Signature
1	<u>*Organisational Commitment*</u> Successful ICT implementation requires the commitment of a firm's senior management.	The underlying assumptions of an organisation's senior management should embrace the potential of ICT to support their organisation's operations. Moreover, the organisation should also hold that ICT can support project level operations if other participants are willing engage with it. Therefore there should be a level of external adaptation in the process. However, at times an organisation's assumptions about the optimal level of ICT engagement could be below or above that of the other participants in the project tending toward cultural conflict. Further subcultures *within* an organisation or project may have different assumptions, adding to cultural conflict. From a functional angle, a sacred cow

Table 1: ICT critical success factors and its cultural context		
No.	**Critical Success Factor**	**Cultural Signature**
		or affect regulator metaphor would be favoured. However, in reality at project level culture tends towards disorder.
2	*Organisational Commitment* The commitment of an organisation's employees is vital to the successful adoption and use of ICT.	Employees underlying assumptions on how and to what extent ICT tools will support their personal work environment will come from their commitment to ICT adoption. The ideal internal environment of an organisation should be characterized by some level of integration - there should be consensus-building among different sections of the organisation regarding ICT engagement. From a functional angle a glue or affect regulator metaphor for culture will be favoured e.g. if the senior management's commitment for ICT use is high and employees believe ICT is not helping them, cultural conflict might arise. However, in practice total integration may not be a possible and therefore a differentiated approach to handle such situations is required until such time as common consensus arises. This suggests a non-functional cultural angle where the culture is disordered .
3	*Organisational Commitment* An organisation's continuous and conspicuous investment in staff development and training is vital to its successful adoption and use of ICT.	Cultural conflict arises when an organisation's management holds the assumption that engaging with ICT is the way to operate their business, but does not believe in the need to invest in employee training. Some organisations may publicly show commitment to employee training, but not reflect this as an underlying belief, which makes it difficult to overtly observe the conflict in their culture. From a non-functional angle the disorder metaphor for culture will seem appropriate.
4	*Organisational Commitment* Transparency and trust among project team participants is vital for the successful adoption of ICT across a project team.	The underlying assumptions of members of a project environment should relate to trusting other team members. However, sub groups or subcultures within the project environment may hold varying underlying assumptions regarding the trust of other members e.g. an architectural sub group may hold, through bad experiences, an assumption of not trusting contractors. Meanwhile, the same architects may trust other design sub-groups as common interests develop over time. In this instance a clan culture may evolve.
5	*Support and Assurance* The security of information is vital in an ICT-enabled project environment.	This factor can be considered to be outside the scope of culture, being principally an ICT capability issue. However, one could also observe a cultural angle, indicating that this factor is related to the ownership of property rights and trust, and therefore may link to culture as contracts.
6	*Support and Assurance* A "champion" should support all new technology that is to be used across a project team within a firm.	This factor is about leadership and the direction of the project. Each member of the project should adapt to the project environment, which is external to their organisation, and create some level of consensus among the project members. This functional aspect of culture could favour either the compass or glue metaphor. There also could be instances with no clear direction on project goals, resulting in little or no consensus regarding values and assumptions. This non-functional aspect of culture favours the disorder metaphor.
7	*Rights and duties* The identification of the ownership of the intellectual property generated during a project should be handled with sensitivity	This factor could mean that contractual arrangements that are in place to safeguard property rights will create or influence the prevailing cultural environment. When there are strong property rights attached to defined actions, the prevailing culture could be more collaborative and open e.g. information sharing. In cases where property rights are not clear, the cultural environment could be characterised by distrust and closed communications. However, in the latter situation a clan culture may create the opposite

Table 1: ICT critical success factors and its cultural context		
No.	**Critical Success Factor**	**Cultural Signature**
		condition. Prior experiences are thought to be the primary determinant of culture.
8	*Rights and duties* Project team members must acknowledge the sensitivity and confidentiality of other participants' information.	This factor is influenced by how much the underlying assumptions of each member are guided by explicit codes of practice and informally held ethics and moral values. The source of these value codes may come from the organisation's procedures, personal upbringing or by education. This factor is heavily influenced by the culture, at many levels.
9	*Rights and duties* Project teams require a powerful ICT "champion" to support the technologically weaker organisations in order to ensure that communication processes continue to function as planned.	In practice this factor can be influenced by number of assumptions about the other members of the project. The powerful member may use of a number of approaches to support the weaker members through leadership, collaboration or as a result of their positional power. Conversely the project team may ignore this role thus increasing the likelihood of chaos and conflict. A supportive approach could create a compass, glue or clan culture whereas an unsupportive project structure could invoke a culture of disorder, depending on how the weaker organisations coped with the pressure.
10	*Organisational Attitude* The availability of standard conditions of contracts that specifically accommodate the issues raised by the use of ICT	This is about contractual attitudes of the members towards the business. Thus the extent to which the assumptions of the members of a project are underpinned by contractual security will exert a powerful influence on the project culture. Members seeking clear definition of property rights and apportionment of risk will regard projects that do not have a unequivocal contractual environment as disordered, and will struggle to adapt to the situation or engage/cope in/with opportunistic behaviour. Under such adverse circumstances, and with members who have no long term relationship intentions, it is questionable whether a clan culture can be created or survive.
11	*Organisational attitude* An organisation should be prepared to engage in long-term collaborative relationships such as partnering	The underlying assumption is that members of a multi-firm project team should acknowledge that it is desirable to develop long term relationships with their trading partners as this will benefit their individual organisations in long run. This runs counter to the industry culture, where it is common to find construction project members acting on the basis of short-term profiteering motives. The development of a project clan culture is one way of fostering a positive project environment.
12	*Investment drive* Organisations should commit to ICT as a long-term strategic decision.	As in 11
13	*Investment drive* Organisations should commit to ICT as a project-based tactical decision.	As in 11
14	*Investment drive* Competitor adoption is the most powerful trigger for the adoption of ICT.	This factor reflects the individual organisation's preoccupation with the potential competitive disadvantage arising out of a decision *not* to engage with ICT in a project setting, possibly indicating conflict between the individual firm's culture and that of the project clan.
15	*Communication structure* Organisations try to limit their use of multiple	This factor could be viewed purely as a technical (interoperability) issue, outside of cultural considerations. However the clan culture can coalesce around a common technical platform,

Table 1: ICT critical success factors and its cultural context		
No.	**Critical Success Factor**	**Cultural Signature**
	online systems promoted by different project participants.	promoting/promoted by a long-term collaborative interest. The rejection of multiple platforms could also be driven by a desire to limit the firm’s exposure to/development of disordered organisational and project cultures.
16	<u>Communication structure</u> A fragmented project team will lead to the ineffective performance of ICT-enabled operations.	This is a structural issue, however it has cultural significance. Culture as manifested by disorder or fragmentation is common in construction due to the loosely coupled organisations required to do projects. Therefore it is desirable to foster a clan culture to mitigate against this situation, rather than purely attempting to address it with contractual arrangements.

Table 1 summarises the connections between the cultural perspectives associated with each of the CSFs. It is thus evident that most of the CSFs cannot be successfully implemented without a clear prior understanding of the cultural context of both the implementing organisation *and* the project environment(s) into which they are to be deployed. A naive approach to implementation is likely to produce a situation where they are regarded as superficial artefacts or espoused values, misleading the observer but not the stakeholders in the firm/project, who lack confidence in them.

7. CONCLUDING REMARKS

This paper identified sixteen of critical success factors for effective engagement of ICT in construction projects and the cultural contexts within which they are likely to be implemented. The discussion highlighted a number of cultural sub-environments, and thus a number of underlying assumptions and beliefs, operating within the firm/project team. It has been argued that understanding these underlying assumptions and beliefs is a critical prerequisite in order to deploy ICT in business operations whilst concurrently avoiding situations of conflict. These underlying assumptions can only be accurately identified through in-situ cultural analysis, on a case-by-case basis. However, the model presented here indicates that the CSFs will generally be deployed in a situation of disorder, due to the complex and uncertain construction project environment. Thus their implementation cannot be expected to result in a total integration of activities, as most functional paradigms suggest.

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THE GENERATION OF CHINESE ICE-RAY LATTICE STRUCTURES FOR 3D FAÇADE DESIGN

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ABSTRACT

Stiny's shape grammar for the generation of Chinese ice-ray lattice structures is revisited and its shape rules, including additional rules for augmenting a polygon by inscribing a triangular shape, adapted to apply to 3D surfaces. The constructive process of rule application for twisted polygons is described, the implementation of the grammar is shortly described, and its use is illustrated in the design of a façade, the shape of which is defined as a twisted polygon.

Keywords Design Generation, Ice-ray Lattice Designs, Shape Grammars, Twisted Surfaces.

1. INTRODUCTION

The motivation for writing this paper comes from the design of a building façade using Chinese ice-ray lattice structures (Figure 1). The inspiration for the design came from the image of an iceberg, which led to the study of patterns that occur within ice as the basis for the façade design. Ice-ray lattices are a particular form of traditional Chinese lattices constructed between 1000 BC and 1900 AD, as catalogued by Daniel Sheets Dye (1949), which do not have a regular structure, but rather mimic the ice-lines formed in the ice-formation process. The Federation Square building in Melbourne by Lab Architecture Studio served as an example in the design of the façade, although the pattern used in the Federation Square building is far more regular. The design of the building in Figure 1 dictated the use of twisted polygons to define the shape of the façade. While Chinese ice-ray lattice structures can be projected onto the twisted polygons, here a non-projected solution based on solid geometry is considered.

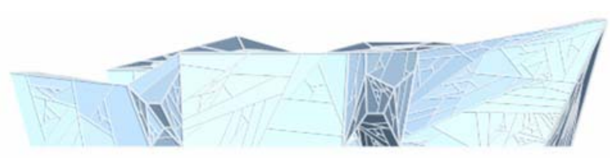

Figure 1. An elevation of the building.

Stiny (1977, 2006) defines a parametric shape grammar for the generation of Chinese ice-ray lattice designs. Stiny's exemplar grammar has four constructive rules allowing for a convex polygon to form two new convex polygons, with approximately equal areas, by placing a single line between two of the original polygon's edges.

Specifically, the rules state that any triangle, convex quadrilateral or convex pentagon, with area greater than some given constant, can be augmented once by placing a line between two of its edges to form, respectively, a triangle and a convex quadrilateral, a triangle and a convex hexagon, two convex quadrilaterals, or a convex quadrilateral and a convex pentagon. Stiny also suggests some additional constructive rules for allowing polygons to be augmented by inscribing a triangular or other polygonal shape, generating other, slightly more complex, ice-ray designs.

Stiny's shape grammar is designed to construct traditional Chinese ice-ray lattice designs, but can be adapted and applied to conceive more contemporary designs. Lab Architecture Studio also considers a fractal pattern, similar to a Chinese ice-ray pattern, in the design of the façades of the SOHO Shangdu building, to be completed in Beijing in 2007. These façades are also not flat but are folded along some of the lines of the fractal pattern.

In this paper, the use of Stiny's ice-ray grammar rules is considered in the design of a façade consisting of 3D surfaces. For this purpose, these shape rules, including the additional rules for augmenting a polygon by inscribing a triangular shape, are adapted to apply to non-flat surfaces, such as twisted surfaces. The four original shape rules each specify the placing of a single line between two edges. In a twisted polygon, such a line can be placed in a similar way leading to two new twisted polygons. The additional shape rules for inscribing a triangular shape specify the placing of three lines extending from a triangle to each touch one of the edges of the original polygon. Thus, the inscribed shape is connected to the original twisted polygon by three points, forming a (flat) triangle.

2. SHAPE RULES

Figure 2 shows the original shape rules in Stiny's grammar. These are parametric shape rules, they apply to any triangle (rule 1), convex quadrilateral (rules 2 and 3) or convex pentagon (rule 4), respectively. Note that Stiny's shape rules are augmented with labelled points in order to guide the generation process and to prevent rule application to apply to the same shape more than once. As a result, Stiny also includes one extra rule – a termination rule – to erase a labelled point. These are omitted here (see below for an explanation in light of the implementation).

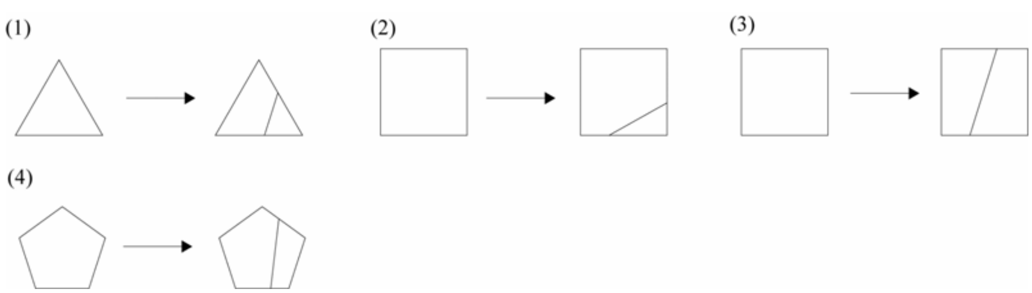

Figure 2. Four constructive rules that split a triangle, convex quadrilateral or pentagon into two new convex polygons (either a triangle and a quadrilateral, a triangle and a pentagon, two quadrilaterals, or a quadrilateral and a pentagon) by placing a single line between two of the original polygon's edges.

Figure 3 shows three additional shape rules that inscribe triangular shapes into a triangle (rule 5), convex quadrilateral (rule 6) or convex pentagon (rule 7), respectively. Stiny also suggests allowing for convex polygons to be augmented by inscribing pentagonal (or hexagonal) shapes. This suggestion is not retained as it is not generally applicable in the context of a twisted surface, whereas the seven shape rules that are presented here are. In case of rules 1 through 4, a single line is placed between two points on two of the original polygon's edges. Such a line can always be constructed. In case of rules 5 through 7, a triangular shape is constructed that connects in the plane of the triangle to three points on three of the original polygon's edges. Since three points always (uniquely) define a plane, such a triangular shape can also be constructed (see figure 4 for the case of a twisted quadrilateral).

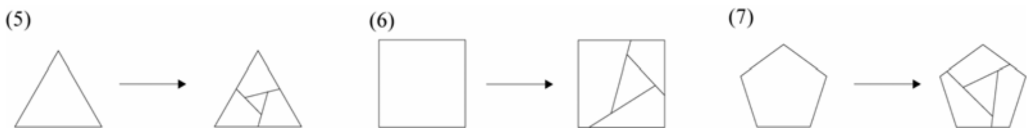

Figure 3. Three additional constructive rules that inscribe a triangular shape between three edges of a triangle, convex quadrilateral or pentagon.

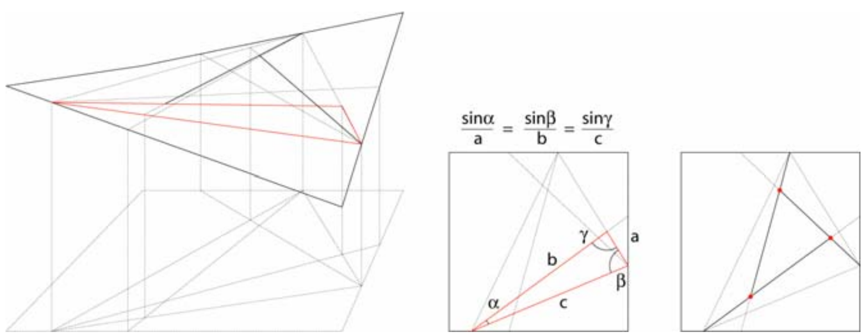

Figure 4. The construction of a triangular shape inscribed in a twisted convex quadrilateral, starting from three points on three of the twisted quadrilateral's edges.

3. RULE APPLICATION

The implementation described below is not of an actual shape grammar, that is, it does not adhere to the definition of a shape as *any* "finite arrangement of straight lines of limited but nonzero length" (Stiny, 1977), nor does it rely on shape recognition algorithms. The implementation instead uses the notion of a polygonal face as defined by the CAD software application it is embedded in. Furthermore, the generation is guided by the order in which the faces are created. In this way, no auxiliary information, such as labelled points, is required in the parametric rules.

Stiny's shape rules are constrained in two ways. First, they only apply to polygons with area greater than some given constant. Secondly, in the case of rules 1 through 4, the resulting polygons have approximately equal areas. Additional constraints on the lengths of the polygon's edges are necessary in order to ensure that an already short edge is not further subdivided. In the current implementation, all constraints are expressed in terms of the lengths of the original polygons' edges (Figure 5). Figure 6 illustrates the constraints on the endpoints of the single line placed in rules 1 through 4. Each endpoint lies within a section of the polygon's edge that is defined by two parameter values specified by the user (Figure 5), e.g., 0.35 and 0.65 where the edge's endpoints have values 0 and 1. A random number is generated between these two values that specifies the parameter value of the point within the edge; in the implementation, a single random value applies for both edges, as illustrated in Figure 6.

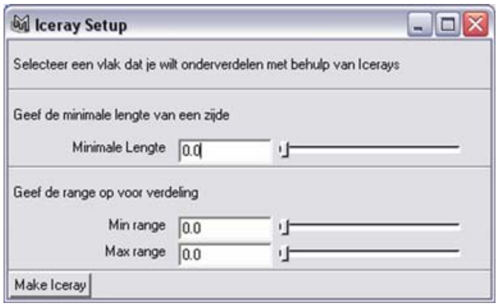

Figure 5. The user interface to specify the minimal length constraint ("Minimale Lengte") and the parameter values ("Min range" and "Max range") that serve to define the section of the polygon's edge wherein the endpoint of the single line (rules 1 through 4) lies.

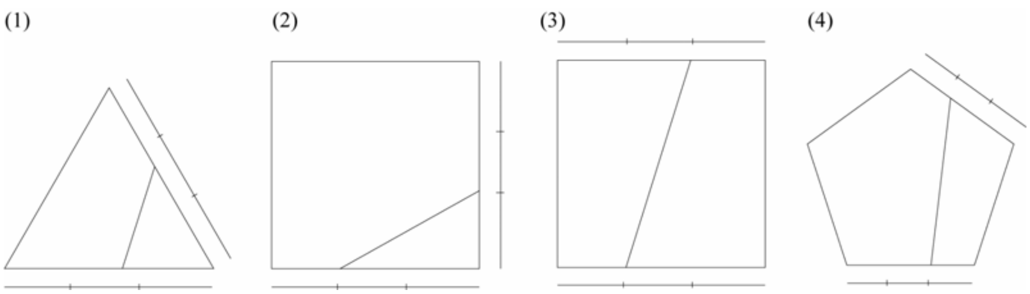

Figure 6. The construction of the single line placed between two edges of the original triangle, quadrilateral or pentagon. Each endpoint lies within a section of the polygon's edge that is defined by two parameter values specified by the user.

Figure 7 illustrates the constraints on the endpoints of the inscribed triangular shape in rules 5 through 7. Each triangular shape is constructed from six points, three of which define the connecting points to the edges of the original polygon, and thereby the plane that embeds the triangular shape, and the other three points define the respective planes, each perpendicular to the plane of the triangle, that embed the edges of the triangular shape. Here too, a random number is generated that specifies the parameter value of a point within the edge and lies between the user-defined parameter values. In the case of a triangle (rule 5), these three points define the connecting points, the other three points are constructed using the same random value applied to the part of the edge between the connecting point and the original edge's vertex with parameter value 1. In the case of a quadrilateral (rule 6), the same construction is applied, with the exception of the first edge, where the first point defines one of the auxiliary points and the second, connecting point lies between the first point and the original edge's vertex with parameter value 0. In the case of a pentagon (rule 7), further variations on this construction technique are considered in order to define the three connecting points and the three auxiliary points (Figure 7).

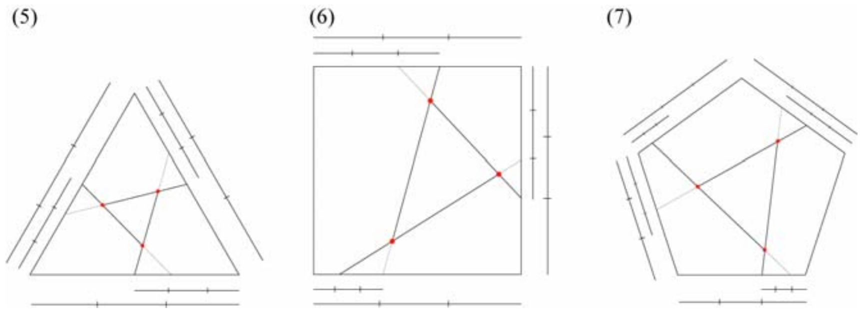

Figure 7. The construction of the triangular shape inscribed between three edges of the original triangle, convex quadrilateral or pentagon. Each triangular shape is defined by three connecting points and three auxiliary points. Each of these points lies within a section of the polygon's edge that is defined by two user-specified parameter values, or within a similarly constructed section of part of the segment as defined by a previous point.

4. GRAMMAR IMPLEMENTATION

The ice-ray grammar for twisted surfaces is implemented in MEL (Maya Embedded Language), the scripting language of the Autodesk® Maya® software. The generation process is guided by the order in which the polygonal faces are created. Rule selection is naturally dependent on the number of sides to the polygon and is further defined randomly. Also, the selection of edges containing the endpoints of the single line or triangular shape is randomly defined among the number of possible permutations. Rule application results in one or more new polygonal faces, but each edge that is created is also separately represented as a linear curve. Each face and curve is assigned a level designator in the process. The level designator of a face is the level designator of the original face it is derived from through rule application plus one. Thus, this level designator corresponds to the number of rule applications that have directly led to the creation of this face (Figure 8). The level designator of a curve equals the level designator of the face it is created as an edge of. Upon completion of the generation process, each linear curve is extruded according to a profile, where the size of the profile (inversely) reflects upon the level designator of the curve (Figure 9). As such, the generation specifies not only the final form of the façade but also its building technical structure, which can then be exported and analyzed for stability using a finite element analysis application. Figure 9 shows an exemplar generation. Figure 10 shows the stability analysis of an (different) exemplar structure using DIANA.

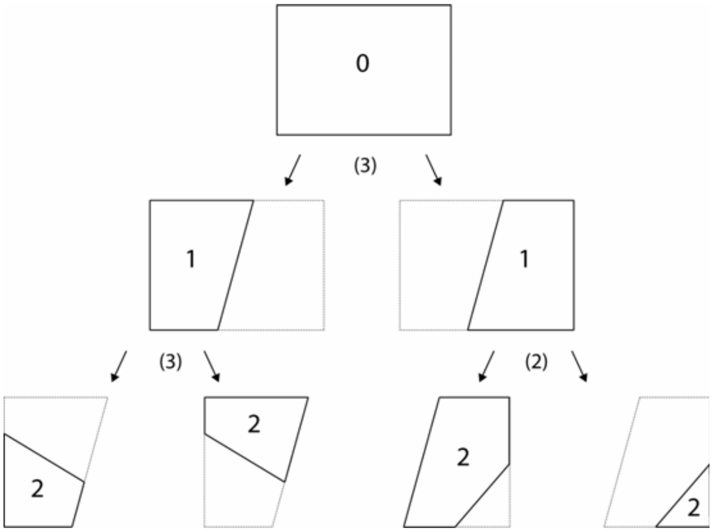

Figure 8. A hierarchy of rule applications (twice rule 3 and once rule 2) and resulting polygonal faces. The number in each face is the level designator and corresponds to the depth of the face in the hierarchy.

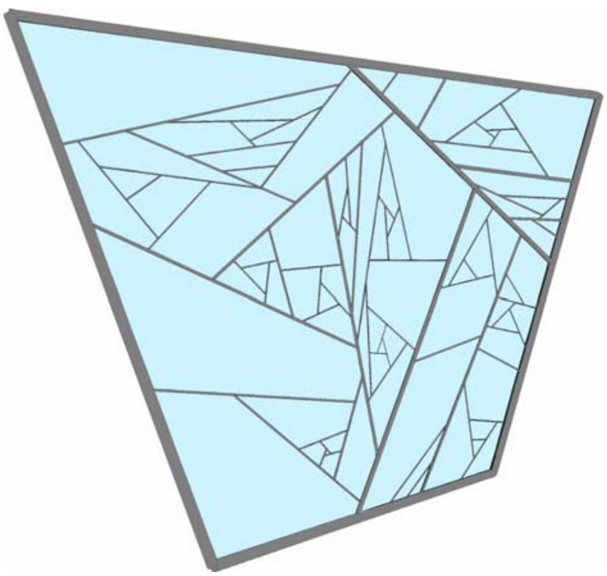

Figure 9. The design of a façade using the ice-ray grammar. The initial shape of the façade is a twisted convex quadrilateral.

5. DISCUSSION

Stiny's ice-ray grammar has been implemented repeatedly, either as a specific implementation (e.g., Liew, 2001) or as an exemplar application of a (more general purpose) shape grammar interpreter (e.g., McCormack and Cagan, 2002). In this paper, another specific implementation of this grammar is described, however applied to 3D surfaces. Both the four original shape rules and the additional shape rules for inscribing a triangular shape apply equally to twisted polygons. Rather than projecting the resulting lattice structures onto the 3D surface, the application of the shape rules to twisted polygons is described using solid geometry. The four original shape rules, each, specify the placing of a single straight line between two edges of the original (twisted) polygon, thereby, creating two new (twisted) polygons. The additional shape rules, each, specify the inscription of a triangular shape in the form of three straight lines extending from a triangle to three edges of the original (twisted) polygon, thereby, creating a planar triangle and three new (twisted) polygons. These rules could be easily extended to apply to polygons with numbers of sides greater than five, such as hexagons. Allowing for polygons with larger numbers of sides could help in better approximating the original 3D surface with a twisted polygon. Alternatively, the original 3D twisted surface can also be approximated as an initial collection of twisted polygons with common edges.

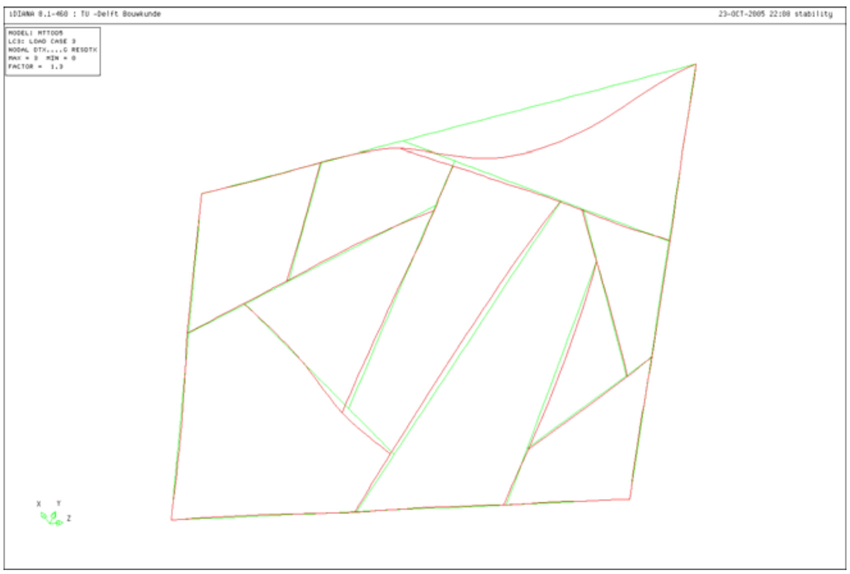

Figure 10. The stability analysis of an exemplar (twisted) ice-ray lattice structure using DIANA, showing the deflection under a uniform load on the top edge of the structure.

The exemplar façade design in Figure 9 clearly illustrates the limitations of the current implementation. Obvious is the variation in the sizes of the polygons that constitute the design. This is a result of the fact that rule application is constrained by the specification of a minimal length for each of the edges of the original polygon. While this may be sufficient in the case of a triangle – a short edge results in a small surface area, even if it is an elongated triangle – it is overly restrictive in the case of a quadrilateral or pentagon. While the constraint could be reformulated in terms of the surface area of the polygon, some constraint(s) on the lengths of the polygon's edges remains necessary in order to ensure that an already short edge is not further subdivided. However, rather than restricting rule application altogether, an edge length constraint should (only) apply when selecting the edges that the rule application applies to, that is, the edges that will be subdivided by the rule application.

Also obvious in Figure 9 is the high amount of inscribed triangles. This is a direct result of the random selection of the rule that applies to any polygon, from those rules that apply to a polygon with the same number of sides. In the case of a triangle or convex pentagon, two rules may apply, one placing a single line and the other inscribing a triangular shape. The chance for each rule to be selected is one out of two. In the case of a convex quadrilateral, three rules may apply, and the chance for the rule inscribing a triangular shape to be selected is one out of three. Instead, the rule selection process can be modified in order to favour the original shape rules or, alternatively, the user could be offered the opportunity to pick which rule to apply at every step in the generation process.

Less obvious in Figure 9 is the fact that in the current implementation a single random value is generated that specifies the parameter value of a point within an edge or part thereof, for all such points that assist in the application process of the rule. It would be straightforward to alter the implementation such that a different random value is generated each time a point is selected.

As stated before, the implementation described is not of an actual shape grammar as it does not rely on shape recognition algorithms to identify the polygons, but instead relies on the polygonal face objects that are defined by the CAD software application it is embedded in. This does not influence the generation process but it does simplify the implementation very much. Implementing it instead as a real shape grammar would only serve the flexibility of the implementation and be worthwhile if the implementation also allows for other shape grammars. On the other hand, using a grammar, or a collection of design rules, as the basis of the generation process does aid in the understanding of the design and construction process of ice-ray lattice structure. As Stiny (1977) describes, “the steps in the ice-ray lattice generation […] could well comprise the frames in a motion picture of the artisan creating his design.”

6. CONCLUSION

The shape rules in Stiny’s ice-ray grammar can be adapted to apply to 3D surfaces. A variety of constraints can be considered for rule application in order to guide design generation. The implementation described above is not of an actual shape grammar; instead, it combines the simplicity of the shape rules with the strengths of the underlying CAD software application.

7. ACKNOWLEDGMENT

This paper extends on a short paper presented at the eCAADe 2006 conference, Volos, Greece, 6-9 September 2006. The implementation of the generative system and its application to 3D façade design form part of an MSc final design project.

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CONTEXT AWARENESS IN CONSTRUCTION MANAGEMENT - KEY ISSUES & ENABLING TECHNOLOGIES

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ABSTRACT

The use of Information and Communication Technology (ICT) is critical in managing construction projects as the right information needs to be delivered to the right person, at the right time, and at the right place. This paper reviews the challenges and issues in the delivery of information in construction management and explores how context-aware computing can help in managing information and services in a construction project. The key issues in context-awareness in construction management are discussed and the enabling information and communication technologies described. The context of a user (such as role, location, time, preference, etc) may be utilised to provide personalised information. Wireless communication technologies allow computing and communication devices to be used virtually anywhere in delivering information and services. The discussion in the paper focuses on the potential application of context-aware computing in construction management using wireless devices. Conclusions are drawn about the possible implementation of these emerging context-aware computing technologies for Construction Programme Managers.

Keywords Context-Aware Information System, Construction Management, Location Based Services, Wireless devices

1. INTRODUCTION

Construction management involves various contexts which include communication, risk, human resource, procurement, quality, cost, time, scope and integration management. A Construction Programme Manager may be responsible for managing multiple construction projects which may involve various activities, people, companies, suppliers, construction sites, offices and locations. From the inception of a project through to its design, construction, and operation, all parties involved are dependent on information and services. Researchers have estimated that if this information could be managed effectively then savings of up to 25% in the construction cost could be achieved (Baldwin et al. 1990). A Construction Programme Manager's roles and responsibilities involve complex management of planning, scheduling, monitoring, reporting and control of multiple projects. Thus, instant delivery of information and services through an intelligent system can play a crucial part in his or her day-to-day managing activities.

Construction activities are widely dispersed and the site location frequently changes (Magdic et al. 2002). It has been suggested by researchers (Aziz et al. 2006a) that by using wireless communication technologies, the information, communications and services delivery between project team members in the field and the office can be enhanced. Thus rapid decisions can be made by the construction programme manager. Researchers (Aziz et al. 2006a; May et al. 2005) however claimed that the existing mobile applications in the construction industry only support the communication of static information (such as project data, plans, drawings, etc.), and are unable to take into account the construction worker's changing context and the dynamic project conditions. Similarly, most of the commercially available mobile applications for construction management are designed primarily to deliver pre-programmed management tools without any consideration of the project manager's context. This often leads to a contrast between what an application can deliver and what the data requirements of a user are.

Context-aware computing is an intelligent system that uses environmental characteristics such as the contextual elements of a user's location, time, identity, and activity to inform the computing device of its current context (Burrell and Gay 2001). Context-aware computing applications examine and react to a user's changing context in order to help promote and mediate people's interactions with each other and their environment (Schilit et al. 2002). In addition, some have the ability to provide highly specific data and services by intelligent interpretation of their context (Aziz 2005). It is suggested that awareness of a user's context (such as user role, task, preferences, location, site condition etc.) in mobile construction applications will enhance the effectiveness of programme delivery by providing information and services relevant to a particular context.

This paper reviews the issues and challenges in construction management and explores how context-aware computing can help construction programme managers in managing construction projects more effectively. The next section discusses specific challenges and issues in construction management. This is followed by a review of the enabling technologies for context-aware computing. The potential applications of context-awareness in construction management are then presented and a number of conclusions drawn.

2. CHALLENGES & ISSUES IN CONSTRUCTION MANAGEMENT

The construction industry is not a homogeneous industry. It is made up of a diverse and competing organizations and professional disciplines such as architects, surveyors, contractors and suppliers, the majority of whom are brought together for one project, before transferring to the next. Each construction project is unique with its own environment, resources, scope and timescale, and may require different information, communications and management techniques.

Modern project management methods have evolved tremendously in order to overcome problems in construction management. However, with the growing complexity of single and multi-project management, the traditional methods of construction management need to be revised. The high degree of complexity results from the number of different companies, organisations and professionals taking part in single or multiple projects. People and resources are at the same time part of two (or more) organisations: their company and project organisations. Therefore, effort is required for coordination and communication, since the volume of information and service delivery is high. In addition, there may be a large distance between the project sites, programme management offices/regional office and the company headquarters.

It is well understood that the use of mobile information and communication technologies (ICT) is critical in managing construction projects as the right information needs to be delivered to the right person, at the right time, and at the right place (Bowden et al. 2006; Magdic et al. 2002). However, the delivery of static information and services to the construction programme manager is inadequate given the growing complexity of construction projects. Mobile applications not only need to be intelligent to the user's changing context (user location, task, profile, etc.) but also to the programme management methodology.

It has been estimated that as much as 30% of project cost is wasted in the construction process (Zou et al. 2006). The problems lie in three main areas:

1). Information history, access and delivery:

- **Poor information and history** – the information passed on is often wrong or inaccurate (Barber et al. 1999), differences in the interpretation of the information, information available is overlooked (Vries 1996), the frustration in not having enough input at the design stage of new-build projects (McAndrew et al. 2005) and lack of information from previous project data.
- **Huge volume of information** – huge volume of project information especially in the multiple project environment, which makes filtering important in order to avoid information overload. Thus, solutions to determine the information relevant to the mobile construction workers current context (Aziz et al. 2006b) are needed to overcome this problems.

2). Communication and collaboration:

- **Poor communication** – senior management often do not know what is happening on site (Barber et al. 1999),
- **Ineffective collaboration -** defects in construction works are often due to poorly detailed drawings, operatives being given incorrect instructions, or technical information not being available (Stupart 2003).

3). Construction Organisational Operation:

- **Complexity and inefficient operation** – complexity factors owing to industry-specific uncertainties and interdependencies. These include the inefficiency of operations in construction management (Dubois and Gadde 2002) such as the number of technologies used and interdependences, rigidity of sequences between the various main operations and overlap of stages or elements of construction.
- **Inaccurate planning** – wrong assumptions are made as to where the project is going in terms of completion date, low technological input, unfavourable clients' attitudes towards projects and lack of support from senior management (Barber et al. 1999).

The problems outlined above becomes more complicated when the construction management firm is involved in a multi-project environment. Researchers (Elonen and Artto 2003) have classified and identified the six relevant problem areas in managing multiple projects: (1) Inadequate project level activities, (2) Lack of resources, competencies and methods, (3) Lack of commitment, unclear roles and responsibilities, (4) Inadequate portfolio level activities, (5) Inadequate information management and (6) Inadequate management of project-oriented organisation.

In summary, the main problems faced in construction management today are the delivery of fast and accurate information, and good communication amongst various parties in the industry. Therefore, the delivery of effective context-specific information and services for Construction Programme Manager’s is very important for the success of construction projects. The use of wireless communication technologies and context-aware computing technologies will enhance information flow in more timely manner between the users at fields and office.

3. ENABLING TECHNOLOGIES FOR CONTEXT-AWARE COMPUTING

There has been considerable interest in human-computer interaction and mobile computing research recently. The increasing availability of cheap mobile devices, wireless technologies and free access to GPS data (that enable the detection of elements of the user's current context, specifically their current location) has created an increasing interest in *context-aware applications*: applications whose behaviour are governed by the user's current context (Brown et al. 2000) and *location-based services*: whose behaviour are governed by the user’s current location (Ferscha et al. 2001). A system is context-aware if it can extract, interpret and use context information and adapt its functionality to the current context of use. There are various terms used for context-aware applications, such as context-aware computing, situated computing, context-sensitive computing and situation-dependent computing (Aziz 2005). These terms however, refer to the same concept which is the ability of the applications to respond to their environment. The enabling technologies for context-awareness are presented below:

3.1 Wireless Networking Technologies

Wireless networking technologies allow computing and communication devices to be used virtually anywhere. Table 1 shows comparisons of the available wireless technologies, which is divided into four categories as the Wireless Personal Area Network (WPAN), Wireless Local Area Network (WLAN), Wireless Metropolitan Area Network (WMAN) and Wireless Wide Area Network (WWAN). The table shows that the WLAN and WMAN technologies are in a better position than WPAN and WWAN to be adopted in future research. This is due to the data transfer rate capabilities in providing documents and drawings to the programme manager (which required bigger data transfer rate) at an acceptable coverage area for construction site (maximum coverage area of 100m for WiFi and 31 miles for WiMax). Although WPAN is able to transfer data up to 1 MB, its limited range will be the disadvantages, whereas WWAN is unable to transfer large data with its wide area coverage.

The introduction of Mesh networking (a networks that employs one of two connection arrangements of WiFi) that enables WiFi providers to go beyond the limitations of hotspots and offer a broadband service in a wider coverage area (outdoor and indoor deployment), may be the key enabler for the adoption of context-aware computing in construction site management in the near future.

Table 1: Comparison of Wireless Networking Technologies (Adopted from Tropos Networks 2004; Wiggins 2006)

Parameters	Bluetooth (WPAN)	WiFi (WLAN)	WiMax (WMAN)	3G (WWAN)
Frequency Band	Varies (Typical 2.4 GHz)	2.4 GHz	2-11 GHz	Varies
Range	10-100 meters (Class 1 – have 100 meters range)	100 meters	31 Miles	>1000 miles
Data Transfer Rate	Up to 1 Mbps	11-55 Mbps	70-500 Mbps	256 kbps
Number of users	Dozens	Dozens	Thousands	Thousands
Key Advantages	Low cost, Support for ad-hoc networking and intra-device communication	Low cost, easy to deploy, wireless broadband support	Very high bandwidth and high range	Ability to access Internet (Mobile IP based)
Key Disadvantages	Difficulty in configuring the network, security issues, limited range, limited data transmission	Limited range, security issues	A developing standard, expensive and market availability is still limited	Limited bandwidth and expensive

Nonetheless, the development of an application for context-aware computing in construction management should not just rely on wireless communication technology to function, other technologies such as the mobile device capability, web services and location-based services are crucial in supplying the right contextual information. Web services and location-based services technologies will be adapted into the mobile devices with the now widely available GPS PDA-phone, thereby increasing the potential for new communicative operations in context-aware computing.

3.2 Mobile Devices

There are two aspects of mobility in mobile communication. First is the user mobility where one communicates (wireless) "anytime, anywhere, with anyone". Secondly there is the device portability in which devices can be connected anytime, anywhere to the network. With a move towards a world in which communications and computing are ubiquitous, mobile phones and pocket PCs are ideally positioned to be a core element in this move. With their existing widespread use and familiarity, the deployment of more complex functionality through wireless technologies has the potential to turn the conventional mobile phone and pocket PC into a multipurpose piece of equipment. There are many types of mobile ICT hardware currently used in construction. These include PDA (Personal Digital Assistants), PDA-Phone (combined PDA and mobile phone), handheld computer (a laptop in a small package) and tablet PC (Bowden et al. 2006). They, however, are not efficiently used in delivering information between the construction personnel due to problems with different application platforms in the device applications. Therefore, futher research is needed to develop suitable applications for mobile ICT software to make it more user friendly and able to communicate with different platforms.

3.3 Web Services

A web service is a technology that describe an interface that consists of a set of operation that can be accessed through XML message over the network (Bonsor

2006). The interface provide all details of a web service such that other web service can interact with this web service. This technology supports machine-to-machine interaction over a network, allowing applications written in various languages and running on various platforms to work with one another. Web services enable Windows and Linux applications platforms to function together and exchange data. According to Aziz et. al. (2006a), a major problem in the existing mobile communication application in the construction industry is that they are based on multiple technology platforms (e.g. PDA, Palm, Pocket PC, Tablet PC). This creates problems in the integration of applications that come with different interfaces, programming languages and out-of-sync information. For example, project management applications files in a windows-based PDA will not be able to run or even open in similar applications in a Palm platform. Web services are Web-based enterprise applications that use open, XML-based standards and transport protocols to exchange data with calling clients. They provide simple services that can interact with each other in order to deliver sophisticated added-value services. Therefore, the use of Web services technology may solve the problems related to interaction complexity.

3.4 Location-Based Services

One of the most important dimensions in context-aware computing is based on location. In many mobile computing research efforts (Pagonis and Dixon 2004; Pashtan 2005), location is often used as a parameter to approximate context and to implement context-aware applications. Mobile computing devices that are operational and operated while on the move, can significantly benefit from a context location. Services built on the location awareness capabilities of mobile devices and/or networks are usually referred to as Location Based Services (LBS) (Pagonis and Dixon 2004). The support for this technical capability in mobile devices presents a great opportunity for application developers to create compelling services that are widely used and highly valued. Location information can be used for a variety of purposes in construction management such as to monitor the locations of construction materials and equipment, thus reducing construction waste and improving construction efficiency (Li et al. 2005).

3.5 Technologies for Location Tracking

Location tracking involves several technologies that are combined to produce a system that can track people, materials or equipment. Current technologies used to create location-tracking and location-based systems (LBS) include: Geographic Information Systems (GIS), Global Positioning System (GPS), Radio Frequency Identification (RFID) and Wireless Local Area Network (WLAN) (Bonsor 2006). Any location tracking or location-based service system will use one or a combination of these technologies. A node or tag has to be placed on the object being tracked. For example, the GPS receiver in a cell phone or an RFID tag on a DVD can be used to track these devices with detection systems such as GPS satellites or RFID readers. Nonetheless, LBS can use different principles for acquiring user location data (Nokia Corporation 2005). These are cell ID (a system identifies the cell site in which a user is currently connected, mapping it to coordinates for an estimate of the user’s location.), Global Positioning System (GPS - a system that uses a network of 24 satellites to triangulate a receiver’s position and provide latitude and longitude coordinates.) and Assisted GPS (A-GPS - a system that uses a combination of cell ID and GPS technology).

The only problem with GPS technology is that it is useless indoors (Hesseldahl 2001). This is because the satellite signals are not all that strong and coverage can be spotty in cities with tall buildings. Therefore, to overcome this obstacle, A-GPS seems to be the solution. A-GPS offers better performance than stand-alone GPS because of superior accuracy, quicker time-to-first-fix, and heightened sensitivity, which leads to better performance in challenging or blocked environments.

4. POTENTIAL APPLICATIONS OF CONTEXT-AWARENESS IN CONSTRUCTION MANAGEMENT

The construction programme manager is at the heart of the Programme Management Office (PMO). The PMO is the organisation that provides the infrastructure and supports necessary to manage multiple projects. Its main responsibilities include: project portfolio management, capacity planning, scope management, inter-project coordination, overall project oversight, cost estimation, contingency planning, quality assurance, subcontract management, project managers' development, process management and tool support. There are many applications that are required to effectively manage a programme management office. The PMO is an operational functioning office, not a policy making office. It is normally led by a Construction Programme Manager who acts as an agent for senior management, providing advice, coordination and overall project oversight.

In managing construction projects, construction project managers typically spend 70% of their time dealing with (generating, managing, sending, collecting and analysing) project data (Fisher et al. 1992). Therefore, a Construction Programme Manager who manages multiple projects may be deeply burdened dealing with huge volumes of project data. The ability to quickly convert data into information, while at the same time reducing the administrative tasks may improve the Construction Programme Manager's efficiency. Context-aware project and programme information and services delivery may be undertaken by intelligently converting and delivering relevant project data (such as project planning, resources, cost, etc) and services based on the Construction Programme Manager's current context.

Having location based services (LBS) allow the application to present information and services that are relevant to the Construction Programme Manager's current position, especially when he/she makes multiple site visits. The LBS application may supply information about the Construction Programme Manager's current location by using tracking technologies such as A-GPS or WLAN technologies. The values are then transmitted from the handheld (PDA-phone) to the server so that it can automatically send appropriate information to the Construction Programme Manager (such as project information required, issues to be resolved at the project site, advice, coordination or overall overview of the project) based on his location. This flow of project information and services can be utilised by the Construction Programme Manager in monitoring a programme plan, progress reports and efficiently managing a multi-project environment. Thus, it increases the efficiency and productivity of the construction project delivery process in a multi-project environment. This section explores the potential applications of context awareness in construction management, particularly with respect to the duties and responsibilities of a Construction Programme Manager.

The potential applications of context-aware computing for programme manager can be developed to have the following functions:

- ***List of tasks and status*** – information such as project progress, contractual information, unfinished tasks and relevant information to the programme manager's current context can be automatically updated on his/her mobile device. For example, when he/she needs to make on the spot decisions about variation orders in certain project, he/she may be able to get the current information (such as project cost, progress, effect of the delay to the programme, etc) and contractual arrangements that are relevant to the current project. This may enhance the judgement and reporting process for Construction Programme Manager's in managing the multiple projects.
- ***Resource usage*** – graphical display of resource allocation over time where the Construction Programme Manager may be able to see the resource allocation, which are busy or free from any task based on the current context. An application can then be developed to trigger the Construction Programme Manager awareness of the current usage of resources on a certain project that is not utilised, so that he/she can relocate the resources to other projects. This may enhance the utilisation of staff in resource management at multi-projects environments.
- ***Context-aware searching*** – the intelligently searching of relevant information for programme or project which is based on the general idea of using contextual information as one of the criteria to search for information. This could be the time of the day when he/she is looking for suppliers near to the project location. For example, the nearest concrete batching plant for concreting works. This may help the Construction Programme Manager in making fast and accurate decisions about selecting the supplier.
- ***Context-aware browsing*** – navigating project information based on the programme manager's physical context (e.g. location). This allows programme manager to browse information or documents that are related and relevant to his/her current context (such as project location and task). Context-aware browsing may reduce the time and enhance the effectiveness of the system in providing efficient browsing information for Construction Programme Manager. The combination of context-aware searching and browsing may overcome the problems of information overload by filtering the information required especially when dealing with mobile devices with limited user interface, where the current browsing quickly becomes tedious. For example, when the user have to gone through multiple layers of menus or list.

Based on these applications, context-aware computing in construction management offers the following benefits:-

- Delivery of relevant data having a context-based filtering mechanism (Aziz et al. 2006a);
- Enhancement of construction collaboration (Aziz et al. 2006a);
- Improvement of health and safety management in construction (Aziz et al. 2006a);
- Reducing the overall cost of construction management by providing only relevant information and services to team members;
- Fast and real time access of information in single or multi-project environment;

- Reducing in the project risk in decision making by tackling the issues based on the user's current context (project type, time and location) and with current information on the projects;
- Improved communications between team members;
- Improved resource usage and allocation based on real time tracking of requirements; and
- Improved overall control and management of single or multiple projects based on intelligent supply of information or services to the right person, at the right time and at the right place.

5. SUMMARY AND CONCLUSIONS

In this paper, the challenges and issues with respect to timely information in construction management are discussed and the enabling technologies for context-aware computing described. Then the potential applications for context-aware computing in construction programme management are discussed. The complexity of multiple-construction projects with dynamic site conditions and multi-layered communication amongst project team members may cause information overload to the Construction Programme Manager. These result from poor communication and service delivery, poor collaboration and inefficient organisational operation. This creates an uphill task for the programme manager in effectively delivering the portfolio of projects on time, within budget and with an acceptable quality. In conclusion, the practical solution to this complex management, dynamic site condition and multi-layered communication problem may be the use of context-aware computing applications. However, in order to determine the most appropriate approach to the adoption of context-aware information and service delivery in construction programme management, the current information needs and flows must be first be understood. This is being explored as part of the next stage of the research and involves interviews with experienced programme managers, and case studies.

6. ACKNOWLEDGMENT

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ASSESSING CLIENT'S CONFIDENCE AND SATISFACTION IN CONSTRUCTION PROFESSIONALS IN NIGERIA

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ABSTRACT

Public interest is the main stay of the existence of any profession because of the continued recourse to and demand for such professional service(s). Construction projects have suffered under-achievement in the recent past because professionals' misconduct have been on the increase, only a fraction of which are reported to the professional bodies. This research looks into professional ethics in construction and the anecdotal relationship with public confidence and clients satisfaction. Questionnaire survey and interviews were conducted, while simple percentile tools validated by data triangulation were appropriated in the study. It was discovered that the image of professionalism in the Nigerian construction industry is not enterprising and needs timely intervention to prevent it from circumstantial extinction otherwise, an irreparable collapse of the system is imminent.

Keywords: client's satisfaction, ethics, Nigeria, professional ethics, services

1. INTRODUCTION

Professional ethics is the justification of abstract standards of behaviour against practical tasks, not necessarily limited to technologies, transactions, activities, pursuits and assessment of institutions, but it involves more of the rhapsody of practical conceptualization of public expectations in the interest of responsibilities, willingness to serve public interest and compliant competencies (Fan et al., 2003; Carey, 1968; HKEDC, 1996; Chalkley, 1990; Poon, 2003; Poon, 2004a, 2004b). The strength of the link between the construction industry and the public sustains its existence through overwhelming recourse to and demand for the services of its practitioners and unique products such that the relationship is a function of the pride of professionalism. Interestingly, the pride of professionalism is a function of core technical skills of professionals and, not less important; the ethical consciousness of professionals. (Chalkley, 1968; Olatunji et al., 2006a).

For centuries, the construction industry reserves the uncompromised pride as the gateway provider and facilitator of global physical development through the provision of infrastructures, manpower development, resource employment, fixed capital formation and improvement of the gross domestic product (Omole, 2000; Hillebrandt, 2000). However, one unfortunate threat to this harmonious relationship between the public and the construction industry is the cultural misalignment between public expectations and the professional conducts of construction practitioners (Pollington, 1999).

Conversely, construction client is getting wiser by the day; knowing more of his rights and kingly sovereignty in the industry. Popular studies refer to construction client as the only party whose opinion matters at the end of the day (Latham, 1994; Egan, 1998; Poon, 2003). As the industry gets more dynamic (complex, uncertain and volatile) (Lam et al., 2001) it is imperative for the industry to sustain public interest, trust and confidence repose in her with time. Therefore, the construction world requires fixed, reliable, flexible, timely and better proactive re-orientation and re-appraisal of her practitioners' technical and ethical strategy in the phase of innovation with respect to client satisfaction and harmonious co-relationship (Doree 2004).

2. CONSTRUCTION PROJECT PERFORMANCE

Principally**,** construction project performance milestones are commonly indicated in cardinal tangibles like cost, time, quality and health and safety risks (Drew and Skitmore, 1992; Olatunji and Aje, 2005c). Poon (2003) opines that construction project performance is best defined as the absolute realization of value for client's money through the satisfactory technical performance of the product as predefined in preliminary outlines and whole life cycle performance as intended for use by client or prescribed end-user, without failing client's or user's anticipated returns all through the project life. Male and Mitrovic (2005) define of project performance as the achievement of fitness-for-purpose in construction and the absolute realization client's satisfaction of all his requirements.

Overtly, clients create the market for the construction industry (Langford & Male 2001), and so should be placed at the center of the construction process (Latham, 1994). Male and Mitrovic (2005) classify construction clients based on knowledgeability, organizational type and size and purpose of ownership. Some clients are knowledgeable, others are not. For instance, some client's firms are small, some are medium sized, others are large. Also, there are individual construction clients, some are corporate clients while others are public clients. Ultimately, Consumer clients/owners require a built physical asset as an important strategic resource, while commercial/developer clients trade physical assets to make a profit.

Male (2003a, 2003b) identifies factors that affect construction client requirement in terms of volume; frequency and regularity, and standardization; components, elements, processes and design. Consequently, Croner's (1999) argues that the characteristics of the construction client's demands in the industry give rise to distinct types of demand and supply chain systems,

Conspicuously, clients' views, opinions, decisions and desires are the most important aspect of project success that must be achieved by the project team (Latham, 1994). Sequel to the complex nature of construction clients' requirements, which at times might be crude and ambiguous, construction professionals reserve the absolute responsibility, trust and expectation of the clients to indemnify clients' rights against certain sensitive negative indicators with respect to project success. This may have to do with variables like cost, time, quality and health and safety risks. This inherent indemnifying trust is one of the delineating factors explicating the strength of public expectations in the construction industry: more from construction professionals than non-professionals (RICS, 1998b; 2000).

Regrettably, like many parts of world (Latham, 1994), the Nigerian construction industry is yet to recover from the avalanche of its wicked perpetual failures to salvage the economic resources often wasted in overruns of time and cost, substandard work and shoddy workmanship, client-contractor-practitioner's acrimonious relationships and non-performance of projects as envisaged by client or end-users in term of health and safety to juxtapose or commensurate huge resources, expectation, interest and respect invested in the industry by the public. Innovative researches in the construction world has attributed the systemic failure to be largely as a result of people issue; professional misconducts, workmanship and organization's conceptualizations of work processes rather than relational arrangements and fundamental logistics imperative to value sharing in the supply chain (Poon, 2003; Fan et al., 2003; Olatunji et al., 2006a; Pollington, 1999; Ridout, 1999).

3. THE IMAGE OF PROFESSIONALISM IN THE NIGERIAN CONSTRUCTION INDUSTRY

The image of professionalism in the Nigerian construction industry is not better than most parts of the world where the menace have its ugly head raised. Therefore, popular opinions from literature resources from all over the world are reliable. Chalkley (1990) opines that professionalism is pivoted by the cardinal duo of technical core skills and acceptable moral standard in practice. However, it seems construction professionals are not in the good books of the clients; whether as private, corporate organizations or public clients and this unfortunate scenario has been in serious topical discourses than any other sector (HKEDC, 1996; CIRC, 2001; HKHA, 2000; Ho and Ng, 2003). Many noble professional bodies are aware that some of their members are unwittingly prone to damaging client's interest both on technical ethical grounds (RICS, 1998b, 2000; Vee and Skitmore, 2003). Thus, professional services and opinions are under chronic criticism; they are mostly unnecessary and unsatisfactory (Yakub, 2005; Latham, 1994; Masidah and Khairuddin, 2005).

From this vantage point, it is imperative to establish the relationship between the poor image of professionalism, apart from core technical skill deficiency, through ethical impropriety and project failure. Although, this is one of the pioneering studies on professional ethics vis a vis client's requirements in the Nigerian construction industry, there are outstanding reports that correspondingly describe the involvement of Nigerian construction professionals in indecent acts as a relationship to project failure.

Pearl et al (2005) present one of such pilot studies in South Africa. The authors discover fraud, bribery, conflict of interest, negligence and collusion as some of the commonest unfair conducts of professionals. Olatunji and Ogunsemi (2006a) explore the ethical perceptions of various levels of quantity surveying staff in Nigeria. Albratt et al (1992) claim that most construction professionals always indulge in vulnerable acts like trading official secrets for unscrupulous contingent reward, abuse of office, patronising despicable level of honesty, refusal to whistle-blow against colleagues or superior indulging in unethical habits and falsification of trade figures and official reports. Dolecheck and Dolecheck (1987) add practitioners' compromise of personal professional instincts in favour of employer's selfish interest against public interest as well as the cover-up of fundamental breaches like copyright and patent rights.

Common phenomena in Nigeria are similar to Hong Kong's situation where Ho et al (2004) condemn salt water scam and short pilling malpractices for which two barely completed 34-storey buildings worth HK$600, 000, 000 were demolished for irredeemable structural defects. In fact, over 100 major building collapses have been witnessed in Nigerian major cities in the last two decades. In like manner, Fan et al (2001) condemn professionals' failure to maintain Professional Indemnity run-off cover, while Ho and Ng (2003) identify irresponsible service attitude, stern denial of fault and poor service quality as unfair practices that degenerate into failure to achieve client's value for money in the construction industry.

4. DATA ANALYSIS AND RESULTS

The empirical bases for this research is pivoted on questionnaire survey and direct interviews administered to construction clients randomly chosen from southwestern Nigeria. The respondents are private individuals, corporate organizations and pubic establishments to assess the of level satisfaction in the performance of construction professionals operating in Nigeria. A total of 67 questionnaires (to represent 82% of the target responses) were received out of the 83 administered at three different times and places in Southwestern Nigeria.. Table 1 shows the analysis of the responses.

Table 1: The analysis of the responses

Clientship	Responses	Percentage
Private individuals	23	34%
Corporate organizations	21	31%
Pubic establishments	24	35%
Total	68	100%

From the analysis in Table 1, 35% of the respondents are Pubic establishment clients, 34% are Private individual clients, while 31% are Corporate organizations clients. Table 2 shows the analysis of the respondents' demographic variables.

Table 2: The analysis of the respondents' demographic background and level involvement in the construction industry in the past 5 years

Clientship	**Academic and professional qualifications**		**Average number of construction contracts administered in the past 5 years**	
	< first degree	≥ first degree + professional qualifications	Group Average	Overall Average
Private individuals	6	17	5.00	1.70
Corporate organizations	1	20	8.81	2.70
Pubic establishments	0	24	10.20	3.60
Total {percentages}	7 {10%}	61 {90%}	8.00	8.00

From Table 2, only 10% of the respondents possess less than first degree but they possess considerable quantum of demonstrable understanding of the industry, having patronized the construction professionals operating in Nigeria for an average of 18 years. 90% of the respondents possess at least first degree, 78% of which are in construction related disciplines, while 37% of them possess recognized professional certificates, 35% of which are from construction related disciplines.

Moreover, further analysis reveals that Individual Client respondents have been involved in an average of 5 construction projects in the past five years, while Corporate Client respondents have been actively involved in an average of about 9 construction projects in the past five years. Pubic Client respondents have been actively involved in an average of about 10 construction projects in the past five years. Overall, an average of 8 projects in the past 5 years was considered reliable for respondents' experience which imperative in the quality of the study.

Correspondingly, respondents identified the recent surge in unfair practices involving construction professionals in the recent past. The resultant effect on project performance is regrettably debilitating. 68% of the respondents ranked contracting practitioners as being highly fraudulent, while 78% assert that contracting practitioners are not trustworthy based on their susceptibility to despicable level of honesty. 48% of the clients (made up of 65% corporate organization clients) have witnessed collusion of contractor on their projects, while 45% (52% of which are corporate clients) claim that they were not encouraged by the site condition and service quality of 60% of contractors that worked for them in recent years.

Moreover, 72% client respondents claim that they have experienced unfair conducts of consulting professionals. About 70% claim to have witnessed consultants receiving undue contingent rewards and unethical inducements from contractors, while 58% have witnessed collusion between the contractors and the consultants. Regrettably, 78% of public client respondents have lamentable records of professionals falsifying trade figures and official reports, while 65% have indicted their employee professionals for trading official secrets with contractors. 58% of the respondent clients strongly agree that most consulting practitioners are corrupt and thus, can be negligent, fraudulent, take and give bribe, refuse to whistle-blow when others default at the detriment of client or public interest, cover fundamental breaches having to do with copyright and patent rights and intentionally fail to provide for Professional Indemnity run-off cover as and when due, while 65% (85% of which public client respondent) assert that they have witnessed consulting professionals despondent relegation of personal professional instincts to favour clients interest against public interest.

In order to establish standard comparative basis for the qualitative study, the foregoing data were triangulated with existing established standards in the construction industry. Although, there are very few research efforts in this area – quantifying the level of satisfaction of clients in the construction industry. For instance, Egan (1998) says 37% of construction clients (in the UK) are dissatisfied with contractors and consultants. Reporting a survey conducted by Construction Client Forum (UK) Poon (2003) reports that 58% of the respondents that participated in a client-survey conducted program overrun with an average of 48 days delay in anticipated delivery, while 32% experience cost overrun. Ridout (1999) reports that 58% of (UK) clients experience defects on their projects.

Despite the pride of technological advantage flaunted by the UK construction industry, the revelations made from data provided above are certainly not too good (Latham, 1994, Egan, 1998). Colin Gray (1996) claims that the UK construction industry has over 64 available cost saving techniques and the construction costs in the UK represents two-third of other countries of equal standard, thus an adoptable level of standard could be appropriated for developing countries as possible benchmark to achieve, if not surpass.

Although, the number of respondents that participated in the survey is too small to represent the interest of construction clients all over Nigeria, but the data proffered are reliable bases to correlate subsequent researches. Consequently, respondents were requested to assess project performance on percentage based on recent personal experiences with contracting and consulting practitioners. Table 3 shows the analysis of respondents' assessment of the level of construction Clients' satisfaction in Nigeria experienced in the last 5 years.

Table 3: Respondents' Assessment of level of client satisfaction on construction project executed in Nigeria in the recent past.

Project Performance Milestones	Satisfaction achieved with Contracting practitioners				Satisfaction achieved with Consultant Practitioners				Overall Average
	Clientship			Average (%)	Clientship			Average	
	Private individuals	Corporate organizations	Pubic establishments		Private individuals	Corporate organizations	Pubic establishments		
Quality Performance	51.75	55.25	61.45	56.15	50.15	71.65	64.35	62.05	59.10
Time Performance	54.25	80.65	48.85	61.25	46.10	54.58	38.19	46.29	53.77
Cost Performance	52.55	68.17	83.85	68.19	58.55	67.36	58.14	61.35	64.77
Health and Safety Performance	34.14	61.57	51.65	49.12	46.32	59.72	66.10	57.38	53.25
Total Average	48.17	66.41	61.45	**58.68**	50.28	63.33	56.70	**56.77**	**57.72**

From the analysis presented in Table 3, only 58.68% of Client's satisfaction is achieved by the respondents in the past 5 years through contracting professionals' assiduity, while 56.77% satisfaction is the best consulting practitioners could offer. In the opinion of the respondents, with the overall satisfaction level of 57.72%, Quality Performance is assessed to have achieved 59.10%; Time Performance 53.77%, Cost Performance 64.77%; and Health and Safety risk Performance 53.25%.

The variation in the level of satisfaction experienced in the assessment of the respondents is explicated in the availability of resources and their corresponding disposition to systemic principles inherent in the industry. For instance, the public procurement system in Nigeria governed by the Due Process policy keenly monitored by the Presidency's Budget Monitoring and Price intelligence Unit. The policy proffers stern adherence to firm price principles which is lowest bid based. Unfortunately, Time Performance has not been very encouraging in the system, which suggests that Quality Performance in the public procurement system governed under

Due Process Policy may be at risk. The analysis also shows that there is little improvement in the level of awareness and provisions for health and safety risks by construction contracting and consulting professionals in the Nigerian construction both in design and construction stages. Further analysis reveals that 41.32% of the respondents are dissatisfied with contracting practitioners (Main contractors, sub-contractors and suppliers), 43.33% are dissatisfied with consulting practitioners (Architects, Surveyors, Engineers, Managers and Planners). Conspicuously, clients are dissatisfied because of contemporary dynamism in client requirement through which it is evident that construction practitioners are lacking both on technical and ethical grounds. Compared with the UK figures earlier retrieved from previous studies, it is worrisome that over a period of one decade, the Nigerian construction industry's practitioners are still about 7 - 10% less enterprising in professionalism.

5. CONCLUSION

Public interest is the single largest factor sustaining the existence of profession in construction and it is largely dependent on client's satisfaction encapsulated in the image of professionalism in the industry. However, it is established in the survey that technical and ethnical dispositions of most construction professionals do not commensurate with the dynamism of client requirements.

Regrettably, the survey reports in the study reveals that only 57.72% level satisfaction is achieved in the Nigerian construction industry. About 41% construction clients are dissatisfied with contracting practitioners, while 43% are dissatisfied with consulting practitioners. Many of the respondents still experiences cost and time over-runs (64.77% and 53.77% respectively) on the their projects in the recent past, while quality performance is still lacking behind expectation. It is recommended that construction professionals should be re-oriented to face modern challenges through innovation and development towards maximizing client value for money and ultimately public interest in construction projects.

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THE DISCOURSE OF CONSTRUCTION COMPETITIVENESS: MATERIAL CONSEQUENCES AND LOCALISED RESISTANCE

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ABSTRACT

It is contended that competitiveness is better understood as a discourse rather than a characteristic that is supposedly possessed. Construction companies, and national construction sectors, are continuously exhorted to improve their competitiveness. The search for competitive advantage is widely accepted as an essential component of enacted strategy, but there remains little agreement on how it can be achieved in practice. Different discourses are derived from the competitive positioning school, the resource-based view and the theory of dynamic capabilities. The associated terminologies are frequently ambiguous and arguments are too often divorced from context. Key terms are subject to different interpretations within different constituencies. Such co-existence of multiple representations of concepts is a common social phenomenon. Different meanings are articulated and mobilised to serve the interests of different social and institutional constituencies. The discourse of competitiveness derives its legitimacy from the enterprise culture that came to dominance in the Anglo-Saxon world during the 1980s. In the UK construction industry, the discourse of competitiveness has had significant material implications for the structure of the sector. The dominant recipe of competitiveness amongst contracting firms has been the need to achieve structural flexibility to cope with fluctuations in demand. In consequence, the UK industry is characterised by a plethora of hollowed-out firms who have failed to invest in their human capital. While the adopted model may be rational for individual firms, the systemic effect across the sector as a whole equates to a form of anorexia. However, the discourse of competitiveness is by no means monolithic and continues to be contested locally. There have also been numerous counter-discourses that have been mobilised in response to the undesirable externalities of unbridled enterprise. A currently important counter-discourse promotes the ideas of corporate social responsibility.

Keywords: Competitiveness, Competitive Advantage, Context, Discourse, Enterprise Culture.

1. INTRODUCTION

The need for a greater degree of competition was undoubtedly one of the guiding threads of public policy in the UK during the 1980s and 1990s. During this era, governments repeatedly exhorted the benefits of competition as a means of achieving efficiency. The combination of espoused and enacted policies became known as the enterprise culture, which has had a lasting effect on industry structure and managerial rhetoric. During the 1980s the enterprise culture was reflected and reinforced by Porter's work on competitive advantage, which addressed how firms should position themselves in the marketplace. An alternative perspective on competitiveness is provided by the resource-based view (RBV) which addresses firms' internal capabilities. More recently, consideration has been given to the dynamic capabilities that firms require if they are to respond to external changes in the business environment. Each of these theoretical contributions to competitive strategy are reviewed and positioned against the discourse of the enterprise culture. Consideration is given to the material manifestations of the enterprise culture in the UK construction industry. Caution is then drawn to the dangers of conceptualising the enterprise culture as a monolithic discourse in isolation of persuasive counter discourses. Finally, attention is directed towards an alternative research agenda drawing from the ideas of strategy-as-practice.

2. COMPETITIVENESS AND THE ENTERPRISE CULTURE

Prior to reviewing the key theoretical contributions to the field of competitiveness, it is appropriate initially to establish the broader ideological context. The legitimacy of 'competitiveness' amongst practising managers is undoubtedly derived from the broader discourse of the enterprise culture, as propagated widely in the UK and USA since the early 1980s. Competitiveness in the global economy became the new mantra of both the Reagan and Thatcher administrations as a means of achieving economic growth after decades of stagflation. Managerial sources on competitiveness both reflected and reinforced this new emphasis on the 'survival of the fittest'. Individual firms, and entire national economies, had to become competitive in order to survive. The espoused policies sought to extend the domain of the free market throughout the economy in the cause of competition. The shift to the political right denied legitimacy for the continued state support of 'lame ducks'. National economies and individual firms were obliged to compete in the marketplace. Harsh medicine was advocated to overcome sluggish economies characterised by low productivity, over-manning and lack of investment. Key policy dimensions of the espoused doctrine included privatisation, deregulation and the reduction of trade union power. Taxation levels were reduced in an effort to encourage 'enterprise', with a consequent reduction in welfare benefits. The combination of policy initiatives, legislation and rhetoric has been characterised as the 'enterprise discourse' (du Gay, 1991; du Gay and Salaman, 1992; Keat and Abercombie, 1991). In this sense, the enterprise culture includes a complex web of ideas, linguistic expressions, policies, social institutions and material practices. And it has had a significant and lasting impact on the UK economy and society at large. The decimation of the manufacturing sector resulted in urban decay and widespread unemployment. Many firms in traditional heavy industries failed to survive exposure to the harsh winds of competition. In the UK, the discourse of enterprise was subsequently enthusiastically embraced – and even extended - by the Blair government elected in 1997. The end result is an economy oriented towards services rather than manufacturing, with consequent growth in part-time and temporary employment. The accepted euphemism for such trends is the 'flexible economy', which is too often characterised by a widespread reduction of employment protection; too many restrictive regulations are deemed ‘uncompetitive’. The discourse of the enterprise culture has shaped business education and practice to such an extent that it has since become accepted ‘common sense’.

3. COMPETITIVE ADVANTAGE

Much of the current managerial discourse of competitiveness is derived from Michael Porter’s work on competitive advantage (Porter, 1980; 1985). Although Porter’s (1979) work initially focused on guiding firms whether or not to enter a particular industry, it is now more commonly used to analyse relative market power as a means of informing strategic action. The approach is often know as ‘five forces analysis’, referring to the forces that affect a company’s ability to serve its customers and make a profit. The five forces are: (i) the bargaining power of customers; (ii) the bargaining power of suppliers; (iii) the threat of new entrants; (iv) the threat of substitute products and (v) the intensity of competitive rivalry. Firms are therefore advised to assess these forces before deciding upon which markets to enter. From this perspective, firms become competitive by analysing market opportunities in terms of the preceding five forces, and choosing the most desirable strategy. Critics argue that Porter’s analysis assumes that the five forces operate independently and that strategic decision makers have access to perfect information (Coyne and Subramaniam, 1996).

Porter (1980) offers a further dimension of his strategic model in the form of his so-called ‘generic strategies’ which he simplifies as cost leadership, differentiation and market segmentation (or focus). Cost leadership strategies are traditionally dominant within the construction sector, largely because firms frequently struggle to differentiate their products. However, larger construction firms frequently develop differential brands oriented towards different demand sectors. Other firms undoubtedly adopt a ‘focus’ strategy by concentrating on particular market niches with a view to providing excellent services to a limited clientele. However, the assumption that such strategies are mutually exclusive has been repeatedly challenged in the literature (Flint, 2000; Klein, 2002). Furthermore, Porter notably offers little advice on *how* organisational resources are to be aligned in the effective implementation of the adopted strategy (O'Shaughnessy, 1996). Powell (2001) further observes that most empirical studies infer competitive advantage from *ex post* observation, but then conclude *ex ante* that creating competitive advantage produces superior performance. In essence, the notion of competitive advantage seems to rest on the tautological observation that the characteristics of competitive advantage or those that make firms successful.

Despite the above difficulties, Porter’s terminology provides much of lexicon of competitiveness and the terms are frequently mobilised by practising managers. This is especially true for those who see themselves involved in setting strategy. The popularity of Porter’s terminology has survived prolonged criticism within the strategic management literature (Connor, 2003; Klein 2002). The notion of ‘competitive advantage’ invariably remains central to any espoused organisational strategy, despite its ambiguity. The broader community of strategic management researchers have frequently commented on Porter's perceived lack of precision (Connor, 2003, Klein 2002, O'Shaughnessy 1996). Whilst the discourse of competitive advantage remains attractive, there is little agreement on what it means in operational terms. Flint (2000) is especially dismissive:

> *"The terminology used in the field of strategic management that might possibly garner the prize for the most overworked and least understood catch-phrase is 'competitive advantage'. The extension of that phrase into 'sustainable competitive advantage' is currently an elaboration of ambiguity"*.

It is indeed notable that Porter avoids offering a precise definition of competitive advantage, other than to suggest that "*competitive advantage grows fundamentally out of the value a firm is able to create for its buyers that exceeds the firm's cost of creating it*" (Porter, 1985). The fundamental ambiguity of 'competitive advantage' means that it can be mobilised to mean different things by different interest groups. According to Connor (2003):

> "*It is clear that the definition will vary with differing points of view and with the nature of the viewer's interest in the performance of business"*.

Rather than understand 'competitive advantage' as something that can be possessed and measured, it is therefore more meaningful to understand it as a discursive resource that is mobilised in the enactment of strategy. The same argument can also be applied to concepts such as the 'value chain' and other such terms derived from Porter's work. Whilst it is easy to acknowledge Porter's significant contribution to the discourse of strategy, this does not mean that we have to accept his models in terms of their substantive content.

4. THE RESOURCE-BASED VIEW

An alternative discourse of competitiveness to that of Porter is offered by the resource-based view (RBV) of the firm (Barney, 1991; Wernerfelt, 1984). The RBV is again intertwined with the discourse enterprise culture, but the focus of attention lies with the unique internal resources that allegedly make individual firms competitive rather than with market positioning. The basic ideas can be linked back to evolutionary theories of the firm such as those offered by Nelson and Winter (1982) and Penrose (1959). Resources can be tangible or intangible in nature, and are variously seen to include: assets, capabilities, organisational processes, firm attributes, information and knowledge Barney (1991). Kay (1999) also refers to capital, equipment, patents and talented managers. Such resources are seen to be controlled by the firm and provide the basis for identifying and implementing strategies for improved effectiveness. Competitive advantage is seemingly secured when a firm is able to implement a 'value creating strategy' that others are not able to replicate due to the lack of necessary resources (Barney, 1991). The RBV therefore focuses on firm-level resources and capabilities rather than the industry-level analysis favoured by Porter. However, the RBV has also been criticised for failing to provide prescriptive guidance to managers (Conner, 2002; Priem and Butler, 2001). Strategic resource assets only seemingly become identifiable as such once 'competitive advantage' has been secured. Resources that secure competitive advantage are held to be those that enable a firm to improve its efficiency and effectiveness whilst being unavailable to other firms. Furthermore, they must be imperfectly imitable and non-substitutable (Barney, 1991). The difficult lies in that many such attributes can only be recognised after the event. In other words, the resources that need to be deployed to ensure competitive advantage are those that have been important in securing competitive advantage. Hence the criticism that the basic argument at the heart of the RBV is tautological.

5. DYNAMIC CAPABILITIES

An extension of RBV is provided by the idea of dynamic capabilities, which relates to a "*firm's ability to integrate, build and reconfigure internal and external competencies to address rapidly changing environments*" (Teece *et al* 1997). Once again, the literature abounds with definitional problems regarding the distinctions between resources, assets, competencies and capabilities. Nevertheless, it is possible to understand dynamic capabilities as 'second order' capabilities relating to a firm's ability to reconfigure its existing substantive capabilities. However, in common with the more static conceptualisation of resources offered by the RBV, dynamic capabilities are too often conceptualised in ways that makes it difficult to separate their existence from their effects (Zahra *et al* 2006). The core literature also too often confuses the dynamic nature of the environment with the dynamic nature of the capabilities themselves. In common with the RBV, research informed by dynamic capabilities literature again tends only to identify capabilities retrospectively on the basis of observed behaviour (Jarzabkowski, 2005). There is little that provides prescriptive guidance for firms wanting to develop new capabilities in response to changing circumstances.

The idea of dynamic capabilities is perhaps most persuasive when linked to organisational learning. Zollo and Winter (2002) recognise the near tautology of defining capability as ability, and in consequence choose to focus on operating routines as the object upon which dynamic capabilities operate:

> "*A dynamic capability is a learned and stable pattern of collective activity through which the organization systemically generates and modifies its operating routines in pursuit of improved effectiveness.*"

Whilst Zollo and Winter (2002) are themselves light on the rhetoric of competitiveness, their contribution provides a bridge between the static RBV and the more dynamic, less commodified, theories of knowledge management and organisational learning. It is these latter concepts that are frequently mobilised in the cause of 'achieving competitiveness'. Many such narratives draw from Grant's (1996) knowledge-based theory of the firm. Nevertheless, those who criticise Porter's work for its ambiguity and lack of precision are unlikely to find much comfort within the conflated lexicons of dynamic capabilities, knowledge management and organisational learning.

6. COMPETITIVENESS IN THE CONSTRUCTION CONTEXT

Given that the topic of this paper is competitiveness within construction, it is appropriate to offer an overview of the evolving context within which construction companies operate. Any such description is of necessity limited and incomplete, but the discourse of competitiveness cannot be understood in isolation of context within which it is applied. Of particular importance is the recursive relationship between enacted strategy and context that unfolds over time (Pettigrew, 1997). Related to this is the way in which the discourse of the enterprise culture has been appropriated to shape the modern-day reality of the UK construction industry.

The rhetoric of competitiveness was perhaps first mobilised in the construction industry during the 1970s in response to policy statements by the Labour Party in support of building industry nationalisation. The Conservative Government elected in 1979 enacted supporting policies by opening up local authority Direct Labour Organisations (DLOs) to private sector competition. The period 1980-1995 saw the widespread institutionalised incentivisation of self-employment through the tax and insurance system, with resulting reductions in trade union membership. In consequence, the percentage of self-employed operatives grew from under 30% in 1980 to over 60% in 1995 (Harvey, 2001; ILO, 2001). Such changes were mutually constituted with the discourse of competitiveness. The process of labour market change was supported by a shadowy organisation called the ‘Economic League’, to which most of the major construction companies subscribed. Its prime role was the blacklisting of ‘militant’ trade unionists in the cause of competitiveness (Hollingsworth and Tremayne, 1989). Many individuals found themselves blacklisted for entirely legal involvement in trade union affairs. Such actions were seen to be necessary in the broader cause of ‘competitiveness’.

Construction firms were therefore not only encouraged to adopt strategies based on outsourcing and labour-only subcontracting by rhetorical exhortations; they also received material incentives through the tax and insurance system. For many, the shift towards non-standard forms of employment aligned perfectly with the adopted model of ‘structural flexibility’ as the key means of achieving competitive advantage (Winch, 1998). The need to expand or contract in response to fluctuating demand became central to the competitive strategy of the construction sector. In consequence, contractors progressively withdrew from taking responsibility for direct employment and training, preferring to rest their competitiveness on effective ‘contract trading’. Associated trends include the retreat of most major contractors from any direct involvement in training. This has led to a dramatic decline of the apprentice system and an increasing reliance on migrant workers supplied through agencies. Such trends were exacerbated by the popularity of ‘management’ procurement routes, whereby teams of management consultants responsible only for co-ordination replaced the main contractor. In consequence, the key capabilities of UK contractors arguably became the efficient use of working capital coupled with the management and co-ordination of sub-contractors. Also of importance is their ability to off-load risk to the supply chain. More recently, the adopted competitive strategy has been legitimised by the discourse of ‘supply chain management’. Of particular note are the isomorphic pressures through which firms in the same sector come to resemble each other (Powell and DiMaggio, 1991). Spender (1989) also refers to ‘industry recipes’ to explain the tendency for firms within the same sector to adopt similar approaches to decision making

As a caveat to be above, there are always exceptions to the dominant industry recipe. This is especially true for sectors as diverse as construction. Nevertheless the emergence of the ‘hollowed-out’ firm as the exemplar of UK contracting companies has raised concerns about the sector’s absorptive capacity and its ability to innovate (cf. Gann, 2001). It could further be argued that the relentless pursuit of narrowly constituted ‘competitiveness’ by individual firms has led to a free-loading mentality whereby the costs of training and investing in the future are left to others. Thirty years of outsourcing and de-layering have resulted in many contracting firms evolving into exemplars of the ‘lean organisation’. While this may be perfectly rational for each individual unit of analysis, the systemic effect across the sector as a whole equates to a form of anorexia (Green and May, 2003).

7. COUNTER DISCOURSES

Notwithstanding the above, there is a danger of over-emphasising the extent to which the construction industry has been shaped by the discourse of competitiveness. Indeed, du Gay’s characterisation of the ‘enterprise culture’ has been criticised for being overly deterministic as a result of paying too little attention to the disrupting affects of counter discourses (Fournier and Grey, 1999). ‘Enterprise’ is ultimately perhaps too vague a term to constitute the monolithic discourse to which du Gay alludes. There is also a danger in conflating too easily the discourses of competitiveness and enterprise. While they are undoubtedly to some extent mutually constituted, there are also important differences in emphasis. For example, enterprise tends to be positioned as an alternative to bureaucracy, whereas competitiveness tends to be promoted as a desirable product of free markets. Again, there is an obvious tautology in that ‘competitiveness’ is the outcome of making markets more competitive.

Perhaps the most obvious counter discourse mobilised in response to competitiveness has that promoted by the political Left, and in particular the trades unions. This has been especially pronounced in terms of sustained campaigns against bogus self-employment and the exploitation of migrant workers. The Inland Revenue clampdown in 1997 resulted in 185,000-210,000 workers moving back into direct employment (Harvey, 2003). This was in part a direct result of trade union success in mobilising a counter discourse. Health and safety is a further continuing concern to those who work in the construction sector, and as such represents a longstanding counter-balance to the dominant discourse of competitiveness. The ethos of professionalism has also been traditionally strong in the construction sector. In many respects, the professions supposedly numbered amongst the institutionalised ‘vested interests’ against which the enterprise culture was directed.

Whilst the status of the professions may have declined in the construction sector, they have by no means been swept aside. The professional institutions continue to provide resistance to the notion of un-regulated enterprise, and certainly continue to play an important part in shaping the self-identities of their members.

Not withstanding the above, there have been numerous managerial counter-discourses that seek to alleviate the damaging side effects of the industry's dominant recipe of 'structural flexibility'. In the construction sector, the Egan Report (1998) arguably marked the highpoint of competitiveness discourse in the UK construction industry. But there have several ebbs and flows both before and since. To suggest that there is one hegemonic discourse that has shaped and patterned the evolution of the construction sector would be to oversimplify the complex processes involved. All discourses are contested and localised arenas are invariably characterised by multiple, competing discourses. Examples are provided by the inter-related narratives of teamwork, partnering and collaborative working. Latham (1994) certainly sought to redress the construction sector's adversarial competitive recipe of 'bid low, claim high'. In this respect the Construction Act of 1996 is a material component of a mobilised counter discourse. Egan's (1998) subsequent focus on narrowly-defined efficiency represented a fight back for the discourse of competitiveness; but even Egan paid lip-service to relational concepts such as partnering and teamwork. The Strategic Forum (2002) subsequently went further in that it embraced trade union concerns about bogus self-employment. Also of significance is the Strategic Forum's emphasis on the need for 'integrated teams' as a supposed antidote to fragmentation. More broadly, it is interesting to observe the increasing interest in corporate social responsibility (CSR) whereby firms are expected to go beyond narrowly defined self-interest in pursuit of social and environmental sustainability. Such arguments undoubtedly run contrary to the uni-dimensional 'greed is good' philosophy of the enterprise culture. However, the extent to which this alternative discourse results in lasting material change remains to be seen.

8. TOWARDS AN ALTERNATIVE RESEARCH AGENDA

The re-conceptualisation of competitiveness as a discourse rather than a characteristic of organisations has significant implications for research. It certainly questions the relevance of positivist research methodologies and points towards a wider acceptance of the insights to be gained from discourse analysis. It further questions the assumption that there can ever be a deterministic relationship between theory and practice within the context of competitive strategy. The emphasis on 'competitiveness' as a discourse focuses attention on the way in which it is mobilised for the purposes of enacting strategy. The ways in which competing discourses are contested across localised arenas is increasingly emphasised within the emerging field of strategy-as-practice (Hendry, 2000; Jarzabkowski, 2004; Whittington, 2003). The notion of strategy-as-practice provides an alternative research focus which addresses strategy as a '*situated, socially accomplished activity constructed through the actions and interactions of multiple actors*' (Jarzabkowski, 2005). Of particular note is the way in which strategy-as-practice research seeks to reinstate the actor to centre stage - both Porter's positioning school and the RBV downplay the fact that strategy is enacted by individuals. Rather than theorising how 'competitive advantage' can be achieved or measured, the focus within strategy-as-practice lies on the way multiple practitioners shape strategy through their actions and practices. Competitiveness therefore becomes one discourse amongst many, and cannot be understood in isolation. Indeed, there is an argument that discourses such as competitiveness are so broad and multi-faceted they can only be understood in interaction with others. Of key importance are the pragmatic and transient assimilations between seemingly competing discourses in localised contexts. Such assimilations frequently have real material consequences and hence are worthy of research effort. Local enactments are also patterned and conditioned by broader contextual issues. Indeed, social scientists have long sought to understand the complex interplay between human action and the context within which it occurs. The important point is that the context within which strategic decisions are made must be conceptualised as an active part of any analysis. But context is not only *shaping*, it is also *shaped* by action (Pettigrew, 1997). Issues of consideration include the relationship between language and action, the way that human agency relates to structural aspects of society and the way that action is structured in everyday contexts. Such a research agenda would require a multitude of research skills beyond those normally mobilised in the cause of construction competitiveness.

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EVALUATING THE EFFECTIVENESS OF PROJECT DELIVERY METHODS

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ABSTRACT

Project delivery method refers to the owners' approach in organizing the project team that will manage the entire design and construction. There are several delivery methods that can be used on construction projects. They can be categorized in three groups: traditional design-bid-build, construction management and design-build. Selecting the appropriate delivery method is a key factor in achieving project objectives and project success. Each project delivery method has its advantages and disadvantages and they deal differently regarding the different owners' objectives. This paper evaluates the effectiveness of project delivery methods in dealing with the different project objectives. Owners' objectives can be categorized into 8 groups including cost, time, scope, quality, owner's organization, funding / cash flow, project characteristics and risk and relationships. Forty construction experts were contacted and filled a questionnaire that evaluates the effectiveness of each method in achieving each of the objectives. Data was then analyzed and summarized to find the effectiveness of each method. A comparison among the different delivery methods is presented in this paper. The results indicate that alternative delivery methods such as design-build and construction management have higher effectiveness in achieving most of the owners' objectives than the traditional design-bid-build method. However, owners should not choose a project delivery method blindly. Each project is unique and the owner's objectives change from project to projects. Thus, owners should evaluate their objectives carefully and then study the effectiveness of each method in achieving their specific objectives before deciding on the most appropriate delivery method. This paper provides the foundation for such decision making process.

Key words: Construction Industry, Delivery Methods, Project Management, UAE

1. INTRODUCTION

Selecting the appropriate project delivery method is a key concern to owners and construction professionals. This choice affects project execution, time, cost, quality and safety which are the main objectives of any construction project. The decision is usually made by the owner based on the unique characteristics of the project, owner's objectives, degree of risk, level of information available or needed at time of construction, level of desired client's involvement, and interaction between design and construction among other factors. The construction industry today faces tremendous challenges due to increased project complexity, tough competition, increased demand on quality and safety, schedule and budget constraints. Construction projects are temporary endeavours undertaken to create unique facilities.

Owners and contractors are faced with the challenge of completing projects on time, within budget and deliver a quality product in a safe way. The term “delivery method” refers to the owner’s approach to organizing the project team that will manage the entire design and construction process (Gould and Joyce, 2003).

There are numerous project delivery methods that owners use on projects. These include Traditional Design-Bid-Build, Design/Build, Construction Management, Construction Management at Risk, etc. Each method has its advantages and disadvantages. The most common method is the traditional delivery method. In the traditional method, the owner contracts with a consultant for the design portion of the project and then separately contracts with a construction professional (contractor) for project execution. One of the major disadvantages of this method is that construction professionals are brought later in the project after the design is complete meaning that the design is not usually reviewed for constructability before it is finished (Gould, 2002). It is also difficult to fast track projects using the traditional delivery method. This arrangement is the longest in terms of design and construction time (Gould, 2002). In addition, this arrangement results in adversarial relationship between owner, designer and contractors which leads to unnecessary claims and delays. The traditional method often positions the constructor against the architect/ engineer/ client, rather than encouraging teamwork toward common targets (Kumaraswamy et al., 2002). One of the alternative delivery methods is Construction Management where the owner contracts with a construction management company to manage the design and construction phases of the project. Another alternative delivery method is the Design-Build (DB), whereby the owner contracts with a single entity to perform both design and construction under one contract (Ling et al., 2004). The new delivery methods offer many advantages to owners such as shorten project duration, reduced cost, and non-adversarial relationships. Thus, owners have to choose a delivery method that enables them to achieve their objectives.

Konchar & Sanvido (1998) compared three project delivery methods in the US in terms of four factors which are unit cost, cost growth, construction speed and schedule growth. Their findings indicated that Design Build was superior to Construction Management at Risk and Design-Bid-Build. Ibbs et al. (2003) compared Design-Build to Design-Bid-Build based on time, cost and productivity. They stated that the timesaving was a definitive advantage of Design-Build while the cost and productivity results were not convincing. Dell’Isola (2002) studied the impact of delivery methods on cost and schedule and compared the advantages and disadvantages of the three delivery methods DBB, DB and CM at Risk. Bai and Hezam (2003) described the advantages and disadvantages of 14 project delivery methods. The factors discussed include contractor early involvement, funding, coordination, design & construction time, price competition, flexibility, single point of responsibility and construction time. Another study (Gransberg et al., 2003) compared the performance of Design-Build and Design-Bid-Build in the US. The study showed that cost growth and time growth are significantly lower for DB than DBB while the cost per square foot was lower but not in all cases. A research by the Construction Industry Institute CII (Anderson, 2003) identified 12 delivery methods and 20 selection factors divided into 3 categories: cost related, schedule related and other factors. The research team also developed a selection model using Excel®. The decision model is based on relative ranking of the different selection factors.

Each project is unique and owners have different objectives. Owners need to decide among many alternative delivery methods using multi objectives. The decision is not a simple one especially with the cognitive bias of decision makers and the tendency to choose the method that they are familiar method. Thus, there is a need for a formal decision making process that allows decision makers to specify their objectives, select the appropriate selection factors and their relative importance, and choose a method based on the effectiveness of that method in achieving the project objectives. This paper presents a comparison among the main delivery methods with regard to their effectiveness in meeting project objectives.

2. RESEARCH METHODOLOGY

The research methodology included two phases. In the first phase, the project delivery methods and the selection factors were identified through an extensive literature review. A questionnaire is then developed. Phase 2 included data collection where 40 questionnaires were completed. On site administration of the questionnaires was used to ensure that accuracy of the data and that the interviewees understand all questions. The data was then analyzed and the effectiveness matrix was developed as an average of all respondents.

The data was collected from 40 projects in the United Arab Emirates including projects in the cities of Abu Dhabi, Dubai and Sharjah. There were 22 public sector and 18 private sector projects. The results indicate that the main delivery method in use is the traditional design-bid-build (60%) especially on public sector projects. The projects included 6 residential, 13 commercial, 6 industrial and 15 infrastructure projects. The contracting parties interviewed were mainly owners (69%) but also included some designers (13%), contractors (13%) and construction management companies (5%). Each respondent was asked to rank the effectiveness of each delivery method in meeting owners' objectives (section factors). These effectiveness values were averaged for all respondents.

3. PROJECT DELIVERY METHODS

Traditional Delivery Methods

Using the traditional delivery method, design-bid-build, the owner has two contracts: one with the designer for project design and bids preparation and a separate contract with a general contractor for the construction phase. During the construction phase the designer and contractor have working relationship. The multiple DBB is used when the owner wishes to divide the project into packages and contracts with a separate designer and general contractor for each package. The multiple prime contractors method is used when the owner contracts with one consultant for the design phase but then awards the construction contracts to multiple general contractors. The advantages of using this method are cost savings and schedule compression, while the disadvantages are coordination and management difficulties.

Management Based Delivery Methods

The management based delivery methods include the construction management method where the owner hires a construction management company to manage the design and construction aspects of the project. In this method, the owner has a separate contract with the construction manager, designer, and general contractor. Construction management contracts are particularly attractive to organizations that periodically build complex structures but do not desire to maintain a full-time construction staff (Halpin and Woodhead, 1998). The agency construction management method is used when the owner desires division of the project into packages so the owner will have a contract with the construction manager, the designer, and multiple trade contracts with separate contractors. The Construction Manager at Risk method is used when the owner hires a construction management company to provide both construction management services and general construction of the project. In this case, the owner transfers much of the risk to the CM company. The Engineering-Procurement and Construction Management method is a hybrid of the design-build and the construction management approach. In this case, the owner hires an EP-CM company for the design and procurement of materials and then assist the owner in managing the construction project. This approach has the advantage that the owner retains the contractual relationships with the contractors while passing the responsibility for managing and coordinating to the EPCM contractor (Hartman, 2003). The Program Management method is used to manage multiple related projects. The owner hires a program manager to manage the separate contracts.

Design – Build Delivery Methods

The Design-Build delivery method is used when the owner contracts with one company to design and construct the project. The Multiple Design-Build method is used when the owner has separate contracts with several design-build contractors. The Build-Operate-Transfer (BOT) method is similar to the design-build but with financing option. It is used when the owner wants the facility but can not afford to own it (Hartman, 2003). The Bridging method is used when the owner hires a consulting company to assist in selecting and monitoring of the design-build contractor.

4. PROJECT DELIVERY METHODS EFFECTIVENESS

The set of selection factors that affect the owners' decision of the most appropriate delivery method were determined through literature review. For this research, twenty-one selection factors are identified and grouped into 8 categories. The effectiveness of each delivery method in dealing with the different project objectives (selection factors) was calculated as an average from all respondents. The effectiveness values are presented in Table 1.

Table 1. Delivery Methods Effectiveness Values

Owners' Objectives (Selection Factors)		1	2	3	4
		Design -Bid-Build	Construction Management	CM at Risk	Design Build DB
1	Ensures Shortest Time	0	80	90	93
2	Stay On Schedule	30	83	88	96

3	Ensures Lowest Cost	89	82	77	80
4	Stay Within Budget	51	88	80	85
5	No Defined Scope	100	93	72	5
6	Handles Changes	2	31	58	95
7	Provides Flexibility	98	75	33	4
8	Attains Highest Quality	20	80	83	97
9	No Experience	48	98	89	89
10	Construction Input	0	99	95	73
11	More Owner's Control	89	75	72	10
12	Single Project Contract	22	17	21	99
13	Single Const. Contract	100	100	100	92
14	Delays Expenditure	89	90	78	5
15	Early Estimating	0	76	83	96
16	Allows Financing	0	0	0	0
17	Essential Projects	10	80	93	99
18	Complex Projects	27	74	89	99
19	Un-familiar Projects	2	62	80	98
20	Reduces Risk	81	78	91	95
21	Minimize Adversarial Relationships	1	77	89	100

Time & Cost Related Factors

Time related factors are extremely important in deciding the appropriate delivery method. This is particularly true in the UAE where competition is increasing and owners desire that their products completed in a short time. The first factor is ensuring that the construction project is completed with the shortest possible time. The second factor is completing the construction project on schedule but not necessarily the shortest time. Cost related factors are always at the center of decision making. These factors include ensuring that the construction project is completed with the lowest possible time. The second factor is completing the construction project within budget but not necessarily the cheapest. Figure 1 presents the comparison of the effectiveness of each delivery method with regard to time and cost related factors.

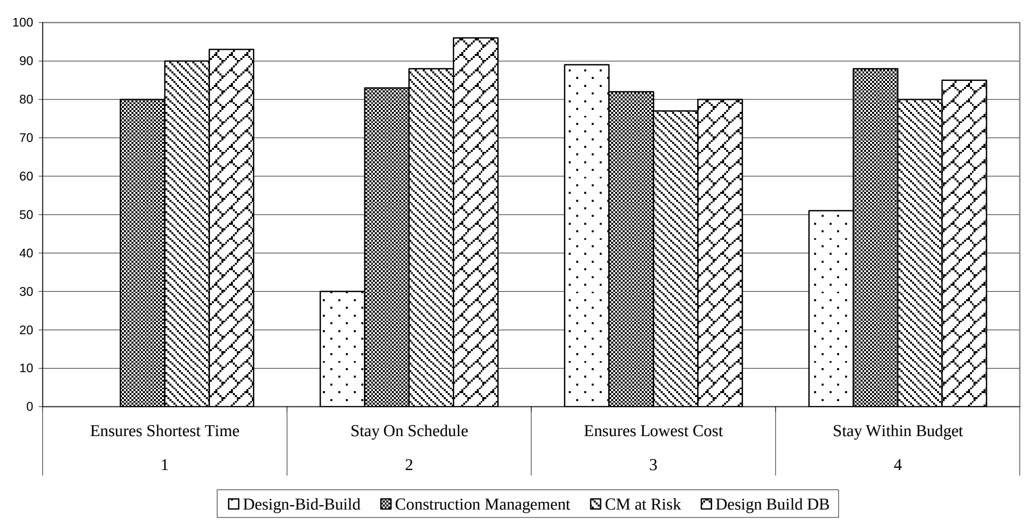

Figure 1. Time & Cost Related Factors

Scope, Changes & Quality Related Factors

Scope related factors include the level of scope definition at the time of contract award. Each delivery method requires a different level of scope definition to achieve the desired results. The level and number of changes expected during project execution is another factor affecting the choice of delivery method. The third factor is the flexibility to make changes. Many owners desire that the delivery method should be flexible enough to allow them to make changes as needed. Quality related factors include one factor to measure the project delivery method's ability to attain the highest overall quality. Although a high quality is always desired by owners, each method achieve this objective indifferent ways. The difference, however, is not as big as other factors. Figure 2 presents the comparison of the effectiveness of each delivery method with regard to scope, changes and quality related factors.

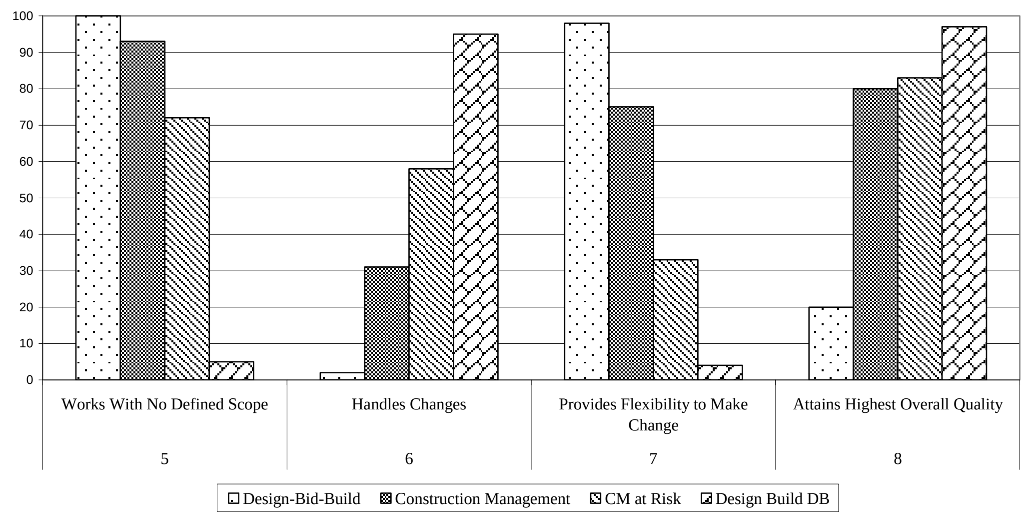

Figure 2. Scope & Quality Related Factors

Owner's Organization Related Factors

Owner organization factors deal with the owner's organization and the level of experience of its staff. These include the level of in-house management experience and the owners' desire for construction professional input during the early phases of the project. Another factor is the owner's desire to be involved in the project and to have control over different aspects of the project. The fourth factor deals with the owners desire for single or separate project contracts. If the owner desires a single project contract, the only delivery methods that support this objective is Design-Build or Build-Operate-Transfer. The last factor is the owners' desire for a single construction contract. Some owners prefer separate construction contracts to benefit from price competition and sometimes faster construction. Figure 3 presents the comparison of the effectiveness of each delivery method with regard to owner's organization related factors.

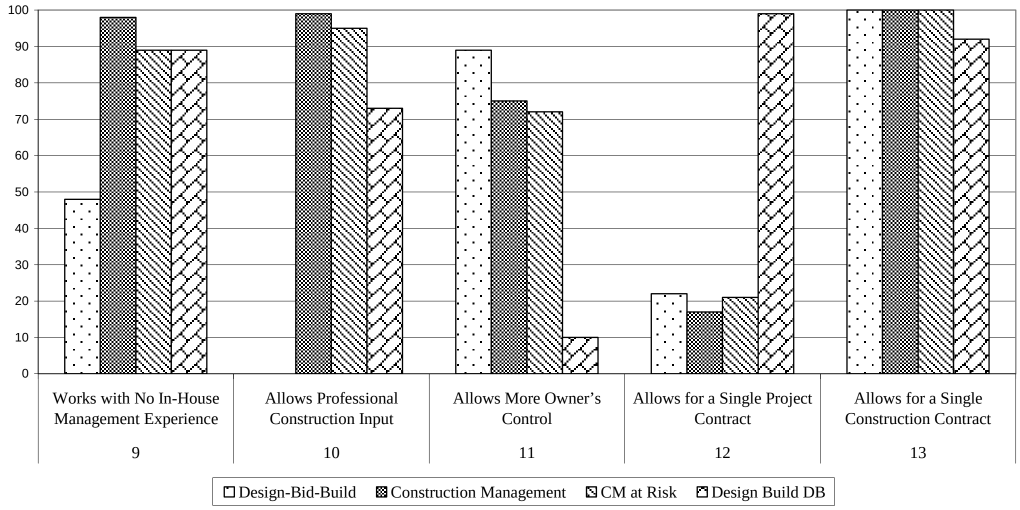

Figure 3. Owner's Organization Related Factors

Cash Flow, Risk and Relationship Related Factors

The next category is funding and cash flow factors. Some owners do not wish to commit the construction cost of the project in the early phases. Design-Build methods require that early commitment. Phased construction delivery methods allows the owner to spread that commitment. The second factor involves the owners' desire for early estimating which is important for budgeting and financial planning. The methods that allow early estimating are the ones that involve construction professional input during the early phases. The third factor relates to the need for financing. If the owner desires financing, the Build-Operate-Transfer method provides that option. Other methods of financing are also available but were not studied in this research. The risk and relationships factors include the amount of risk the owner is willing to take and the owners' desire to minimize adversarial relationships. Almost all respondents agreed that the traditional method is not effective in minimizing adversarial relationships. Figure 4 presents the comparison of the effectiveness of each delivery method with regard to these factors.

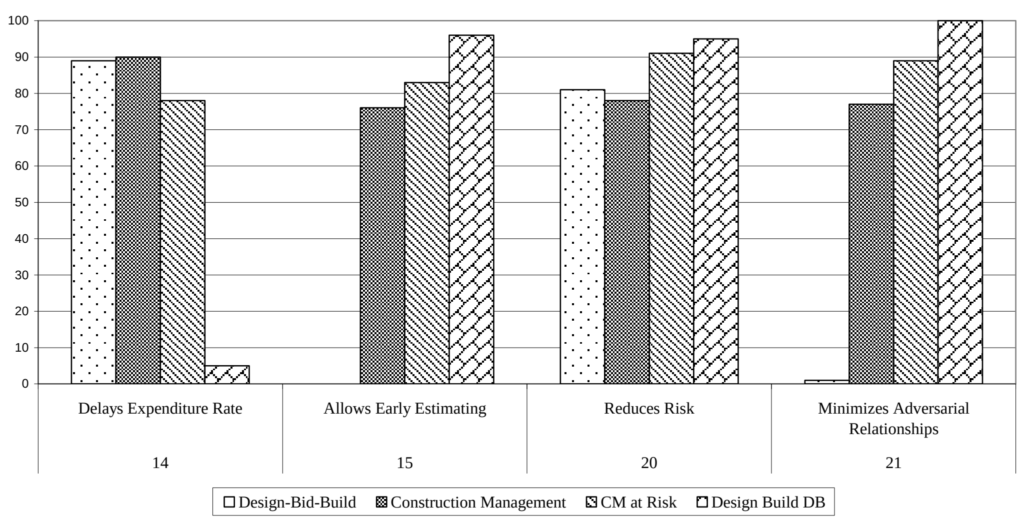

Figure 4. Cash flow, Risk and Relationships Factors

Project Characteristics Related Factors

Project characteristics factors relate to the importance of the project to achieving organizational objectives, the project complexity and the familiarity of the owners' staff with the type of project. Management based and design-build methods are more suited to handle important, complex and unfamiliar projects. Figure 5 presents the comparison of the effectiveness of each delivery method with regard to these factors.

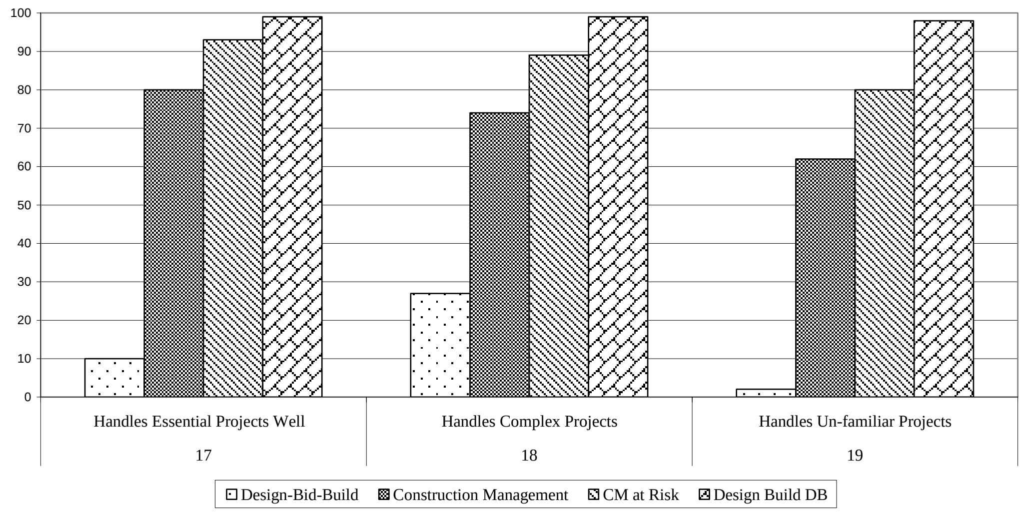

Figure 5. Project Characteristics Factors

5. CONCLUSIONS

The study results indicate that Design-Build methods are more effective in meeting most project objectives followed by construction management at risk, construction management and lastly the traditional design-bid-build. Design-build is relatively more effective in ensuring the shortest project duration than Construction Management methods. The traditional delivery methods are not effective in ensuring the shortest duration. Construction management method is the most effective in ensuring staying within budget. The results also show that the Design-Bid-Build methods provide the greatest flexibility to incorporate changes during the design and construction of the project. However, this may come at a higher cost. Design-Build is better suited to handle changes and ensuring the highest quality.

The organizations with limited experience required a delivery method that included a construction professional to be present at the early phases. Design-Build methods do not allow a high level of involvement by the owner. Using Alternative delivery methods and minimizing the number of contracting parties help minimizing adversarial relationships. With regards to project characteristics, design-build method is more effective than construction management at risk, construction management and design-bid-build (in that order) in handling essential, complex and unfamiliar projects.

Selecting the appropriate project delivery method is a key decision that has to be made in the early phases of the project. There are many delivery methods that can be used on any project. The decision is usually based on certain factors of importance to the owner. Owners are usually tempted to use the delivery method that they are familiar with. However, this might be a great mistake since familiar methods are not necessarily effective in all situations. The effectiveness of the delivery methods vary according to the factors. Owners must rank their objectives and choose the method that maximizes the effectiveness in achieving the project objectives.

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RISK ALLOCATION IN OIL EXPLORATION CONTRACTS IN NIGERIA

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ABSTRACT

Oil exploration contracts are generally affected by several risks which often hamper the development of economic and sustainable projects in the oil and gas sector of the economy. This paper examines the risk allocation between parties in oil exploration contracts. A questionnaire survey based on 23 identified risk factors and criteria for the distribution of these identified risks were administered to a population of 60 senior management staff of four multinational oil companies and government-owned oil company, out of which 48 responses were collected representing 80% of the population. The data collected were analysed using descriptive statistics. The results show that some of the leading risk factors are low crude oil reserves, low crude oil yield, price fluctuation, project delays, unsuitable government policies and civil unrest. Eleven of the identified risks are allocated to the government-owned oil company, 4 are allocated to the multinational companies, 6 are shared by both parties and 2 are not allocated to either the government-owned oil company or multinational company. Six identified factors are used for the distribution of the risks. The study suggests that similar studies could be conducted in other oil producing countries since risks vary with culture, social, political and economic environment.

Keywords: Multinational companies, Nigeria, Oil exploration contract, Risk allocation, Risk transfer.

1. INTRODUCTION

Nigeria's oil sector accounts for more than 90 percent of the country's export, 80 percent of public revenues, and 25 percent of GDP (Imran, 1993). Oil prices and revenues are uncertain and subject to large and frequent fluctuations. The Nigerian economy is highly dependent on a number of external variables beyond the control of policy makers and domestic agents. Most important among these variables is the price of oil, which is highly uncertain and determined in fluctuating international markets. The exposure of risks associated with oil is to a large extent incurred either in the form of variable tax revenues from multinational oil companies or through the sales of Nigeria's oil share by the government-owned oil company (Montenegro 1993).While Nigeria as a whole is exposed to external oil risk; such exposure is not evenly shared by government-owned oil company and multinational oil companies. Institutional and contractual arrangements between government-owned oil company and multinational companies determine these relative external exposure shares. The multinational oil companies might have a higher participation in the management of external exposure. This might imply some allocation of ownership to the multinational oil companies via alternative financial and equity arrangements (Hausmann, 1992).

A wide range of risks exist throughout the life cycle of oil project contracts. These risks often lead to unstable contracts and in many cases to failure of development projects. Sometimes, these projects are economically attractive in aggregate terms but unattractive to one or both parties. The serious implications of these projects in Nigeria are manifested in six areas. These are (1) declining development of marginal oil fields (2) poor reserve planning leading to less exploration activities to boost proven reserves, (3) Poor reservoir management leading to non-optimal depletion of reservoir (4) high production costs (5) cut-backs in production targets and (6) low patronage of local content.

Understanding and monitoring these risks are critical to proper planning in the execution of projects within the planned duration, thereby minimizing the occurrence of cost overrun, ownership and operational disputes. This informs the research into the allocation of risks between parties involved in oil exploration contracts and the criteria for the distribution risks between the parties.

2. RISK AND RISK ALLOCATION

Risk is defined as the possibility of loss, injury, disadvantage or destruction (Simmons, 2003). Risk is an occurrence of an event that has consequences for, or impact on projects (Klein and Ludin, 1997). The influences can be on the schedule, the resources, the scope and the quality. When a risk escalates, it becomes a liability which is a negative event or circumstance that hinders the project.

Upstream oil operation consists of (1) Exploration (seismic surveys and appraisal drilling), (2) Production (Development drilling, treatment and stabilization) and (3) Market comprising of sales. Masten (1998) stressed that one or more risks can arise at any given stage of the operation life cycle. The earlier the stage that a risk arises, the greater will be its impact on a project. As the project proceeds through its life cycle, the level of uncertainty and ambiguity begin to decline, provided the risk is properly managed. For example, at the exploration stage, there is great uncertainty concerning geologic factor, for example, reserves and yield .Eventually, risk associated with development operation and revenue can arise but revenue risk are given dominant consideration.

Razavi (1996) categorized risks associated with oil/ gas operations into two groups. These are: (1) Commercial risks, for example,. cost overruns, delays and shortfalls in project revenue caused by uncertain sales and prices and (2) Political risks, for example, .expropriation or nationalization of assets, civil unrest, foreign exchange inconvertibility and lack of well established legal institutional and regulation systems/policies (particularly in developing countries) which give rooms for government interference that could substantially affect costs and revenue streams

Using the PMI (2000 ed) system, risk allocation is the sharing of the risk burden with other parties. This is usually based on a business discussion when a client realize that the cost of doing a project is too large and needs to spread the economic risk with another firm. A typical example of using risk allocation strategy is in the formation of a joint venture.

Rahman and Kumaraswamy (2005) Opined that a comprehensive risk allocation can not be achieved through contract conditions because all risk items cannot be identified at the planning stage.

3. OIL EXPLORATION CONTRACTS

One of the first decisions that governments must make is to choose the type of contractual system it will use to establish the terms of the development process (Radon, 2005). An apt description of the relationship between the government-owned oil company and multinational oil companies is that of unequal partnership. It is formalized through the three types of joint agreements in the industry namely; the joint venture agreements, the production sharing agreement and the risk sharing contract (Omorogbe, 1991). Government policy on the oil industry is propagated through various legal and contractual arrangements, which guide operations and activities within the industry. (Olisa, 1987and Omorogbe, 1986)These legal relations include (1) The concessions, which require the multi national oil companies to solely bear all risks and costs of exploration and (2) The joint ventures, which are defined in terms of four legal arrangements, namely; the participation agreements, operating agreements, head of agreements and memorandum of understanding. The modern of concession agreement often grants an oil company to explore, develop, sale and export oil or minerals extracted from a specified area for a specific period of time(Radon,2005).In this type of contract companies compete by offering bids and signing bonuses, for the license to such rights.

Under a production sharing agreement, a foreign company or a consortium of companies bears the cost of exploration and risks losing its investment if no oil is discovered (Stephan; 2005).Companies are rewarded for taken this risk by receiving a share of any oil that is discovered and produced.

4. THE RESEARCH SURVEY

A questionnaire survey based on 23 identified risk factors and criteria for the distribution of these identified risks were administered to a population of 60 senior management staffs of four multinational oil companies and the government-owned oil company, out of which 48 responses, were collected representing 80% of the population. The data collected were analysed using descriptive statistics.

5. RESULTS AND DISCUSSION

Table 1: Respondents' Characteristics

Respondents' Characteristics	Frequency	Percentage
Designation		
Director	0	0
Project Manager	9	19
Engineer	36	75
Facility Manager	3	6
Educational Qualification		
HND	3	6
B.Sc/B.Eng.	27	56
M.Sc	18	38
Ph.D	0	0
Years of Experience		
1 – 10	15	31
11 – 20	33	69
21 – 30	0	0
Mean Work Experience 12 Years		

About 75% of the respondents are designated as engineers, about 19% as projects managers and about 6% as facility officers. This is expected because they belong to the senior management cadre and they are involved in the execution of oil exploration contracts.

About 56% of the respondents hold first degree; about 38% hold second degree and about 6% hold Higher National Diploma. This shows a high level of educational qualification of the respondents. This is expected as many of the oil multi-national companies in Nigeria employ people with a minimum of first degree for senior management positions.

The mean work experience of the respondents is about 12 years. This is expected because the respondents are senior management staff and takes a number of years for people from the lower cadres to be promoted to senior management cadre.

Table 2: Response to Questionnaire by Organisation

Oil Companies	Number of Questionnaire distributed	Number of Questionnaire returned
Multinational Oil Company 1	12	9
Multinational Oil Company 2	12	11
Multinational Oil Company 3	12	10
Multinational Oil Company 4	12	9
Government-Owned Oil Company	12	9
Response rate 80%		

A total of 60 questionnaires were distributed to four oil multinational companies and the Government-Owned Oil Company 39 questionnaires were returned by multinational companies and 9 by the Government-Owned Oil Company. The effective response rate is 80%, which is considered very adequate.

Table 3: Criteria for risk allocation

Criteria	frequency	Percentage
Extent to which risk can be influenced/controlled	33	68.8
Party benefiting from opportunities associated with risk	12	25.0
Party's ability to bear damages and insurability	21	43.8
Requirement of party (proficiency, expertise, competence etc.)	24	50.0
Commercial requirements (risk/rewards)	12	25.0
Bargaining power of parties	24	50.0

Table 3 shows six criteria used for the allocation of risks these are (1) the extent to which risk can be influenced\controlled (2) the requirement of the party (3) the bargaining power of parties (4) the parties ability to bear damages and insurability (5) the party benefiting from opportunities associated with the risk and (6) commercial requirement. The extent to which risk can be influenced\ controlled is very crucial in allocating an identified risk to a party. A party with a better ability to control a risk could have the risk allocated to him/her. The requirement of the party may impose restrictions on the use of new technologies in oil exploration.

Table 4: Risk allocation to the Multinational companies and the Government-Owned Oil Company. (GOC)

Risk factor	Percentage allocation			Preferred Risk allocation
	GOC	Multinational	Shared	
Low crude oil reserves	56.3	0	43.7	GOC
Currency devaluation	68.8	0	31.2	GOC
Inflation rate fluctuation	68.8	12.5	18.7	GOC
Sanctions	74.8	12.5	12.7	GOC
Corruption	75.0	0	25.0	GOC
Interest rate fluctuation	81.3	0	18.7	GOC
Change in industry regulations	81.3	0	18.7	GOC
Nationalizations of assets	81.3	12.5	6.2	GOC
Civil unrest	87.5	0	12.5	GOC
Instability of legal system	87.5	12.5	0	GOC
Unstable government policies	93.8	0	6.2	GOC

High credit/finance cost	6.3	62.5	31.2	Multinational
Force majeure	18.8	62.5	31.2	Multinational
Low crude oil yield	18.8	68.8	12.4	Multinational
Health hazard	0	75.0	25.0	Multinational
Differences in technology/infrastructure	37.5	12.5	50.0	Shared
Low quality of crude oil	37.5	6.3	56.2	Shared
Production loss	0	43.8	56.2	Shared
Inadequate distribution of authority	31.3	0	68.7	Shared
Project delays	25.0	0	75.0	Shared
Price fluctuations of crude oil	12.5	6.3	81.2	Shared
High crude oil exploration cost	25.0	37.5	37.5	Not allocated to either party
Inadequate distribution of responsibilities	31.3	25.0	43.7	Not allocated to either party

The results from table 4 show four options used in allocating risks to the parties involved in oil exploration contracts. These options are (1) allocated to Government-Owned Oil Company (2) allocated to the multinational oil company (3) shared between Government-Owned Oil Company and the multinational oil company and (4) not allocated to either party. The principle of risk allocation is based on the majority opinion. If over 50% of the respondents are in favor of allocating a risk factor to Government-Owned Oil Company then the allocation approach of this risk is categorized as “allocated to Government-Owned Oil Company”. A similar principle is applied to “allocated to multinational” and shared between Government-Owned Oil Company and multinationals. If none of the frequencies is over 50%, this risks factor is regarded as “not allocated to either party”.

The results show that eleven risks are allocated to Government-Owned Oil Company. These are (1) unstable government policies (2) instability of legal system (3) civil unrest (4) nationalization of assets (5) change in industry regulations (6) interest rate fluctuation (7) corruption (8) sanctions (9) inflation rate fluctuation (10) currency devaluation (11) low crude oil reserves. The majority of the risks allocated to the Government-Owned Oil Company are those having a bearing with the economic policies of the government.

Four risks are allocated to the multi nationals. These are (1) health hazard (2) low crude oil yield (3) force majeure and (4) high credit\finance cost. The allocation of the health hazard risk to the multinational oil company is expected. Multinational oil companies are required by regulation all over the world to take precautions to prevent environmental pollution which poses a lot of health hazards to the communities in which they operate. They are also required to provide their workers with safety clothing, boots, and equipment in order to minimize injuries on the occurrence of accidents on oil fields. The allocation of low crude oil yield to the multinational is not out of place because they also benefit from the sale of the crude oil. Force majeure is involved in contracts when events that are beyond the control of parties to a contract occur. This risk ought to have been shared between the parties. The cost of financing is very huge. It is not out of place to allocate this risk to the multinational companies because many of them have a lot of experience in international financing of oil contracts.

The survey results show that six risks are shared between Government-Owned Oil Company and the multinational oil companies. These are (1) price fluctuation of crude oil (2) project delays (3) inadequate distribution of authority (4) production loss (5) low quality of crude oil and (6) differences in technology\infrastructure. The price of crude oil in the international market is normally determined by the interplay of demand and supply forces. The activities of ethnic militia groups in the Niger delta have led to disruptions of production resulting in a shortfall in production. It is left to be seen how the price of crude oil in the world market will be affected by the disruption of production in the Nigerian Niger delta region. There are many factors which could lead to projects delays. Disagreement between the multinational oil companies and their host communities over payment for compensation often occur in the Nigerian oil industry. Another possible reason for project delays could be inadequate consideration of project logistics by the oil companies.

Two risks factors are not allocated to either of the party. These risks are (1) high crude oil exploration cost and (2) inadequate distribution of responsibilities. The high crude oil exploitation cost could be due to lack of an enabling environment to accommodate new technologies in oil exploration. Inadequate distribution of responsibility could arise from the different management styles of the parties.

6. CONCLUSIONS

The results of the survey show that 21 identified risk factors are allocated to the parties involved in oil exploration contracts. Eleven of these risks are allocated to Government-Owned Oil Company. Six of the risks are shared between Government-Owned Oil Company and the multinational oil companies. Four of the risks are allocated to the multinational oil companies. Two of the risks are not allocated to either of the parties. Six criteria are used for the allocation of the identified risks. The parties adopted the principles of risk sharing in the management of risks associated with oil exploration contracts. The size of risks shared could vary with the types of contracts such as joint venture, production sharing and concession agreements. The number of risks identified and the criteria used in the allocation of the risks are in no exhaustive. Further studies could be conducted incorporating more risk factors since risks vary with culture, social, political and economic environment.

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RELATIONSHIP MANAGEMENT IN THE AUSTRALIAN CONSTRUCTION INDUSTRY: A CATALYST FOR CULTURAL CHANGE

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ABSTRACT

Numerous studies have been undertaken in the area of construction procurement methods. Recent evidence shows that the construction industry requires cultural change in order to move away from traditional adversarial relationships into cooperative and collaborative relationships. There is also increasing concern and discussion on alternative procurement methods, drifting away from traditional procurement systems to those which are relationship-based. Relational contracting approaches have become more popular in recent years, and have appeared in common forms such as partnering, alliancing and relationship management contracts. This paper reports on a study of relationship management approaches in two public sector organisations in Queensland, Australia. The paper also presents the findings of a survey undertaken with a private organisation based on a no-dispute alliance contract which identifies the critical factors that influence the success of the alliance project.

Keywords Alliance contracts; Culture; Public sector projects; Relationship Management and Trust.

1. INTRODUCTION

Relationship based approaches are seen as the way forward for the construction industry towards cooperative and collaborative working and true teamwork. Business systems and strategies need to be redefined and move from a short-term project to project culture to a more strategic, long-term perspective (Walker, et al, 2000). The concept of these relationships is centred on the development of greater customer focus. Organisations seek relationships with companies to form a complementary value chain and hence, greater business agility (Walker and Hampson, 2003).

However, such approaches require a culture change and cannot be brought about merely by adopting a different set of conditions of contract. The problem addressed in this research is the implementation of relationship management through a range of Government projects in Queensland, Australia with a focus on client body staff.

Empowerment, regional development and promotion of a sustainable industry are key goals of the Queensland government and relationship management is seen as a mechanism for helping to achieve these goals. The participating organisations have experience of partnering and alliancing and success has been proven on large projects. Unfortunately, performance has been variable and it is recognised that an improved system of implementation is necessary in order to achieve political, industry and project goals. Thus, a need has been identified to examine individual skill sets, contractual obligations, organisational structuring and leadership needed for the successful implementation of relationship management.

The research has been conducted within participating organisations, analysed, rationalised and the results generalised and the team then moved on to produce generic deliverables and "participating organisation specific" deliverables. This paper sets out the work undertaken and the links between the various elements.

The rationale behind this research is that Relationship management approaches in general require a change of mindset, i.e. a culture change; both the client and the Contractor must change; greater integration is required between project delivery strategy, organisation structures and organisation culture; and conditions of contract must facilitate these processes.

2. RESEARCH METHOD

The research methodology used is a grounded, triangulated approach. A grounded theory is one which is discovered, developed and provisionally verified through statistical data collection and analysis of data pertaining to that phenomenon. Therefore, data collection analysis and theory stand in reciprocal relationships with each other. One does not begin with a theory, then prove it, rather one begins with an area of study and what is relevant to that is allowed to emerge (Strauss and Corbin 1990). According to Love (2001) triangulation is an appropriate research approach for extending the scope of theory in Construction Management research. If researchers are to effectively solve the problems that industry faces then they need to adopt a robust research method in order to better understand phenomena that influence organizational and project performance in construction procurement.

This paper presents findings from two recent research studies. It begins by reporting the relationship management approaches in two public sector organisations in Queensland, Australia. It presents the findings of a series of interviews within public sector case studies. Seven case studies were collected from two public sector organisations. A total of 34 interviews were conducted with key project team members who had experiences on partnering, relationship management and/or alliancing. Interviewees included project manager, project director, client's principal, consultant, superintendent, superintendent representative, engineer, foreman and site inspector. The second half of this paper presents the findings of a survey undertaken with an alliance team (public/private organisations) based on a no-dispute alliance contract and a series of interviews within public sector case studies. The response rate for the questionnaire survey was 32 of a total of 50 staff members, representing 64% of the whole alliance team. Eleven one hour interviews were conducted with key members from a variety of positions including Design, Services, Alliance Management, Construction, an external Facilitator and a Project Alliance Board Member.

3. TRUST

Trust is defined as the willingness to rely upon the actions of others, to be dependent upon them and thus be vulnerable to their actions (Wood and McDermott 1999a). Where there is no vulnerability, there is no need for trust. Trust is also perceived as a result of effective collaborative relationships and leading to higher levels of partner/customer satisfaction (Zineldin and Jonsson 2000; Mohamed 2003). Moorman, Deshandè and Zaltman (1993) believe that trust is built up over a series of interpersonal encounters, in which the parties establish reciprocal obligations. Yet, Gambetta (1998) sees trust as a precondition of cooperation because partners need some assurance that the other parties will not defect. Thus, trust is a necessary pre-requisite for relationship management which goes beyond the letter of the conditions of contract.

4. IMPLICATIONS AND NATURE OF TRUST

The implication of high trust is that one would feel confident and psychologically secure. One is more relaxed, less suspicious and defensive towards the organisation that one is entrusted to (Westwood 1993). High trust between parties not only reduces transaction costs, making possible the sharing of sensitive information, permitting joint projects of various kinds, but also provides a basis for expanded moral relations in business (Brenkert 1998).

Trust is said to have a direct effect on work group process and performance, and Dirks' (1999) findings show that better coordination and greater efficiency are found in a high-trust group and hence better performance. Barney and Hansen (1994) believe that a firm characterised by a culture of trustworthy values and beliefs will often behave with a relationship based on a strong trust in exchange.

McAllister (1995) and Das and Teng (1998) refer to trust as the expectation of positive motives (behaviour) of the trustee. Trust also has a social meaning concerning both individual and organisation. Social trust is described by Earle and Cvetkovich (1995) as a bridge from State A (disequilibrium or non-normal) to State B (equilibrium or normal). It constitutes the in-group and out-group theory where people will behave differently in groups, and is culture specific (Earle and Cvetkovich 1995, Fukuyama 1995).

Trust is particularly important when a relationship contains the following elements:

- Entering into any form of contract;
- Exchanging information;
- Uncertainty arising from unforeseeable future contingencies;
- Risk sharing;
- A degree of interdependence between agents;
- The threat of missed opportunities;
- The need to enhance the effectiveness of a relationship which depends upon extensive cooperation at both inter-organisational and intra-organisational levels;
- Developing the business relationship to a higher level;

- Reaching alternative goals by group members;
- Negotiation to avoid confrontation.

Such a set of conditions are likely to exist in partnering, alliancing and relationship management contracts and so providing mechanisms to build trust within the bounds of the conditions of contract are essential transactions costs in this process.

5. TRUST IN THE CONSTRUCTION INDUSTRY

Construction project teams are unique entities, created through a complex integration of factors, with inter-disciplinary players, varying roles, responsibilities, goals and objectives (Goodman and Chinowsky 1996). Collaboration and teamwork are therefore crucial since sharing up-to-date information between participants leads to minimisation of errors, reduction of time delays and breaking the widespread rework cycle. Benefits of collaborative, rather than adversarial, working relationships within construction organisations are well documented (Walker and Hampson 2003).

Successful collaborative relationships rely on relational forms of exchange characterised by high levels of trust. However, the construction industry has a stronger preference for distrust rather than the full benefits of cooperation (Wood and McDermott 1999a). There is a need for culture change to bring about increased cooperation between parties on a long-term basis. With relationship contracting, based on long-term relationship and trust, a win-win situation can be created for both the client and contractor. The development of trust between organisations is seen as a function of the length of the relationship between them (Bresnen and Marshall 2000). The construction industry is one which requires trust due to the high levels of uncertainty in the industry.

Partnering has been criticised as benefiting the clients' side only (Green 1999). Bresnen and Marshall's work (2000) shows that contractors may absorb extra costs in the interest of maintaining good relationships with the client and increasing chances of gaining future work. Yet, one may ask why contractors are still involved if they do not gain; the reason behind this may be the global pressure for change. Partnering has become a pre-qualification requirement in recent years.

However, relationship management benefits not just the clients but also the contractors because of the prospect of future work. Maintaining a good working relationship to sustain a long-term business relationship leads to reduced tendering costs, by means of reduction in transaction costs, which benefits both the client and the contractor.

Various authors have suggested that a relational approach to contractual governance entails long-term social exchange between parties, mutual trust, interpersonal attachment, commitment to specific partners, altruism and cooperative problem solving (MacNeil 1978; Darwin 1994; Darwin et al, 2000). Partnering, Alliancing, Public Private Partnerships (PPPs) and Joint-Ventures are examples of relationship contracting approaches that were introduced to the Australian construction industry in the 1990s (Construction Industry Institute 1991, Construction Industry Board 1997, Construction Clients' Forum 1998).

6. CASE STUDY AND SURVEY FINDINGS

The findings of a series of public sector case studies and survey undertaken with a private organisation based on a no-dispute alliance contract are presented below. Information collection included conducting a questionnaire survey, face-to-face interviews, collection of archival data, and observation of a number of team meetings. Critical factors and challenges that influence the success of the alliance project are also highlighted.

7. PROJECT DELIVERY SYSTEM SELECTION IN THE PUBLIC SECTOR

Like most public sector organisations, open or select methods of tendering are generally called for building and construction projects managed by Australian State public works and highway departments. Both government departments have established methodologies for determining when to use alternative project delivery systems and how to determine which delivery system to use. The highway department is very structured (see QDMR 2005) whereas public works department's approach is based on expertise. The choice of project delivery system relies mainly on a risk assessment, rule of thumb based on staff expertise (see QDPW 2006), and further consideration of the client basis (e.g. different government agencies), risk profile and scale of project. Major projects would normally be carried out with non-traditional contracts, and traditional lump sum contracts for other and minor projects.

8. RELATIONSHIP MANAGEMENT APPROACHES IN HIGHWAY AND PUBLIC WORKS DEPARTMENTS

The highway department has a policy of including the supplementary specification for "Relationship Management" in contracts with a value of $10M or greater and a period of construction of 12 months or more. Some districts adopt a partnering arrangement by agreement after contract award for projects of lesser value and shorter construction periods. The Metropolitan District has a section on Relationship Management in the "Infrastructure Delivery: Metropolitan District Supplementary Specifications".

The specification is intended to establish and maintain good relationships between the parties within the contract. However, it does not replace requirements detailed elsewhere within the contract such as the provision of notices, information exchange and dispute resolution. The specification details work operations including:

- Relationship Management Workshop (held at the beginning of the project with duration of 1.5 days).
- Team and Relationship Skill Building Activities (some are carried out during the workshop, dinners and/or barbeques are also held to stimulate use of informal communication channels).
- Relationship Management Meetings (relationship objectives are rated individually).

Under the current system, relationship management projects are tendered on a lump sum basis and payment for this item is made progressively, on a monthly pro-rata basis.

Projects using standard forms of contract such as AS2124, AS4300, AS4000 or other special forms such as Managing Contractor and Cost Reimbursable Performance Incentive often have an additional degree of complexity and unknowns despite attempts to manage them during the brief and design phases. As the degree of uncertainty and complexity increases, the need for collaboration and good relationships also increases. Adopting a formal relationship management process in the project encourages positive collaboration in the project team and development of good relationships.

Traditional project delivery systems (e.g. traditional lump sum contract, design and construct lump sum contract) often lead to time and cost over-runs upon project completion, as well as creating an adversarial environment for the project team. Knowing relationship elements should be injected into the project documents, both state highway and public works departments are using more relationship-based contracts. The most commonly used relationship-based procurement methods are relationship management, partnering and alliancing; this ordering reflects a progression from somewhat informal procedures to the formalised collaboration adopted in alliance projects.

Both departments see partnering as an add-on to some forms of contract, an additional contract document. It is seen as a business strategy, not a procurement strategy; relationship management is an agreement and obligation which binds the contract, making sure the parties in the project team are working closely together. Alliancing is defined as an alliance with a team of companies, without a fixed price or a maximum price, but a target cost which also includes a protocol on profit margins. A pain/gain arrangement is often involved to ensure all participants have an equitable share with the owner, whether the actual performance is better or worse than the pre-agreed targets (Ross 2003).

There is an increasing use of relationship management procurement methods in both departments' projects. Most projects have been carried out using traditional hard dollar type of contract as a basis, such as AS2124, with relationship management detailed in Supplementary Conditions of Contract. For example, in the state motorway and highway upgrade and duplication projects, the Supplementary Conditions of Contract included a "Relationship Management" section, which detailed relationship management activities in the projects such as the relationship management workshop and monthly relationship management meetings.

9. ALLIANCE CONTRACTS AND TEAMWORK

An alliance contract does focus attention on performance and not on documentation. Team members are encouraged to deal with performance and the process of documenting problems, disputes and errors is put to one side. The alliance also provides an environment within which free and open communication takes place. This is part of the focus on performance and breaks down defensive barriers, which slow down the whole of the process and which force the participants to resort to documentation. An outcome of this open communication and focus on performance is the naturally occurring move to value managing all aspects of the project which takes place continuously throughout the project. Innovation starts to become a natural event and participants are encouraged to look at problems from different angles, in new ways and brainstorm and generate new and innovative solutions. This climate facilitates career and skill development as participants are exposed to problems, issues and solutions that develop their skills. Many of the issues, both positive and negative, which arose whilst working in and managing alliances are very similar to those identified in Matrix organisation (Knight 1967).

10. HOW DOES AN ALLIANCE WORK?

In order to ensure that an alliance will work effectively it is necessary to provide more money up front. There are extra transaction costs within an alliance contract due to the number of meetings which have to take place and the constantly evolving nature of the project. These extra transaction costs are of course very similar to those engendered in the Matrix organisation. In the cases studied there were a number of instances where people were employed to undertake specialist roles in the alliance such as coach, innovation manager and alliance psychologist. These people played a maintenance role in ensuring that the spirit and ideas embodied in the philosophy of the alliance actually took place in practice. Another interesting phenomenon was the severing of authority ties from the parent organisation. Individuals in the alliance from different organisations undertook a new way of working where they were a new team and did not show allegiance specifically to their parent organisation but to the project instead. This was, of course, often a source of contention between the line managers in the parent organisation and the independent bodies in the alliance. Indeed, the alliance team tends to develop a language and social life of its own, it develops its own social infrastructure. By working in close proximity and adopting the same philosophies the participants become very much a new body separate from the parent organisation and this can be quite disconcerting for senior management based back in the parent organisation. The concept of alliance players being type B contractors as opposed to the hard-nosed type A contractor has emerged. However, all participants recognised that the alliance had a finite life and the fact they needed to go back to another home at the end of the project. This is one of the most difficult issues to address and rehabilitating alliance members into the parent organisation is a serious issue. In order for such an approach to work effectively it is necessary to address these issues in the conditions of contract in some way in order to legitimise the transaction costs and the distancing of the parent organisation.

11. PROJECT TEAM PERFORMANCE

There are many issues which arise during an alliance which could impede performance. However, with the relationship management philosophy of open communication and blame free communication these challenges can be faced and dealt with during the duration of the project. These can be summarised as:

- Barriers between design and construction participants which, although having their roots in the professional divisions which are characteristic of the industry, can result in frustration and miscommunication. Initiatives to address this issue are team building workshops, being located in the same offices, and effective dispute resolution procedures which are not multi-levelled.
- The existence of a host of companies and procedures which lead to time consuming work to comply with standardised systems and procedures developed for each project and which result in a steep learning curve for members.
- The decision making process must be effectively stream-lined to make it compatible with the fast paced nature of the project; this is a serious challenge in an alliance project where many companies legitimately wish to have their say and protect their position;
- All parties to the alliance take collective ownership of all risks associated with the project delivery with equitable pain/gain sharing; this underlying commercial alignment goes hand in hand with a "no-blame, best for project" philosophy and all participants must focus on achieving common objectives. If the "common" view is not adopted by all then the alliance philosophy fails.

12. THE FUTURE

Interviewees also discussed future challenges for alliances. Four issues were identified as major concerns:

- Maintaining the momentum of the project and the project team;
- Commitment of parent organisations;
- Assimilation of members back into their own organisation; and
- Flexibility of existing contracts to enable effective alliances.

The final point is crucial. Existing conditions of contract are based upon documentation, procedures and defined roles and relationships and the concepts of open, blame-free communication and effective collaboration do not feature in the contracts. The clauses relating to dispute resolution and claims in existing contracts run counter to the ethos behind these principles and the challenge is to encapsulate the philosophy of relationship management into the wording of future contracts. The examples discussed previously illustrate that wording and actions must be in unison in order to be effective. This underlines the need for an industry-wide culture change in order to make this goal a reality.

13. CONCLUSION AND RECOMMENDATIONS

Relationship management cannot be legislated for by contract. As it concerns managing relationships, roles and procedures need to be explicitly documented, understood and reinforced on a daily basis. This can be contained in a contract but it must be proactively managed and maintained. Financial components in relationship management must be specifically laid out in the contract conditions as it is common to employ alliance coaches, innovation managers and alliance psychologists. These all involve a transaction cost and the purpose of such roles is to maintain the social infrastructure and enhance collaboration in the project team.

Relationship management needs to be measured and referred to in the contract conditions. Incentives for relationship management uptake and maintenance must be included in the contract conditions with both pain and gain consequences for all participants. Clauses in contract documents must be flexibly developed and evolved through experience where the supply chain is included. Ensuring consistency of clauses is vital in relationship management arrangements and the contracts must be seen to be fair to and by all parties.

In conclusion, relationship management cannot be legislated, but its development depends on a solid underpinning in the contract. According to the project participants, the selection process and the project delivery system chosen are more important than the clauses in the contract and setting off on the right foot is vital. Additionally, the contract must be consistent and clearly support the open, frank communication necessary for relationship management.

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DEVELOPING A CONCEPTUAL MODEL FOR INNOVATION DIFFUSION EVALUATION IN ARCHITECTURE AND ENGINEERING DESIGN ORGANISATIONS

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ABSTRACT

For the past decade, innovation in construction has been a topic of interest for many academicians and industry practitioners. In particular, numerous studies have investigated the influential factors which can lead to successful innovation outcomes for organisations striving to excel in their particular industry. However, the majority of existing research models tended to depict the effects of macro-level variables on innovation outcomes yet overlooked the potential mediating role of intra-organisation dynamics, especially of organisational climate. This paper attempts to overcome these deficiencies by building a more robust model that accommodates the numerous variables which encapsulate the collective innovation climate of an architecture and engineering design (AED) firm. The developed conceptual model includes the hierarchical key enablers of innovation diffusion, namely, organisational culture, leadership and team climate. Fostering such innovation enablers should undoubtedly deliver outcomes for AED firms in terms of state-of-the-art technology utilisation, best-practice design solutions and other products of innovation. Moreover, AED firms that proactively implement strategies for accommodating innovation should also experience improvements in business performance. Ultimately, the competitiveness of AED firms in the knowledge economy will depend on their ability to embrace technological and organisational changes while fostering and supporting dispersed teams.

Keywords: Architecture and Engineering Design, Innovation Diffusion, Organisational Culture, Team Climate Inventory

1. INTRODUCTION

To many organisations, innovation is considered to be a *sine qua non* for their business success and proliferation in the current competitive, complex and capricious environment. Evidence can be seen from the rapidly changing industries such as information technology, automobiles, biotechnology, etc. where innovation is a prescription not just for organisations to succeed but to survive in their particular industry. In construction, despite being seen as a mature industry in which changes are developing slowly, innovation is needed to form the backbone of a company's strategy in order to accommodate rapid changes embodied in complex products and processes (Manseau, 2005; Slaughter, 2000). In this vein, the internal dynamics of construction organisations must be such that they are flexible, adaptive, and responsive to change (Steele and Murray, 2004). A great deal of research has attempted to study the key to success of construction innovation by focusing on the macro-level factors that affects innovation. However, there is still a limited number of empirical studies focusing on intra-organisation dynamics which could potentially regulate the effectiveness of innovation. Moreover, despite the fact that architecture and engineering design (AED) is one of the most critical processes in the construction project life cycle, innovation in this specific area has remained largely unexplored. It should also be noted here that, although there are some recently developed models which evaluate the innovation climate of a firm and the resulting business outcomes, such models seem incongruous in construction, especially in the AED context. To overcome these deficiencies, a model for innovation diffusion evaluation is required, particularly for AED organisations.

2. CONCEPTUAL MODEL DEVELOPMENT

Researchers have suggested the importance of various factors that potentially affect innovation in an organisation such as leaders, champions, organisational culture and climate, group processes and resources (King and Anderson, 1990). In construction, many research studies have also postulated the importance of these factors by demonstrating some certain organisational behaviours and characteristics which influence innovation in construction (e.g. Dikmen *et al.*, 2005; Steele and Murray, 2004). These factors were integrated and commonly used for developing instruments for measuring organisational climate for creativity and innovation (e.g. Amabile *et al.*, 1996; Ekvall, 1996; Siegel and Kaemmerer, 1978).

The aforementioned organisational factors are undoubtedly crucial as antecedents to innovation. However, the process of achieving effective innovation diffusion is far more challenging to realistically model and evaluate for AED organisations because of the impact of numerous other complex social-psychological factors. Moreover, it is the dynamics of these factors that constitute certain social process in the organisation which is, in fact, one of the major elements in Rogers's (1983) theory of innovation diffusion. Therefore, to adequately evaluate innovation diffusion, it would be sensible to understand the relational behaviours of these factors in addition to the identification of organisational factors affecting innovation. Based on these premises, a conceptual model has been developed to evaluate innovation diffusion by focusing on the dynamics of social factors within the organisation. Essentially, this conceptual model attempts to understand the relationship between three major social-psychological factors, which generally exist in an organisation and potentially influence the diffusion of innovation, including organisational culture, leadership and team climate. Figure 1 illustrates the proposed model with hypotheses developed for future research.

3. CLIMATE FOR INNOVATION

Over the past 30 years, various definitions of climate have been put forward. Among them, as summarised by Anderson and West (1998), two main approaches have received considerable support – the cognitive schema approach and the shared perceptions approach. The former focuses on *individual perception* of proximal environments (i.e. psychological climate) while the latter emphasises on the *shared perception* regarding organisational practices, policies and procedures (i.e.

organisational climate). In fact, these two approaches are not mutually exclusive. When appropriately operationalised, psychological climate can be aggregated to represent organisational climate, alternatively referred as "collective climate" (Joyce and Slocum, 1984).

According to Figure 1, a collective climate for innovation encompasses the perceptions of three hierarchical levels of organisational climate which are management level, supervisory level and peer level. These three climate levels are represented by the terms organisational culture for innovation, leadership for innovation, and team climate for innovation, respectively.

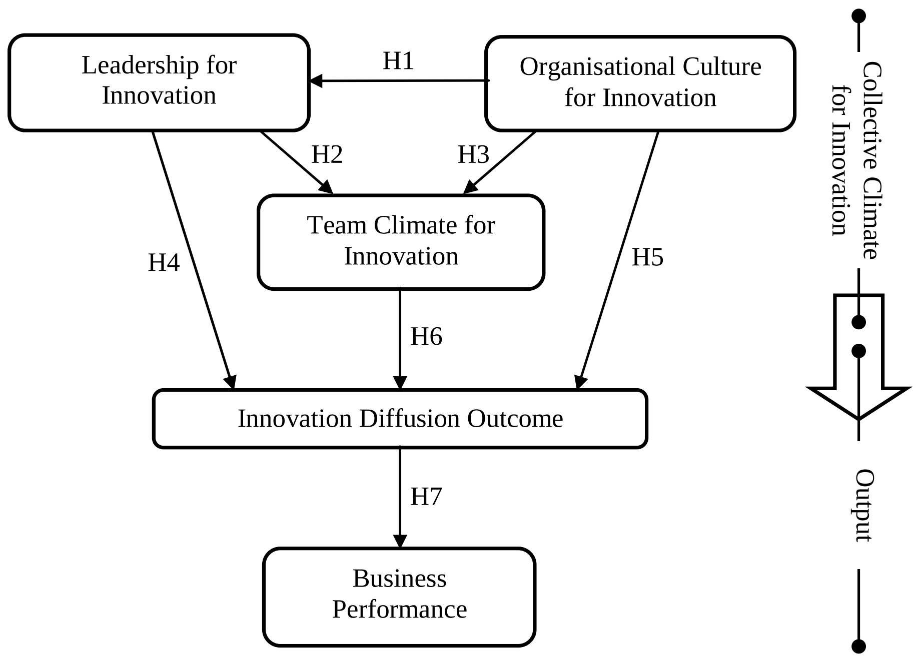

Figure 1 Conceptual model for innovation diffusion evaluation

Organisational Culture for Innovation

Given the fact that consensus is not easily achieved among researchers, it is not unusual that the terms "climate" and "culture" have been used synonymously, and are sometimes overlapped (Patterson *et al.*, 2005). Since both terms are used in this paper, it is important to differentiate between the meanings of them. The term organisational culture is used here to represent a set of perceived norms and routines, resulting mainly from collective management practices manifested in an organisation. Noting that, unlike the climate which is in the foreground of member's perceptions, culture in this regard is more in the background and defined by beliefs and values which form an integral part of the general functioning of the organisation (Burke and Litwin, 1992). Essentially, exploring into an organisational culture can help explain employee's perception of organisational climate (Patterson *et al.*, 2005).

During the past decade, research on innovation has demonstrated a number of cultural factors that lead to creativity and innovation in organisations. Four factors, which are creativity stimulation and encouragement, freedom and autonomy, recognition, and resource allocation, have been commonly addressed in the literature as innovation-conducive cultures. Table 1 describes organisational culture for innovation sub-factors and their associated references.

Table 1 Organisational culture for innovation sub-factors

Sub-factor	Description	References
Creativity stimulation and encouragement	Concerned with the culture that stimulates and encourages creativity in terms of perceived degree of flexibility, risk propensity, and encouragement in the organisation	Amabile *et al.*, 1996; Ekvall, 1996; Siegel and Kaemmerer, 1978
Freedom and autonomy	Concerned with the extent to which an organisation allows members to have choice in how to carry out their work	Amabile *et al.*, 1996; Ekvall, 1996; Patterson *et al.*, 2005
Recognition	Concerned with the extent to which people are recognised for their innovation efforts and achievement	Amabile *et al.*, 1996; Chandler *et al.*, 2000; Scott and Bruce, 1994
Resource allocation	Concerned with the perceived availability of resource in terms of training, manpower, time and money set aside for innovation activities	Chandler *et al.*, 2000; Martins and Terblanche, 2003; Scott and Bruce, 1994

Empirically, perceived innovation culture has been found in many studies to be associated with other elements in the proposed model. Scott and Bruce (1994) in their study of engineers, scientists and technicians employed in a large R&D facility found that perceived organisational support for innovation (characterised by flexibility, creativity encouragement, freedom and recognition) is positively related to innovative behaviour. By adapting Scott and Bruce's measurement, Park *et al.* (2004) and Dulaimi *et al.* (2005), in their recent series of study, found that resource supply influences the championing behaviour of construction project managers, and is a motivator of construction project team members which drive innovation effort in team. Furthermore, they also found a significant relationship between perceived support for innovation and level of innovation in construction projects.

Leadership for Innovation

Leaders and champions are commonly identified as crucial players for the success of innovation in construction projects (Nam and Tatum, 1997). Among many theories of leadership, transformational leadership (Bass and Avolio, 1994), change-oriented leadership (Yukl *et al.*, 2002), innovation championing (Howell and Higgins, 1990), and leader-member exchange (LMX) (Graen and Uhl-Bien, 1995), have been recognised as relevant to innovation and creativity in organisation. By reviewing these theories, it is found that there are compatibility and similarity among the underlying concepts. Therefore, relevant factors from each leadership style have been synthesised into four factors characterising innovation-conducive leaders including encouraging and stimulating innovation, providing and inspiring vision, individualised support, and teamwork development. Table 2 details sub-factors of the leadership for innovation along with their associated references.

Relationships between leadership styles and perceptions of innovation climate have been identified in past empirical studies. Tierney (1999) found a positive link between the quality of LMX relationship and employees' perception of change-conducive climate. Scott and Bruce (1999) also found significant and positive relationships between the quality of LMX relationship and perceived innovation-supportive climate as well as between the quality of LMX relationship and innovative behaviour. In addition, many authors have also suggested that there is an influence of transformational leadership on team climate for innovation (e.g. Dackert *et al.*, 2004; Pirola-Merlo *et al.*, 2002).

Table 2 Leadership for innovation sub-factors

Sub-factor	Description	References
Encouraging and stimulating innovation	Concerned with the degree to which a supervisor inspires, seeks out, promotes and support creative idea and innovative approach in solving problems	Bass and Avolio, 1994; Howell and Higgins, 1990; Yukl *et al.*, 2002
Providing and inspiring vision	Concerned with the extent to which a supervisor creates, communicates and inspires a shared vision	Bass and Avolio, 1994; Podsakoff *et al.*, 1990
Individualised support	Concerned with the quality of supportive relationships between a supervisor and subordinates	Graen and Uhl-Bien, 1995; Tierney, 1999
Teamwork development	Concerned with the degree to which leaders involve team members and share information and resources when making decisions	Bass and Avolio, 1994; Podsakoff *et al.*, 1990; Yukl *et al.*, 2002

Team Climate for Innovation

Since teams have become an important building block in organisations, understanding factors that hinder and foster creativity and innovation in teams is of utmost important (Nijstad and De Dreu, 2002). Teams are particularly important for construction organisations where business survival relies upon the ability to integrate dispersed knowledge, skills and abilities (KSAs) of project team members. Basically, by combining KSAs of individual with different perspectives and backgrounds, teams provide ideal conditions for stimulating creativity and innovation via social and psychological processes (Bain *et al.*, 2001). As a result, focusing on teams and creating necessary condition for them is one mean by which innovation can be fostered in organisations (Mohamed, 2002). Despite this, the study of innovation climate at team level has not received adequate attention. This point has been well taken by Anderson and West (1998) who point out that there has been a paucity of research that addresses the work group or team as a level of analysis distinct from the wider organisation or the individual. They further assert that an appropriate level to analyse the perception of climate is the proximal work group.

To study the innovation climate at team level, this paper adopts the model for team climate for innovation presented by West (1990). The author proposed the “four-factor theory” which basically outlines four essential climates for innovation including vision, participative safety, task orientation, and support for innovation. This theoretical model subsequently led to the development of the instrument for measuring climate for innovation in teams namely “Team Climate Inventory (TCI)” (Anderson and West, 1998). Table 3 describes team climate for innovation sub-factors and their associated references. According to past empirical studies, team climate for innovation was identified as a predictor of innovation outcomes by many authors. For example, in a study among work groups of a U.K. oil company, Burningham and West (1995) found an association between team climate and innovative ideas. Another finding that suggests the important role of team climate is that of Pirola-Merlo *et al.* (2002), they found that team climate mediates the relationship between leadership and performance among the members of R&D teams.

Table 3 Team climate for innovation sub-factors

Sub-factor	Description	References
Vision	Concerned with the establishment of a team's clearly defined and shared vision that provides focus and direction to team members as a motivating force at work	Anderson and West, 1998; West, 1990
Participative safety	Concerned with the degree to which involvement in decision making is motivated and reinforced without fear of criticism among team members	Anderson and West, 1998; West, 1990
Task orientation	Concerned with the degree of shared concern with quality of task performance in relation to shared vision or outcomes among team members	Anderson and West, 1998; West, 1990
Support for innovation	Concerned with the degree of expectation, approval and practical support of attempts among team members to introduce new and improved ways of doing things	Anderson and West, 1998; West, 1990

4. INNOVATION DIFFUSION OUTCOMES

Innovation diffusion is defined by Rogers (1983, p. 34) as "the process by which an innovation is communicated through certain channels over time among the members of a social system". In addition, innovation diffusion involves the process of either adopting or generating the innovation (Gopalakrishnan and Damanpour, 1994). Thus, this paper focuses on evaluating the outcomes of innovation diffusion process in terms of: (1) the utilisation of state-of-the-art technologies (e.g. CAD, VR), and pioneered methods or concepts (e.g. green design, value-based design) that facilitates the design activities and practices; and (2) innovative design products or solutions (e.g. awarded design, flexible design). Table 4 describes the sub-factors of innovation diffusion outcomes and their relevant references.

5. BUSINESS PERFORMANCE

Since innovation is a key to survival to many organisations, effective innovation that contributes to the significant performance improvement of the firm must be ensured. Thus, evaluating the efficacy of innovation should take into account factors that indicate the competitiveness of the organisation relative to innovation efforts. One mean by which the assessment of organisation's competitiveness can be achieved is to look at the business performance, which can be measured in a number of ways. Table 5 presents sub-factors which are used to measure business performance along with their associated references. Generally, it has been anticipated that business performance will be improved with the presence of innovation. This notion has been attested by past empirical studies which identified a relationship between innovation and organisational performance (e.g. Han *et al.*, 1998; Agarwal *et al.*, 2003)

Table 4 Innovation diffusion outcomes sub-factors

Sub-factor	Description	References
Innovation utilisation	Concerned with the degree of utilisation of state-of-the-art technology and pioneered theories or concepts that facilitates the design activities and practices	Kale and Arditi, 2005; Manley and McFallan, 2003; Mohamed, 2002; Tang *et al.*, 2003
Innovative design products	Concerned with the level of innovativeness of the design solutions	Ng and Chow, 2004 ; Tang *et al.*, 2003

Table 5 Business performance measures

Sub-factor	Description	References
Financial performance	Concerned with the level of profitability, turnover growth, and market share	Darroch, 2005; Kale and Arditi, 2003
Business competitiveness	Concerned with the degree of business competitiveness in terms of reputation and ability to gain new contracts	Kale and Arditi, 2003
Client satisfaction	Concerned with the level of client satisfaction	Agarwal *et al.*, 2003
Goal achievement	Concerned with the degree to which the firm's most important goals are being met	Darroch, 2005

6. RESEARCH HYPOTHESES

As illustrated in Figure 1, a number of relationships between model constructs may exist and should be investigated. In total, seven hypotheses, representing the relationships between constructs of the proposed innovation diffusion evaluation model, have been developed:

- H1: Organisational culture for innovation positively influences leadership for innovation
- H2: Leadership for innovation positively influences team climate for innovation
- H3: Organisational culture for innovation positively influences team climate for innovation
- H4: Leadership for innovation positively influences innovation diffusion outcomes
- H5: Organisational culture for innovation positively influences innovation diffusion outcomes
- H6: Team climate for innovation positively influences innovation diffusion outcomes
- H7: Innovation diffusion outcomes positively influence business performance

At present, work is underway to ascertain the validity of the factors and relationships illustrated in the proposed model. A questionnaire is being carefully developed based on the extensive review of existing literature and past empirical studies. The complete questionnaire will be administered in Australia, targeting design team members' of various AED firms. The questionnaire will contain a number of statements reflecting the model constructs and respondents will be requested to rate the performance of individual innovation enabler and outcome variables. Following the questionnaire dissemination and data analysis, a series of case studies with specific AED firms in Australia will be conducted to confirm the validity of the model.

7. SUMMARY

Despite numerous studies addressing construction innovation, academicians and practitioners still lack a comprehensive understanding on how intra-organisational factors can lead to effective innovation diffusion. However, one finding that is consistently supported in the literature is that innovation diffusion must be implemented within a climate that is perceived by employees to be supportive. Furthermore, innovation activities tend to engage complex social-psychological processes in an organisation. Therefore, a robust innovation diffusion evaluation model needs to encapsulate the dynamics between the organisational culture, leadership, and team climate that capture the collective climate for innovation. The proposed model developed in this paper should enable AED organisations to understand, through the eyes of their team members, the dynamics of their existing conditions and desired outcomes. Moreover, the model should expound on the competitiveness of AED organisations by reflecting their abilities to effectively embrace technological and organisational changes. This could guide the organisations to develop prudent strategies for accommodating innovation to achieve short-term goals and, ultimately, to sustain long-term competitiveness.

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SUSTAINABLE URBANISM: IDEALS, IDEAS, AND IMPLEMENTATION IN VAUBAN

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ABSTRACT

This paper describes the guiding urbanism principles and their implementation in the planning and design of a new major development of a sustainable city district that is currently nearing completion: Vauban, a 38-hectare former barracks site near the town center of Freiburg, Germany. The site was purchased by the city in 1994 with the goal to convert it into a flagship environmental and social project. It comprises 2,000 homes to house 5,000 people, as well as business units to provide about 500-600 jobs. The paper presents the main ideas of two important documents that articulated ideals and ideas for Vauban: "Ten Guiding Principles for the Planning and Development of a New City Quarter", authored in 1993 by the former Head of the Building Department of the City of Freiburg and "Ten Theses for Sustainable Urban Development", a publication that articulated results of the 1999 Freiburg UrbanVisions conference. The paper then discusses how the ideas and ideals embodied in both the Principles and Theses for sustainable urban development were made into comprehensive policies, regulations, and initiatives that would lead to the desired results, and describes how the formation of citizens' groups empowered to reify the goals of such a development. The topics include building regulations, building co-operation (participatory models), community building, building programs, green spaces, mobility concepts, traffic infrastructure, and public space. In its conclusion, the paper evaluates Vauban's achievements in terms of the social and environmental sustainability goals articulated in Principles and Theses, and discusses to what extent the new city district can be seen as a viable and real alternative to sub-urbanization of neighborhoods and the loss of the sense of urbanism and citizenship in residential developments.

Keywords Co-communities, environmentalism, sustainable architecture, sustainable housing, sustainable urbanism

1. INTRODUCTION

Context

Freiburg, a university town in the southwest of Germany has a young and motivated population, and with some twenty years of environmentally sensitive policies and practices, it has often been called the European capital of environmentalism. The purchase of Vauban, a former French barrack quarter, which was used from post-WWII to German Reunification, presented the excellent opportunity for the city to build a flagship environmental city quarter with a vibrant social mix. The project was to be completed in three phases between 1998 and 2006.

Freiburg: capital of environmentalism

Freiburg's environmental leadership was apparent already in the mid-80s, when city authorities in co-operation drew up a rational energy plan for the city with regional energy and water companies. By the 90s, two regional schemes were in place for citizens' active participation in sustainable development principles. In 1996, an environmental protection plan to reduce CO2-emission by 25% by year 2010 was put in place by the City Council. To date, Freiburg enjoys a well-developed public transportation system that gives pedestrians and cyclists priority on the roads and where half the journeys in the city are made on bicycles, household waste sorting and recycling and widespread use of solar energy has long been part of daily life in the city. As a positive impact on the city's economy, more than 10,000 jobs are created in the fast-growing environmental sector, based on the combined efforts of businesses, the university and municipal authorities. The city also houses the headquarters of Solarfabrik, one of Germany's largest solar paneling manufacturers, and the Fraunhofer Institute for Applied Research into Solar Energy. A wide-ranging program entitled "Freiburg – Solar City" was exhibited at the Hanover EXPO in 2000.

Figure 1: aerial photograph of Vauban, July 2006, source: authors' own

The Vauban Quarter

Following the fall of the Berlin Wall in August 1992, French troops stationed at Freiburg, Germany vacated the barrack quarter known after WWII as Vauban. In 1994, the city purchased the 38-hectare site from the Federal State, and by 1995, a decision was made to convert this into a flagship environmental and social project. The main aims of the project were to achieve:

- A good mix of housing and workplaces
- Alternative modes of transport – by foot, bicycle or public transportation instead of cars
- Preservation of existing mature trees and the protection of the green area in the environs of an adjacent stream
- Balanced relationship between external and internal spaces
- Low-energy buildings

Three phases were planned for implementation between 1998 and 2006, and comprised 2000 homes for a population of 5000, plus small businesses to provide 500 to 600 jobs within the quarter. (Gauzin-Müller, 2002)

2. TEN GUIDING PRINCIPLES FOR THE PLANNING AND DEVELOPMENT OF A NEW CITY QUARTER

In 1996, the proposal for Vauban was presented as a best German practice on HABITAT II, the United Nations Conference on Human Settlements, in Istanbul, Turkey. Between 1997 and 1999, LIFE, the European Union's financial instrument for the environment, supported the project under the title "Realization of the Sustainable Model District Vauban". (European Union – LIFE, 2005)

In 1999, the Landesentwicklungsgesellschaft (State Development Authority) Baden-Württemberg and the City Planning Department Freiburg published a document on the planning and design of Vauban that included a document with the title "Ten Guiding Principles for the Planning and Development of a New City Quarter". This document, authored by the former Head of the Building Department of the City of Freiburg already in 1993, outlines the vision applied to Vauban. (Jehle, 1999) The following sums up the main ideas of the document:

(1) *A vision of a pluralistic community* – city planning and design as a communal task: a city quarter that is designed and built today should mirror today's social needs and anticipate a desired future. City planning and design should not be limited to urban planners and engineers but embody an interdisciplinary approach so that it becomes a communal task.

(2) *Responsible city planning and design unites* –pluralistic societies demand variety. Responsible city planning and design should avoid the deadening zoning ideology of the past. It should be under the shared responsibility of city authorities and citizens. This approach rejects the currently dominant model in that private developers plan, design, build, market, and sell on a large scale. The approach favors instead a involving of a multitude of architects working with different possible design solutions.

(3) *A thorough mix* –what should be achieved is a mix of working and dwelling, old and young, locals and foreigners, handicapped and non-handicapped. Wherever possible public institutions should bring together the various generations. Social housing should be mixed with privately financed housing. Buildings should be designed in a way that stigmatization of social groups is absent.

(4) *New layouts* – openness for a multitude of uses: farsighted city planning and design should adjust to changing demands and anticipate the future. Single-households, single parents, and traditional families all have different needs and require specific solutions. This requires flexible layouts that allow for a multitude of uses.

(5) *Quality through public safety* – visibility and social control: public safety is a topic that requires increasing attention in city planning and design. Public safety can be achieved at relatively low costs through the careful constellation and design of public, semipublic and private spaces.

(6) *Public space as experience and meeting space* – the design and appearance of public spaces play a crucial role in the creation and cultivation of neighborhoods. A good city quarter should have a farsighted mobility concept. Public transportation in cities should be conceived with tramlines that can serve as backbones for city development. Buses should only take on complementary routes. Urban planning and design should pursue a bicycle-friendly city and experiments with car-free or at least parking-free neighborhoods should be pursued wherever possible. Public spaces, streets and squares should increasingly be regained as experience and meeting spaces. They should be accessible for all citizens, independent of their status and age and be a "designed invitation" for all citizens to meet, discuss, and encounter.

(7) *Clear guidelines for ecologically responsible city planning and design* – city planning and design should be ecologically responsible. Guidelines should apply to mobility concepts that seek environmentally friendly solutions in combination with reasonable restrictions. It also applies to energy concepts through low energy standards, the use of solar energy, resource-conservation such as the collection and use of rainwater, and recycling.

(8) *Creation of public buildings and institutions on manageable small parcels of land* – decentralized concepts of city development need public buildings and institutions. This applies not only to social and cultural institutions but also to the location of public amenities for everyday life that can help to achieve pedestrian-friendly neighborhoods and reduce car traffic. The development of large shopping centers should be avoided, whereas small-scale commercial and retail facilities are desired.

(9) *Flexibility of city planning and design for future developments* – city development should be oriented towards the future. Therefore it has to be able to adapt to future developments and changing social needs of the next decades. A farsighted city planning and design therefore has to include flexibility in the layout of housing, public institutions and allow for future densification.

(10) *City planning and design for and with the citizens* –participatory models should be introduced in an early project phase. This leads to stronger identifications of citizens with new city quarter and as well as to unique individual and personal articulations of neighborhoods. Larger city quarters planning and design should be approached in building phases. This allows a learning-by-doing approach that can take into account the experience of earlier phases.

3. SUBSTANTIATION OF GUIDING PRINCIPLES: TEN THESES FOR SUSTAINABLE URBAN DEVELOPMENT

In 1999, the Deutsche Bundesstiftung Umwelt (German Federal Foundation for the Environment) funded an international conference on sustainable urban development under the title "UrbanVisions". Forum Vauban and ICLEI, the International Council for Local Environmental Initiatives, organized the conference that included over 100 participants from 21 European countries. UrbanVisions was a preparatory event for Urban 21, a global conference on the urban future that took place in Berlin, Germany in 2000.

UrbanVisions culminated in the publication of a document with ten theses for sustainable urban development. (Glatz, 2006) Six years after the articulation of "Ten Guiding Principles for the Planning and Development of a New City Quarter" by the Building Department of the City of Freiburg, UrbanVisions built on the earlier ideas by substantiating these with comprehensive notions of how to integrate sustainable architecture and urbanism with regional economies. UrbanVisions went beyond social ideas to encompass political and economic aspects as well. The following sums up the main ideas of the "Ten Theses for Sustainable Urban Development":

(1) *Promotion of an integrated planning culture* – goals and measures of urban development should be chosen at an early stage by integrating all relevant sectors of the city administration, local politicians, external experts, and citizen representatives or groups. The approach should be on of learning while planning. Measures should be monitored during and after their implementation to ensure the possibility to correct them at a later stage. Structures and procedures of the local administration should be transparent.

(2) *Use of new forms of citizen participation* – citizen participation should be practiced beyond what is required by law with sufficient time and financial resources. Participation should be visible, i.e. results should have a direct impact on the implementation. Existing neighborhood structures can serve as starting points for local participation. Citizens should be empowered and become crucial actors in achieving a sustainable city.

(3) *Implementation of sustainable transport and mobility concepts* – planning should aim at reducing and avoiding traffic by favoring districts of short distances, high density, mix of functions, and poly-centrality. Ecologically sound mobility should be given priority, i.e. public transport, car-sharing, bicycles and pedestrians. Planning should promote districts with less or no cars and reclaim public space.

(4) *Promotion of environmentally sound and healthy building measures* –building measures should save resources and only use healthy and environmentally friendly materials and processes. Planning philosophies should be integrated with regard to good design. The whole life span of buildings should be taken into account. Natural cycles should be respected, the resources soil, water, and air should be used considerately, and biological diversity should be protected.

(5) *Ecologically sound energy supply and minimization of energy consumption* – the energy consumption of buildings should be minimized, e.g. by building passive houses and adding insulation to old buildings. Co-generation and renewable energies should be promoted, especially solar energy for heating, hot water, and power production. That includes the application of modern energy services, like least cost planning, contracting, and demand side management.

(6) *Strengthening of regional economies* – planning should concentrate on regional structures and diminish the instabilities of economy. It should multiply the net product obtained from national trade and increase the scope for a democratic steering of economic development. The regionalization of material streams reduces transport volume and makes environmental impacts visible and appreciable to consumers and

decision makers. The strengthening of the service sector contributes to the dematerialization of economic activities and creates new jobs. The strengthening of regional economies can offer opportunities for regions undergoing structural change.

(7) *Design of socially oriented living spheres* – planning should assure good accessibility to social and cultural facilities, places of education, shopping facilities, attractive public spaces, recreational areas and public transport. It should promote a mix of live and workspaces and assure accessibility for different social groups in the quarter. Spaces within the neighborhood should be for a variety of needs, ranging from privacy to communication and should encourage the residents' identification with their city. There should be a diversity of lifestyles. Flexible uses of living spaces in the various phases of life should be promoted. There should be far reaching participation and shared responsibilities for tenants.

(8) *Mix of requirements with supporting measures* – certain measures of sustainable city planning (ambitious minimum requirements) should be made part of the building requirements or be required in the contracts. The implementation of additional voluntary measures should be promoted through advisory services as well as by financial incentives.

(9) *Cultivation of good contacts and exchange of experiences* – the exchange of experiences between cities, experts, and projects is vital for the spreading of good practices. Regional, national, and international networks are excellent tools for this kind of exchange.

(10) *Courage to leave the beaten track* – existing opportunities for initiative should be used proactively and follow the goals of sustainable development. Unconventional solutions can sometimes make a big difference.

4. IMPLEMENTATION

The ideas and ideals embodied in both the Principles and Theses for the sustainable urban development of Vauban had to be made into comprehensive policies, regulations and initiatives that would lead to the desired results, as well as the formation of citizens' groups empowered to reify the goals of such a development. The following summarizes the implementation tools for the development of the Vauban quarter:

Building regulations – the Freiburg city authorities had been able to achieve their environmental and social aims through planning regulations and conditions for the sale of individual plots. These included increased building density, social and functional mixes, flat roof greening, and rainwater disposal within the building boundaries. The requirements for Vauban further some of these aims, some more stringent than national requirements. In the new quarter, all buildings must meet the low energy house requirements of an annual heating energy consumption 65Wh/m2 or less. (Disch, 2006) Also included in the development are houses designed as Passive Houses that are oriented north to south and unobstructed by adjacent buildings and use less than 15kW/m2 per year of heating. Other houses are powered by a wood-chip powered heating plant, which use a renewable source of energy. (Fabian, 2006)

Building co-operation – a large part of the success of the Vauban development could be attributed to the ground-up community planning process facilitated by the non-profit organization, Forum Vauban (now Stadtteilverein Vauban), founded in 1994 at the inception of the project as a forum to initiate public participation that went far beyond what was legally required. (Fabian, 2006) The *Baugruppen* model (groups of future builders) proved to be crucial for Vauban. The extended citizen participation in Vauban led to a large number of workshops in that participants discussed topics like designing residential streets, green spaces and energy consumption that often led to suggestions, which were presented to the official planners and often became part of the planning and design of the new district. (Glatz, 2006) The Forum is still active and has 200 members and provides a continual public platform for discussions of community needs and issues.

Community building – the implementation of joint building projects and public participation through Forum Vauban helped to forge a mix of residential buildings and workplaces. Community relations were built even before physical building. (Glatz, 2006) In an attempt to determine a heterogeneous community, a model called the "Blockprofil" was developed along categories of resident types in terms of martial status, number of children, occupation, etc, to ensure that the desired diversity was fulfilled. Where Vauban fails to meet the ideals stated in the documents discussed in this paper is goal of a mix of age groups. The large majority of the district's population is between 18-24 and 45-49 years old followed by the 6-9 years and the 10-17 years old. The age group over 60 does almost not exist in Vauban. (Fabian, 2006)

Programs – Vauban houses its population not only in new buildings, but also included the use of some renovated barrack buildings as student housing, an asylum-seekers' center and functions to service the quarter, such as schools, shops and various offices related to the new city quarter.

Green spaces – in anticipation that at the completion of the development, the built-up areas would have taken up about half of the surface area of the ground area, provisions for rain water collection in the form of large 1 meter wide trenches along the streets to ensure that rainwater could be returned to the soil to maintain the natural water table.

Mobility concept – the new city quarter is designed to reduce the need for car-use and to cut overall journey distance. A city bus already runs through the district and in 1998, the city authorities approved the extension of the existing tramline to run the length of the main street in the development, with the plan to enable connection between tram and the rail network in the near future. The compactness of the development reduces the need to use a car between home, workplace, school and amenities, while tram stops are placed not more than 500 m from buildings in the neighborhood. The car parking garages located at the edge of the development support the creation of car-free Vauban – car access is limited and restricted to the main access road. In Vauban car ownership is 35% under that of other city quarters. Less residents own cars but use alternative forms of transportation. (Fabian, 2006), (Sperling, 2003)

Traffic infrastructure and public space – in car-reduced Vauban, the streets are taken over by a multitude of public functions besides being access roads. On the development's main tree-lined thoroughfare that links the quarter to the city, the street is bounded by a 6 m wide footpath-cum-cycle track, which buffers the housing developments and community gardens. There is a speed limit of 30 km/h on the main thoroughfare, while the 4 m-wide side access roads have a limit of 10 km/h and are no-parking zones, aside for set-downs and deliveries. As such, they take on the function of "communication spaces," or "urban courtyards." Furthermore, these linear spaces function as space under which utility networks run and are bordered by rainwater ditches and a 1.5 m-wide planting strip. The main public square of the quarter is surrounded by shops, offices, medical facilities and cafes. Other types of public spaces include the arcade spaces created by lifting apartments above ground floor businesses and retail units and are fronted by a 1.5 m wide pavement and short-term parking area. The north-end of the quarter has streets, which are entirely residential and have a lush quiet ambience.

5. CONCLUSION

The substantiation of ideas from stated ideals to policies and tools for implementation for the Vauban project illustrate in many ways on a micro-scale how sustainable urban development can be implemented. The initial ideas embracing environmental and social ideals have found shape and structure through becoming entrenched in local economies, politics and social infrastructure. Drawing from the impetus found through the viable economics and political and social capital, the notions of sustainable Vauban were fleshed out over less than a decade of building. The project history of Vauban illustrates the complexities of environmental city planning and design. A multitude of new ideas and goals that were articulated in the two documents presented here were realized: the use of new energy concepts through the consequent application of low energy standards for all buildings, innovative ways of dealing with storm water and use of solar energy to name just a few. The ambition to make Vauban not just another example of sustainable building but to address sustainability on a city scale is what makes it a unique project.

It is often said that the proof of the pudding is in the eating, and so we evaluate the Vauban project as it is built against the ideas and ideals embodied in its inception. This analysis also points out possible conflicts that some of these ideals present when implemented as a whole. For the sake of the discussion, these ideals are condensed in the following four thematic areas. The following discussion raises questions of idea versus actual form, and are open-ended as many of these observations may have to be quantitatively verified to be used as actual data:

Community

That Vauban was conceived on the site of former French Army barrack grounds government allowed for an experimental community on grounds which in parts offered almost a tabula rasa condition. Such a condition both afforded innovation, but to some degree, detachment from the surrounding environs of Freiburg. These include the adjacent upper middle-class bedroom communities of Sankt Georgen and Merzhausen, the exclusive retirement community of the Augustinum and a commercial district of Uffhausen. It is also unclear how well the work-live environment expressed in the brief for Vauban has come to fruition. The employment opportunities within the quarter are few, consisting mainly of operators of the small retail outlets, services providers such as cafes, schools, and limited number of small offices. Our field studies show on a typical weekday afternoon at Vauban crowds of women and children. The pluralistic communities mentioned in the ideals translate in the actual quarter to a population that seemed composed of young married couples, middle-class white-collared workers, especially of selected professional fields such as those related to the design industry, college students and those who share the similar progressive mindsets. About 20% of Vauban's current population is under the age of 10. Such a demographic also creates demands for places in nurseries, pre-schools and amenities for children, which might become obsolete once this clustered demographic age-group outgrows these facilities. It is a rare sight in Vauban to see middle-aged to older persons, or those from more diverse racial and occupational backgrounds.

Planning Paradigm

Vauban is planned and implemented along very clear guidelines, based on mixed land-use, a particular model of transport and mobility concept, and sustainable building principles, including use of renewable energy sources. Vauban's main street corridor, Vauban Allee is about 35 meters wide, with a street car track and stations situated in the median. However, if one were to consider the urban scale of the project by analyzing a section through its main street in relation to the buildings on both sides, one would expect such a scale to suggest an urban thoroughfare. However, Vauban's policy of limiting cars in the precinct is in contradiction to such a scale. The main street also leads to a dead end on the West of the site, so that the street would not become a vehicular thoroughfare. Such a policy does keep traffic low, but also leads to a cut-off from surrounding neighborhoods. While the clear guidelines for sustainable building leads to interesting and diverse solutions for the house and apartment forms, it is not clear how the ideal of "growth" could be implemented, as Vauban has clear boundaries. The adjacent communities may add to the conviviality of Vauban's town center, but it remains to be seen if these communities form networks.

Public Space

The most successful public spaces in Vauban are the small-scale residential streets, which are car-free zones, and function as children's play areas. These streets act like extended front porches, and are often meeting places of neighbors, and provide a good sense of public safety. However, as one moves towards the scale of the main street and the arcaded walkways, a real sense of urbanity is lacking in its public space. it also seems as though there is a lack of critical mass of population to make these lively areas. The scale and nature of the public space at Alfred-Döblin-Platz as it now stands, seem too wide, with little opportunity to linger around except for the beer garden on one end of the square. The occasional space of the market square on Paula-Modersohn-Platz, if adjacent to this square, could have shared the synergy of activity.

Participation and Networks

It would be interesting to see how the model of active participation of the community in building the quarter continues as a progressive model to see to the continued growth of the quarter and to a more diversified population. The question is, if and when such a population becomes established in time and place, whether citizen's groups like

Forum Vauban would eventually function like a typical “homeowner’s association” in its narrow interests of protecting property rights. The nature of social networks in Vauban should also be analyzed further – if they extend beyond the boundaries of the quarter, or if they are place-bound communities. As mentioned earlier, the work-live environment and contained space of Vauban, with its “no-through” main street, may result in a contained community of similar interests and family background.

Vauban presents itself as a viable and real alternative to sub-urbanization of neighborhoods and the loss of the sense of urbanism and citizenship in residential developments. Without a preconceived model of architectural typology or urbanism, Vauban is a bold experiment in the planning and design of housing for the future, and bringing back the qualities of the city into neighborhood developments, yet at the same time seeking alternatives such as limiting but not prohibiting car-use by making such a need almost non-existent. Despite the open questions discussed in this paper, the case study of Vauban allows us a glimpse of possible alternatives to urban neighborhood development, which allows flexibility for change, yet not depleting the resources for future generations to come.

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USING TREEMAPS AS A PREDICTIVE INDICATOR OF PROJECT COST OVERRUNS

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ABSTRACT

Treemaps are a method of data visualization that allows complex data sets to be studied without resorting to complex statistical procedures. Treemaps were applied to bidding data to study the relationship betting bidding ratios and cost increases on highway projects constructed in the states of Texas and California. The bidding ratios were used to identify the nature of submitted bids by measuring the spread of the bids, and the existence of outlier bids. The treemaps indicated that projects with high ratio values typically experienced a larger weighted average percentage difference between the low bid and completed project cost than projects with low ratio values when the weighting factor was the magnitude of the project low bid. The treemap analysis also indicated that increasing numbers of bidders also affects the tendency for project costs to increase.

Keywords: bidding, data visualization, highway projects

1. INTRODUCTION

Data visualization is an emerging technology that can allow users to more easily discern relationships in complex data sets. One data visualization technique is treemaps. Treemaps can be extremely useful in the construction industry because development of treemaps and their understanding does not require extensive statistical knowledge. Busy construction contractors may not have the time or knowledge to construct regression models to define relationships between cost data. With treemaps they can more easily visualize relationships between the data. Treemap software is now available with an easily understandable user interface that allows users to visually analyse and to more readily perceive relationships in data.

Treemaps are a method for displaying information about entities with a hierarchical relationship, in compactly in two dimensions (such as a computer monitor). Treemaps display rows of data as groups of squares that can be arranged, sized and coloured to graphically reveal underlying data patterns (Wikipedia, 2006). Treemaps work by dividing the display area into rectangles whose size corresponds to an attribute of the data set. Treemaps combine characteristics of Venn diagrams and pie charts (Bederson et al., 2002). Shniderman (1992) originally developed the concept of the treemap as a method of representing the multiple levels of directories and files contained on a computer hard drive. It was found that information about the location of files on a disk and their size could allow users to find and manipulate files on a hard drive more easily then the textual listings of files given by the MS-DOS operating system at that time.

Treemaps can be used to find relationships in construction cost and bidding data that would not be immediately obvious. This paper will demonstrate how treemaps can be used to visualize the relationship between characteristics of the bids for highway construction projects and the completed project cost. The bidding characteristics are defined by a series of ratios that define the spread and variations of the submitted bids.

Applications of Treemaps in Construction

Several applications of treemaps to construction problems have been reported in the literature. Songer et al. (2004) have applied treemaps as a way of visualizing cost overruns on an $18.8 million dollar construction project. Treemaps were used as a way of visually representing project cost items that were over and under budget. The treemap visualizations were tested against more traditional methods of providing cost data including a printout from a spreadsheet. Users were found to produce more accurate answers when viewing the treemap than the cost spreadsheet. Cable et al. (2004) have discussed how treemaps can be used to analyze performance for a portfolio of projects. Treemaps were constructed for 41 projects grouped by project life cycle phase. Each rectangle in the treemap represented a project, the size of the rectangle represented the projects size and the colour of the rectangles indicated the value of a performance metric. Three performance metrics were a cost index, a schedule index, and a critical index that represented a combination of schedule and cost performance. When index values indicated a problem the project was displayed in shades of red. While projects exceeding performance expectations appeared in shades of green. They concluded that linking earned value management with treemaps to visualize the performance of an entire portfolio has the potential to improve project portfolio management.

Demain and Fruchter (2004) have used treemaps to provide an interface to a knowledge management system. The system functions as a corporate memory repository that provides users with links to knowledge about a company's previous designs. Information about projects, disciplines, and building components are shown as nested rectangles in a treemap. The size of each rectangle denotes the amount of content contained in that project, discipline, or component (number of versions, annotations, linked documents, etc.). The colour of each rectangle denotes that item’s relevance to the current design task based on text analysis. Asahi, Turo and Shneiderman (1994) have developed treemaps as a way of manipulating and visualizing the output of an Analytic Hierarchy Process analysis to determine if a particular site is suitable to build a dam. The treemaps were able to visually represent the hierarchy structure and enabled users to change various design parameters to visually assess their impact on the building decision.

2. BIDDING RATIOS

To quantify the nature of the bids submitted for a construction project several ratios can be calculated. Williams (2005) has described five ratios that describe the nature of the submitted bids. These ratios were developed as a way of representing the relationships between bids for a project that are dimensionless and are not dependent on the project magnitude. The rationale for the use of the bid ratios is that ratios describing the "signature" of the bids for a project can give clues about the projects likelihood to experience cost increases during construction. Potentially, bids that are closely bunched together or contain extreme outliers may give clues about the completed project cost. The ratios include the second lowest bid ratio, the mean bid ratio, the maximum bid ratio and the coefficient of variation of the submitted bids. The formulas used for the calculation of the ratios are given below. A ratio was calculated to compare the second lowest bid with the low bid amount. This ratio determines if the low bidder and next lowest bidder basically agree about the project cost. The ratio is given as:

Second lowest bid ratio = ((Second Lowest Bid)-(Low Bid))/(Low Bid)

Another ratio measures the difference between the low bid and the mean bid. It is given as:

Mean bid ratio = ((Mean Bid)-(Low Bid))/(Low Bid)

The mean bid ratio may indicate the degree of clustering of the bids. If the ratio of the low bid to the mean bid is large, it probably indicates a mistaken bid or a project where there is little agreement about costs. A median bid ratio was also calculated. It is given by:

Median bid ratio = ((Median Bid)-(Low Bid)/(Low Bid)

A ratio is also calculated relating the maximum bid to the low bid. The formula is:

Maximum bid ratio = ((Maximum Bid)-Low Bid))/(Low Bid)

This ratio indicates the spread of the submitted bids, and indicates if there is significant variation in the range of values of the submitted bids. It is also an indication of the existence of an extremely high bid. As a way of measuring the agreement between bidders the coefficient of variation can be calculated. The coefficient of variation is given by:

$$\text{Coefficient of Variation} = s/\bar{x}$$

Where s equals the standard deviation of the bids submitted for a project, and $\bar{x}$ is the mean of the submitted bids. Essentially, the coefficient of variation is a measure of the spread of the submitted bids.

Further research by Williams et al. (2005) has indicated that there is a statistically significant link between the level of the ratios and the completed project cost. Their study was conducted using highway bidding data from Texas. There was found to be statistically significant difference in the value of the bidding ratios between projects completed at a cost near the low bid amount and projects where the completed project cost differed significantly from the low bid amount. Higher values of the ratios are observed for projects completed with significant deviations from the mean. Projects completed near the original low bid amount tend to have lower values of the ratios. It was also noted that the elevated ratio values seem to occur for projects that have large cost increases and for projects that are completed for significantly less than the original bid amount. It was also found that it was difficult to develop accurate models using neural networks and multiple linear regression that could predict actual values of project completed cost. It was also found that due to the noise in the bidding data it was difficult to construct regression or neural network models that could exploit knowledge of the bidding ratios to predict the magnitude of a project's likely cost increase during construction.

3. DEVELOPMENT OF THE TREEMAPS

Williams et al (2005) were unable to produce regression or neural network models that made accurate predictions of project cost overruns. In an effort to exploit the relationship

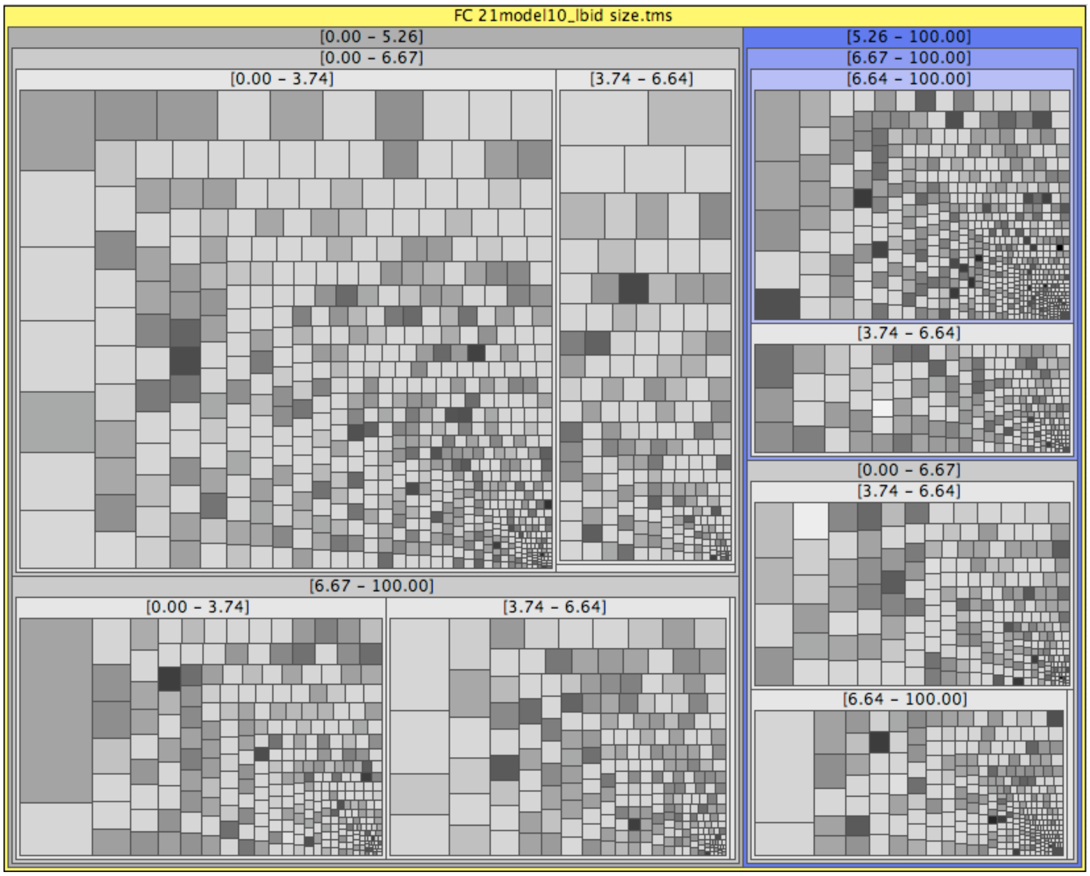

Figure 1. Treemap showing Texas highway project data

they found between the bidding ratios and a tendency towards higher levels of project cost overruns treemaps were studied to determine if they could provide a useful way of analysing the ratio values and providing an indicator of project cost overruns. Treemaps were constructed that separated the Texas projects into rectangles based on the level of the calculated bid ratios. The number of Texas projects included in the treemap analysis is 2763. The projects were constructed between 1995 and 2000. To create the treemaps the Treemap software developed by the University of Maryland Human Computer Interaction Laboratory (http://www.cs.umd.edu/hcil/treemap/) has been used. The program accepts data as text files, which can be easily created using a spreadsheet program. Each column in the spreadsheet corresponds to a data attribute.

A data attribute is selected to define the colour scheme of the treemap. In this case, the percentage deviation between the completed project cost and the original low bid were selected. The level of this attribute determines the colour that will be displayed for each project in the treemap. The user can select any type of colour scheme. The treemaps presented in this paper have been created in different shades of grey. The user interface of the program allows various hierarchies of the input data attributes to be displayed. Data can also be filtered to remove ranges of values of the attributes from the treemap analysis.

Data Included in the Treemap Analysis

Each of the five calculated ratios was included in the treemap input. Because the ratios were very small numbers the ratios were transformed to an index value between zero and 100 to be more understandable to users of the treemap. The transformation is given by the formula:

Ratio Index=((Ratio Value-Minimum Ratio Value)/Range of Ratio Values)*100

The low bid data was included as an attribute to show the size of individual projects. This enabled projects to be scaled by their cost magnitude on the treemaps. Finally, the percentage difference between low bid and completed cost was included. It is the primary data attribute of interest. The hierarchy of the treemaps will be organized in an attempt to separate the characteristics of the projects with little cost change from projects that experience significant cost increases during construction.

4. ANALYSIS OF THE TEXAS DATA USING TREEMAPS

Figure 1 shows the Texas highway data displayed in a treemap. The treemap has separated each project into a hierarchy based on the index values of the coefficient of variation, the second lowest bid ratio, and the maximum bid ratio. The treemap has been set to divide the coefficient of variation index, and the second lowest bid ratio into two bins with equal numbers of projects in each bin. The maximum bid ratio data has been divided into three bins with an equal number of projects in each bin. The rectangle for each individual project is proportional to the low bid amount. The shading of the treemap is set so that projects with a large positive percentage difference between the completed project cost and the original low bid amount are darker in colour. Projects with little increase in cost are lightly coloured. Projects that were completed for less than the original bid amount have the lightest colours. Analysis of Figure 1 shows several

Table 1. Percentage increase in completed project cost for treemap rectangles.

Coefficient of Variation	Second Lowest Bid	Maximum Bid	Number of Projects	Average Percentage Difference	Weighted Average Percentage
Low	Low	High	5	12.14	9.76
High	High	High	599	7.73	8.29

High	Low	Medium	244	6.85	3.62
Low	Low	Low	618	5.73	4.32
Low	High	Medium	246	5.73	4.97
High	High	Medium	227	5.56	6.56
Low	High	Low	299	5.09	5.61
Low	Low	Medium	204	4.99	3.98
Low	High	High	10	4.70	3.59
High	Low	Low	5	2.10	1.83

interesting features of the data. It is clear that larger projects tend to have lower ratio values. Secondly, The treemap rectangle where all three of the ratios are at their highest levels includes more projects with large cost increases. This is shown in the upper right corner of the treemap.

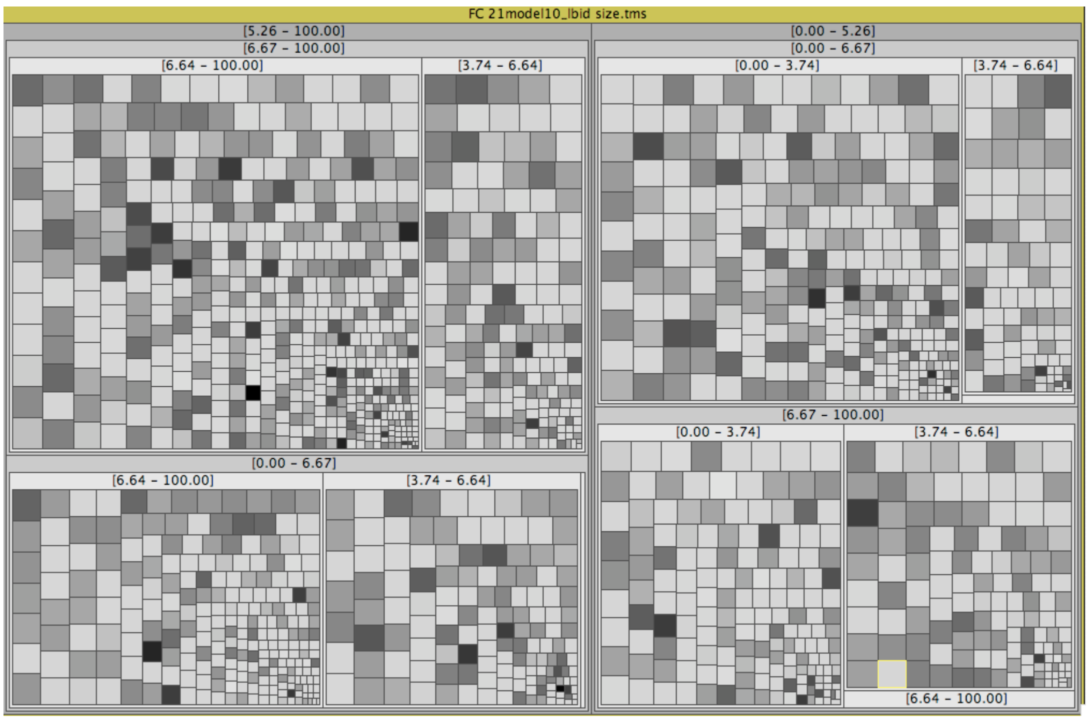

Figure 2. Treemap for small Texas projects

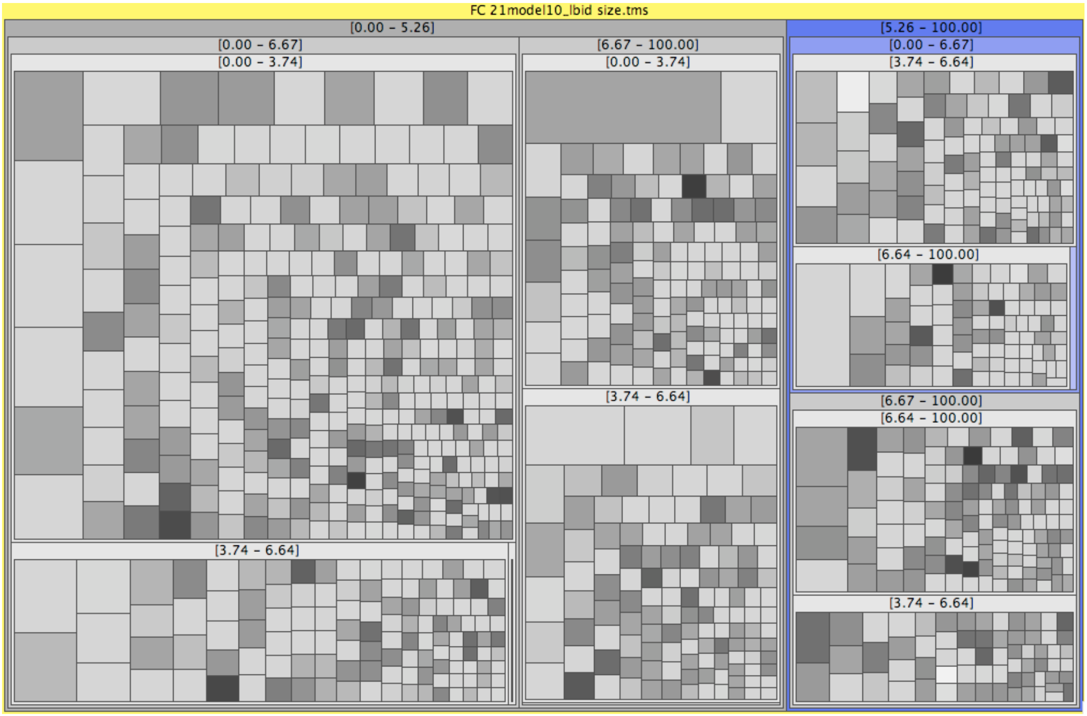

Figure 3. Treemap of large Texas projects.

Table 1 shows a more detailed analysis of the Figure 1 treemap. Table 1 shows the average percentage difference between the completed cost and low bid for the various rectangles in the treemap. The weighted average for each of the rectangles was also calculated. The project was weighted in the average proportionally to the size of the low bid. Therefore, larger projects were given a greater weight in the calculation of the averages.

The table shows that projects where all of the ratio values were calculated to be high simultaneously tended to have larger costs increases during construction. The table indicates that elevated values of the coefficient of variation ratio and the maximum bid ratio tend to indicate that a project will tend to have higher cost increases. There is considerable noise in the data, and this analysis indicates that elevated ratio values should only be used as an indicator of potential cost overruns. The projects that had low values of all of the ratios did not have the lowest average percentage increase, and there are several individual projects with low ratio values that still had large cost increases during construction. Perhaps, this indicates that not all of the factors that cause costs to escalate on a project are embodied in the bidding behaviour observed for a project.

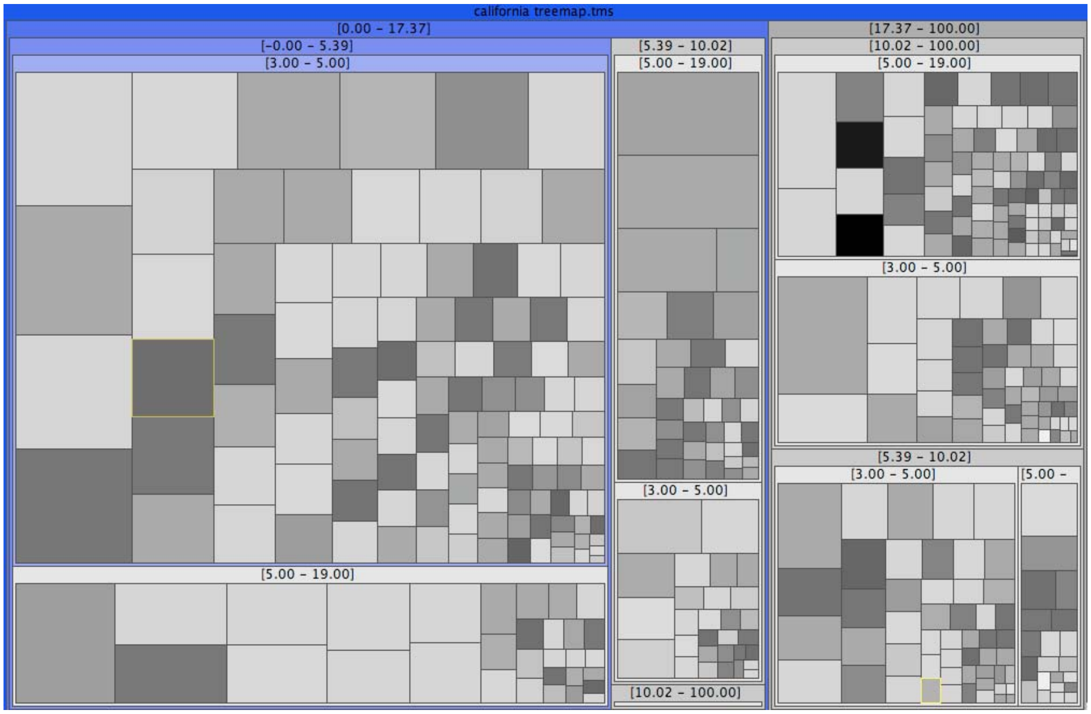

Figure 4. Treemap using California data with number of bidders added

Filtering the Data By Project Size

To further analyse the relationship of project size to the bidding ratios two additional treemaps were created. One treemap included projects from the minimum low bid size observed ($9,497) to $1,274,422. This represented 59% of the data set. The second treemap analysed the large projects in the data set with project low bids from $1,274,422 to the maximum observed bid of $108,160,696.

Figure 2 shows the treemap for the small projects. The small project treemap is similar to the treemap for the total data set shown in Figure 1. The rectangle containing the ratios at

their highest level had the highest average difference between the final project cost and the low bid of 6.19%. The rectangle containing projects that had low levels of the three ratios simultaneously had an average percentage difference between the completed cost and the low bid of 3.07%.

The treemap in Figure 3, the treemap for Texas projects with low bids greater than $1,274,422, illustrates that the relationship between the ratios and the cost increase observed is more complex for larger projects. The large projects show some differing characteristics from the smaller projects. First, it can be observed that a much larger proportion of the large projects have low levels of the all the ratios simultaneously. Secondly, the observed percentage difference between the final cost and the low bid tends to be lower for the larger projects. The average percentage difference for all of the larger projects is 2.08% and for the smaller projects is 3.96%. The rectangle where all of the ratios are at their highest level appears to contain a higher proportion of dark shaded projects than other areas of the map yet the rectangle where all of the ratio values are at their lowest level has a higher observed percentage change (2.67%) than the rectangle where the value of all three ratios is at their highest level (1.55%).

However, the weighted average percentage differences for the instance where all of the ratios are elevated is 8.42% and 4.11% when the ratios are all at low levels. The treemap shown in Figure 3 seems to indicate that larger projects tend to experience less chaotic bidding because more established firms bid on large projects and higher levels of expertise are required to submit bids for a large highway project. The fact that the weighted average of the bids is much larger for projects with elevated values of all three ratios indicates that some relationship between the nature of the bids and the project outcome does exist for larger projects, but it is subtler than for smaller projects.

Table 2. Percentage increase in cost for treemap cells in California treemap

Coefficient of Variation	Maximum Bid	Number of Bids	Number of Projects	Average Percentage Difference	Weighted Average Percentage Difference
High	High	High	107	12.94	21.59
Low	High	High	20	11.43	9.98
Low	High	Low	1	7.50	7.50
Low	Low	High	53	6.80	3.77
High	Low	Low	21	5.49	4.95
Low	Low	Low	139	5.22	4.06
High	High	Low	84	4.66	5.19

5. ADDING THE NUMBER OF BIDDERS TO THE TREEMAP ANALYSIS

Highway project bidding data from California was also analysed Data from 422 projects were studied. This data had the number of bids as inputs to the Treemap program as well as the bid ratio indices. The number of bids was included to study if bidding patterns are different for projects with high levels of competition versus projects with less bidder interest. Figure 4 shows a treemap of the California data that includes the number of bids in the hierarchy. The hierarchy includes the coefficient of variation ration, the maximum bid ratio and the number of bids. Each of the data attributes were divided into two equally sized bins. The groupings for the number of bids were for projects from 3 to 5 bids, and for projects with greater than 5 bids to a maximum of 19 bids. The treemap shows that like the Texas data elevated levels of the ratio values were associated with a larger percentage increase in the completed project cost. It also indicates that the projects with a large number of bidders tended to have a larger percentage difference between the completed cost and the low bid then projects with a small number of bids. Table 2 shows the percentage change between the completed project cost and the low bid associated with each rectangle in the treemap. The table shows that projects with a large number of bidders tended to have greater percentage increases than the projects with a small number of bidders.

6. CONCLUSIONS

Constructing the treemaps for the construction bidding data has illustrated several points. They are:

- Treemaps provide a useful way of analysing patterns in complex data sets. It was possible to analyse the data without the use of complicated statistical methodologies.
- Elevated values of the bidding ratios seem to be an indicator of a projects tendency to experience a large percentage cost increase from the original low bid amount.
- The treemap analysis suggests that a potential method of determining a projects potential to have large cost increases is to calculate the bidding ratios and compare them to historical averages from past projects.
- The number of bidders for a project seems to have an effect on the projects potential for cost increases with projects with larger numbers of bidders tending to have greater cost increases during construction. The data analyzed were from highway projects in the state of California. All of the projects considered were awarded to the low bidder regardless of the number of bidders.

The patterns found in the treemaps suggest that a useful area for additional research is the application of data mining techniques that can produce a set of rules describing the pattern of expected cost increase based on the level of the various ratios and the number of bidders.

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RESOURCE ALLOCATION IN REPETITIVE CONSTRUCTION SCHEDULES USING ANT COLONY OPTIMIZATION

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ABSTRACT

Project scheduling is one of the most important topics in construction management. Many construction projects, such as highway construction, pipelines, tunnels, and high-rise buildings, typically contain activities that are repeated continuously at different locations. Research has shown that many widely used scheduling techniques are not efficient enough in scheduling linear construction projects with repetitive activities. This paper proposes an Ant Colony Optimization (ACO) approach, evolutionary methods based on the foraging behavior of ants, to resource allocation in repetitive construction schedules constrained by the activity precedence and multiple resource limitations. This paper algorithm is used to optimally assign resources to repetitive project activities in order to minimize the overall project duration as well as the number of interruption days. A sample case study is utilized to illustrate the application of the model.

Keywords: Construction scheduling, Recourse Allocation, Ant Colony Optimization

1. INTRODUCTION

Project scheduling is one of the most important topics in construction management. Many scheduling techniques have been developed and are widely used for construction projects. A bar chart is one of the simplest scheduling techniques but it does not clearly show the dependency among activities. The Critical Path Method (CPM) is another popular scheduling technique used in project scheduling. Due to its network presentation capability and ease of use, 93% of the Engineering News Record’s top 400 contractors use it as their main scheduling tool (Tavakoli and Riachi, 1990).

Many construction projects, such as highway construction, pipelines, tunnels, and high-rise buildings, typically contain activities repeated continuously at different locations. Research has shown that CPM lacks efficiency in scheduling linear construction projects with repetitive activities (Rahbar and Rowings, 1992). According to Harris (1996), CPM is unable to provide work continuity for crews or resources to plan the large number of activities necessary to represent a repetitive or linear project, to indicate rate of progress, to accommodate changes in the sequence of work between units, and to accurately reflect actual conditions.

Johnston (1981) introduced the Linear Scheduling Method (LSM) in a highway construction project. A typical Linear Scheduling Method Diagram (Figure 1) is a time-versus-distance or -location diagram. Activities are presented as line segments, blocks, or bars in the diagram. The slope of the segments represents the production rate of the corresponding activities. A LSM diagram, which provides a visual presentation of an activity, can clearly show the scheduled progress status of any activity at any given time, as well as identify conflicts between activities. Few of the previous LSM researchers have studied the impact of project duration with resource limitation constraints. Harmelink (1995) implants the concept of CPM into LSM by defining a controlling activity path, which is similar to a critical path on the CPM method. He established a heuristic algorithm to determine the controlling activities path but with no resource limitation considered. Mattila (1997) proposed a model of a highway construction project with the consideration of resource levelling. The proposed model was solved by mixed integer programming. Liu (1999) proposed another resource allocation model with the consideration of a single resource. He also developed a heuristic solution procedure using the Tabu Search Algorithm.

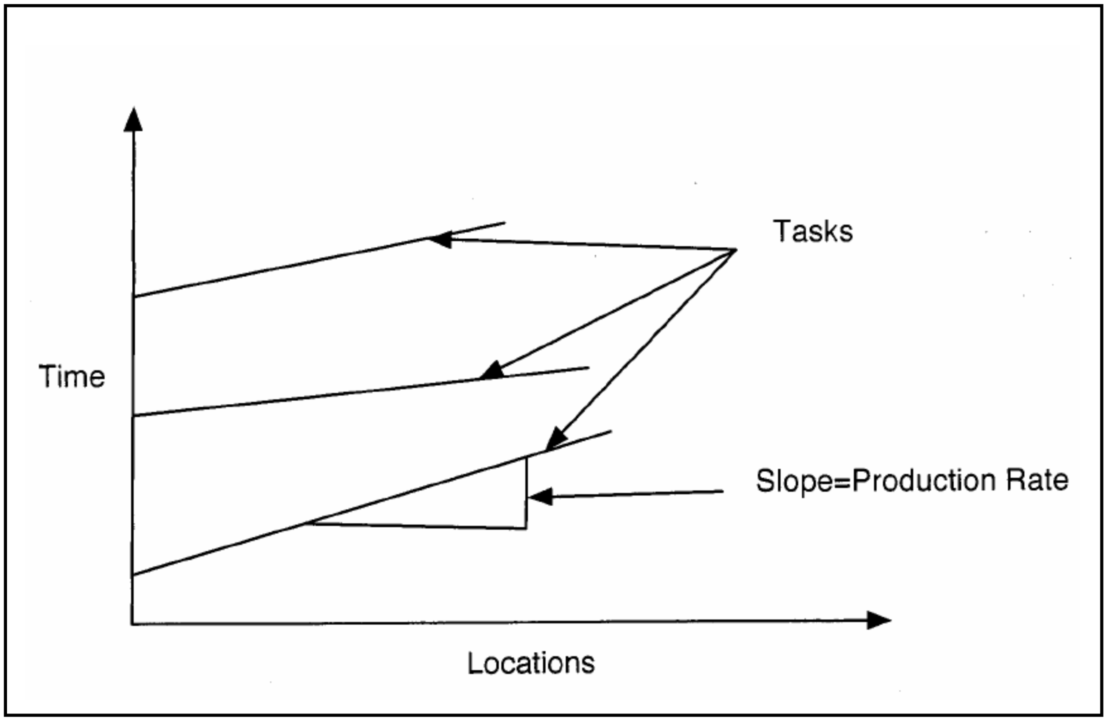

Figure 1: Typical Linear Scheduling Method Diagram

The previous research projects initiated the study of Linear Scheduling with resource constraints. However, in real world practice, resources are usually limited. In many cases there may be more than one critical resource that is limited and may affect the project duration. Therefore, it is important to study project scheduling with the constraints of multiple resource limitations. Optimizing resource usage under multiple resource limitation profiles is the primary consideration, but minimizing the resource usage fluctuation is also important. Levelling the resource usage will minimize the amount of idle resources and, therefore, reduce the total cost.

Resource levelling and resource allocation problems usually can not be formulated as a linear programming problem without adding assumptions to simplify the problem. This type of problem usually requires a great deal of computing time to identify the global optimum (Clough and Sears, 1991; Ahuja, et al., 1994). Therefore, heuristic algorithms are often utilized to efficiently find a reasonable solution for such problems. Several heuristics searching techniques such as Genetic Algorithm (GA), Tabu Search, and

Simulated Annealing have been developed in the past (Liu 1999; Leu & Hwang, 2001; El-Rayes, 2001) and are widely used in finding acceptable solutions for combinatorial problems.

In this paper, the authors propose an Ant Colony Optimization (ACO) approach to resource allocation in repetitive construction schedules constrained by the activity precedency and multiple resource limitations. The ACO approach has recently been applied to scheduling problems, as Job-shop, Flow-Shop, and Single Machine Tradiness problems (Bauer at al, 1999; Den Besten et al., 1999; Colorni et al., 1994; Merkle and Middendorf, 2000, Stutzle, 1998; Vander Zawaan and Marques, 1999). In ACO several generations of artificial ants search for good solutions. Every ant of a generation builds up a solution step by step, going through several probabilistic decisions. In general, ants that found a good solution mark their paths through the decision space by putting some amount of pheromone on the edges of the path. The following ants of the next generation are attracted by the pheromone so that they will search in the solution space near good solutions. In addition to the pheromone values, the ants will usually be guided by some problem-specific heuristic for evaluating the possible decisions.

2. PROBLEM DESCRIPTION

The resource constraint project scheduling problem is normally characterized by objective functions, features of resources, and pre-emptive conditions (Lee and Kim, 1996). Minimizing of project duration is often used as an objective function, while other objectives such as minimization of total project cost and levelling of resource usage are also considered. This paper will assume a construction project containing repetitive activities (N) that are repeated at different locations (M). Different critical resources (I) will affect the project schedule. The problem is to determine the resource assignments of all resources for all activities at all locations. The goal of this problem is to find a best-resource assignment combination and a project schedule to optimize the following two objectives: (1) to minimize the total project duration, and (2) to maintain the fluctuation of resource usage. The resource assignments also need to satisfy the resource limitation constraint, while the project schedule needs to follow the activities precedence relationships. The model will be based on the following assumptions:

a) A resource can not be split
b) A task can not be split
c) Resources are limited
d) The amount of resources assigned to a task at a certain location will remain constant until the activity at that location is finished. However, the amount of resources assigned to a task can vary from location to location.
e) Resources are assumed to maintain a constant productivity level within a certain range of assignments.

Based on the assumptions described above, the formulation of a repetitive project scheduling problem with multiple resource constraints can be presented mathematically as:

Objectives

Minimize:

Max { $f(n,m) \mid = 1..N; m = 1..M$

$$\sum_{t=1}^{T-1}\sum_{i=1}^{I} w_I\left(dp_{t,i}+dm_{t,i}\right)$$

Constraints

1.Activities Precedence Relationships

$$s(n,m+1)\geq f(n,m)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \forall n=1,Nm=1,m$$

$$s(n,m)\geq f(p,m)+L(n,p)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \forall m=1...M,\forall p\in P$$

2.Resource Availability

$$\sum_{m=1}^{M}\sum_{n=1}^{N} r_i\ (n,m,t)\leq RA_i(t)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \forall t=1,T\quad i=1,I$$

3.Activities Completion

$$\sum_{t=1}^{T} r_i(n,m,t)\geq TR_i(n,m)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ \forall n=1,N;m=1,M;i=1,I$$

4.Resource Usage Deviation

$$\sum\sum\left[r_i(n,m,t+1)-r_i(n,m,t)\right]-dp_{t,i}+dm_{t,i}=0\ \ldots\ldots\ldots\ldots \forall t=1,T-1;i=1,I$$

There are two objective functions for this model. The first one is to minimize the project duration. Since the largest finish time among all activities is equal to the project duration, it can achieve the purpose of minimizing the project duration. The second objective function is to minimize the total sum of the absolute resource usage fluctuation, which can be achieved by minimizing the total sum of the absolute resource usage change at any two consecutive days for the entire project time span. Because resources may have different critical levels, a weighting factor w_i is used and multiplied to its respective resource fluctuation.

3. ANT COLONY OPTIMIZATION

The first ACO meta-heuristic (Figure 2), called ant system (Colorni et al., 1991; Dorigo, 1992), was inspired by studies of the behaviour of ants (Deneubourg et al., 1983; Deneubourg and Goss, 1989; Goss et al., 1990). Ants communicate among themselves through pheromones, a substance they deposit on the ground in variable amounts as they move about. It has been observed that the more ants use a particular path, the more pheromone is deposited on that path and the more it becomes attractive to other ants seeking food. If an obstacle is suddenly placed on an established path leading to a food source, ants will initially go right or left in a seemingly random manner, but those choosing the side that is, in fact, shorter will reach the food more quickly and will make the return journey more often. The pheromones on the shorter path will therefore be more strongly reinforced and will eventually become the preferred route for the stream of ants.

The works of Colorni et al. (1991), Dorigo et al. (1991), Dorigo et al. (1996), Dorigo and Gambardella (1997), Dorigo and Di caro (1999) offer detailed information on the workings of the algorithm and the choice of the values of the various parameters.

/* Initialization*/
For each edge (i, j) **do**
  Set an initial value $\tau_{ij}(0) = \tau_0$
End for
Let T_+ be the shortest tour found from beginning and L_+ its length

/* Main loop*/
For t = 1 to $t_{\max}$ **do**
  /*Starting node*/
  For k = 1 to m **do**
    Place ant k on a randomly chosen node
    Store this information in $tabu_k$
  End for

  /* Build a tour for each ant*/
  For k = 1 to m **do**
    Build a tour $T_k(t)$ by applying n-1 times the following steps:
      Choose the next node j with the probability given by the equation (1)
      Store this information in $tabu_k$

    Compute the length $L_k(t)$ of the tour $T_k(t)$ produce by ant k
    If an improved tour is found **then**
      Update T_+ and L_+
    End if
  End for

  /* Update pheromone trails*/
  For each edge (i, j) **do**
    Update pheromone trails according to equation $\tau_{ij}(t+1) = \rho * \tau_{ij}(t) + \sum_{k=1}^{m} \Delta\tau_{ij}^{k}(t)$

    Where $\Delta\tau_{ij}^{k}(t) = \begin{cases} Q / L_k(t) & if\,(i, j) \in T_K(t) \\ 0 & otherwise \end{cases}$
  End for

  Empty all $tabu_k$
End for
Print the shortest T_+ and its length L_+

Figure 2: Ant System (Colorni et al., 1991).

An ACO meta-heuristic was used to treat the complex problem that has been described. The formula is based on the well-known Quadratic Assignment Problem (QAP). Each node will be processed to represent each activity location and will be treated as an empty site in the QAP network. In a single objective QAP network, a matrix D shows the relative importance between each facility (resource) and the empty site. In our optimization problem, each (d_{ij}) represents a set of conditions required to allocate resources for activity j if it is preceded by activity i.

When the ant moves from node I to node j, it will leave a trail analogous to the pheromone on the edge (ij). The trail records information related to the previous use of the edge (ij) and the more intense this use has been, the greater the probability of choosing it once again.

At time t, an ant k at node I chose the nest node j to visit based on the probabilistic rule $p_{ij}^{k}(t)$ as calculated in the following equation:

$$p_{ij}^{k}(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]^{\alpha}.[\eta_{ij}]^{\beta}}{\sum_{l \notin tabu_k} [\tau_{il}(t)]^{\alpha}.[\eta_{ij}]^{\beta}} & if \quad j \notin tabu_k \\ 0 & if \quad j \in tabu_k \end{cases}$$

In this equation, the visibility (η_{ij}), defined as being $1/d_{ij}$, favors the closer nodes. The choice probability is also affected by $\tau_{ij}(t)$, which is the intensity of the pheromone trail on edge (ij). At initialization of the algorithm, the trail on each edge is set at an arbitrary but small positive level, τ_0. Parameters α and β are used to vary the relative importance of the visibility and the trail intensity. To ensure the production of a feasible assignment, nodes that have already been visited on the current assignment are excluded from the choice through the use of a taboo list. Each ant will have its own tab list, $tabu_k$ recording the ordered list of nodes already visited.

At any given time, more than one ant seeks a feasible tour. A cycle is completed when each of the m ants have completed a tour of the n nodes. At the end of each cycle, the pheromone trail intensity will be updated according to the evaluation of solutions found in this cycle.

4. NUMERICAL EXAMPLE AND RESULTS

The numerical example used in this study illustrates the application of the model. The example considers an artificial housing project. Assume the project consists of four activities: foundation, ground-floor walls, ground-floor walls floor slab, and finishing. A total of five housing units will be constructed in this project and all activities are identical for each unit. The following table lists the activity ID, the duration, the precedent relationship with other activities, and the required resources for each activity. The five units are planned to be built in order, from unit 1 to unit 5. Two different labors were assumed to be required in the housing project. The activity priority shows the importance in which it will be used in the resource allocation procedure. Labor 1 supply was limited to eight (units /day), while labor 2 has a limit of nine (units/day).

Table 1: An Artificial Housing Project Example (Durations, Relationships, and Resource requirements)

Activity ID (Description)	Dur. (days)	Predecessor (Lead Time)	Labor 1 (men/day)	Labor 2 (men/da y)	Activity Priority
A/ Foundation	1	--	1	3	1
B/Ground-floor walls	3	A (1)	4	2	2
C/Ground-floor walls	5	B (0)	5	2	3
D/Finishing	3	C (1)	3	4	4

The ACO model was encoded using Matlab. The parameter settings of ACO chosen for the computational experiments (α =1, β =1, ρ = 0.1, τ_0 =0.01, n=10) were taken from other applications in which they have proven to be advantageous (Colorni et al., 1991). The only exception is parameter q_0; it was increased from 0.9 to 0.99 because lower computational time is desired for the application. An alternative solution is obtained from the model created, with project duration of 37 days and is presented in the following table:

Table 2: An Alternative solution obtained from the Ant Colony Optimization Model

Activity	Start	Finish	Duration	L1 assigned	L2 Assigned
A1	0	1	1	2	3
A2	1	2	1	2	3
A3	2	4	2	1	3
A4	4	5	1	2	3
A5	5	7	2	1	3
B1	2	6	4	3	2
B2	6	10	4	3	2
B3	10	14	4	3	2
B4	14	18	4	3	2
B5	18	22	4	3	2
C1	7	12	5	3	2
C2	12	17	5	5	2
C3	17	22	5	5	2
C4	22	27	5	5	2
C5	27	32	5	5	2
D1	22	25	3	3	4
D2	25	28	3	3	4
D3	28	31	3	3	4
D4	31	34	3	3	4
D5	34	37	3	3	4

5. CONCLUSION

An Ant Colony Optimization model has been developed to satisfy practical requirements in repetitive construction schedules to find a best-resource assignment combination and a project schedule to optimize the following two objectives: (1) to minimize the total project duration, and (2) to maintain the fluctuation of resource usage. The ant colony optimization algorithm is very efficient and is able to solve difficult problems, such as the proposed one. The computational requirements are very nominal. An artificial housing project was utilized to illustrate the application of the model. In real-world practice, resources are usually limited and repetitive project scheduling with resource constraints is always encountered in construction management. The ant colony approach can be included in the list of reliable and useful optimization tools for solving such problems.

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7. NOTATIONS

$s(n,m)$: Start time of activity n at location m.

$f(n,m)$: Finish time of activity n at location m.

$dp_{t,i}$: Absolute difference plus value of resource I assignment between day $t+1$ and day t

$dm_{t,i}$: Absolute difference minus value of resource I assignment between day $t+1$ and day t

w_i: Weighting factor for resource i

$r_i(n,m,t)$: Resource i assigned to activity n at location m at time t

$RA_i(t)$: Resource i availability at time t

$TR_i(n,m)$: Total amount of resource i required to complete activity n at location m

A FRAMEWORK FOR SUSTAINABILITY IN COMMERCIAL ARCHITECTURE

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ABSTRACT

The issues of environmental sustainability, fossil fuel use, resource use and waste have only very recently become established commercial Corporate Responsibility. The traditional barriers of capital cost, lack of precedent and perceived need have been replaced by the more urgent drivers of brand management and business risk. Despite the number of initiatives available, environmental analysis of commercial projects in the UK have been limited to site environmental impact assessment required for planning approval and written sustainability statements submitted as supporting information. These documents are rarely referred to once the planning stage has been passed and substitution of materials form routine cost saving measures through the Design and Build procurement route. Moreover, the layered nature of speculative development; where the client is an investor and the tenant is responsible for their fit-out and plant, limits the level of innovation and continuity of thought between all stakeholders. This paper seeks to explain how this breakdown can be avoided, firstly in expectation of new energy performance legislation in the UK in 2006 and more importantly in anticipation of changing client appreciation of their responsibility to the environment and desire to remain competitive within their market.

This emerging client need for more sustainable buildings requires that a design methodology framework is adopted to enhance the end product for all stakeholders whilst avoiding possible criticism of "greenwash". This paper follows the identification of criteria for the framework in relation to existing methodologies, its design development and application to real examples, and integration of the methodology into practice. Using intuitive discursive analysis as the most readily adaptable methodological process with the use of risk identification and mitigation as the management technique for project content. This research upholds the need for a structured and integrated approach for design, development and delivery of commercial facilities, for speculative development, owner occupier and tenant situations. It is of interest to design and construction consultants.

Keywords: Commercial Architecture, Corporate Responsibility, Framework, Risk management, Sustainability.

1. INTRODUCTION

Sustainability has become a major issue only very recently in commercial design and construction. It is being led by transformation of consciousness (Barrett, 2006) within major commercial client organisations such as investors and retailers towards an appreciation of their responsibility towards the environment and wider society. This has occurred alongside an increased dissemination to the public of Corporate Responsibility (CR) through the media and internet.

Changes in UK building regulations and the EU Directive for Energy in Buildings have brought the issue of energy to the fore in commercial speculative development. The traditional landlord and tenant arrangement has allowed the developer to provide a shell that meets thermal performance regulations and the tenant has installed the lighting and HVAC that they require for their business operation. Now it is expected that the shell developer will facilitate micro-generation and less convention heating and cooling methods installed by the tenant. In response, tenants can be expected by landlords to reduce their electrical load in a bid to minimise carbon footprints.

Context

This research has been carried out within and supported by the experience of a UK architectural practice that is part of a larger group of companies providing design, development and contractual services to a wide range of commercial clients. The initial purpose was to develop a framework to tackle the management of sustainability issues for retail fit-out where high levels of lighting and cooling, short life cycles and waste of resources were seen to be major problem (ACE, 2000). However, the demand for the framework more readily transpired in complex urban mixed use commercial schemes that typify a slow and difficult journey through the planning system followed by a fast design development and construction period. These projects were used to refine the content and process of the framework.

The need for a methodology

Observation and experience in this sector of the construction industry has shown that there are a number of distinct crisis points in the procurement of a scheme that hinder sustainable initiatives. Developers believe that there is no demand for buildings that exceed legislative requirements; investors and tenants do not have a sufficiently well developed policy for selection of more sustainable investments or sites, mainly because so very few exist and so the lack of demand is easily perpetuated. The speculative nature of these schemes requires that the capital costs are less than the potential revenue from sale and lettings for the project to be developed to a scheme design. Schemes must have minimal design costs prior to planning applications being made, which limits the consideration that goes into the design before commitments are made to plan, form and structure. Current UK planning requirements require a written design and sustainability statement, which is easy to manipulate without firm commitment. Even when the cost of initiatives have been accepted by the developer as an acceptable planning gain, potential for their abandonment is exacerbated by lack of clear planning conditions. Once planning approval has been achieved, schemes must rapidly proceed through design development and on to a site to maximise revenue. This again limits the improvement or refinement of the design. The construction procurement method is often by Management or Design and Build contract forms which allow the contractor to eliminate insufficiently documented initiatives to make savings. Perception of risk, lack of precedent and insurers exclusions can prevent or hinder new technologies and methods of construction. Commercial schemes are often managed by an investor (or fund), and lack of co-ordination between management and tenants can prevent optimum energy efficiency and resource use being reached. The success of commercial developments is gauged on the rental value of the tenancies, and this is linked to service charges for utilities, maintenance of the public areas, and retail potential.

Architects may have both the interest and knowledge in sustainable design, but without the support of the developer by providing a suitable brief, the investor by creating a market for sustainable investments, the planning authority in taking better control and an enlightened contractor to adopt the philosophy, the vicious circle is perpetuated. It is easy to assume these things will not happen as there is too great a resistance to change in the commercial sector. However, in some cases, the necessary forces come together very quickly and demand a very different approach from the procurement team. This research intended to prepare a framework to support the change when it indeed very rapidly came.

2. DESIGN METHODOLOGY

A conceptual definition was provided for sustainability as the balanced meeting of economic, social and environmental needs using a literature review strategy and tactics of definition though logical argumentation. That is however a very simplistic representation of a more complex representation of responsibility. Three dimensions can be assigned to sustainability. Philosophy relates to the approach to solving problems with technology (technocentric), the actions of people and climate (deterministic) and the biosphere (ecocentric) Figure 1. Profundity (Figure 2), measured by the level of effort made against resistance and falls into four broad categories of passive (minimum effort necessary), active (some effort), proactive (considerable effort) and industry leader (maximum effort) shown in. Futurity (Figure 3) is measured by how consideration extends beyond immediate needs in years.

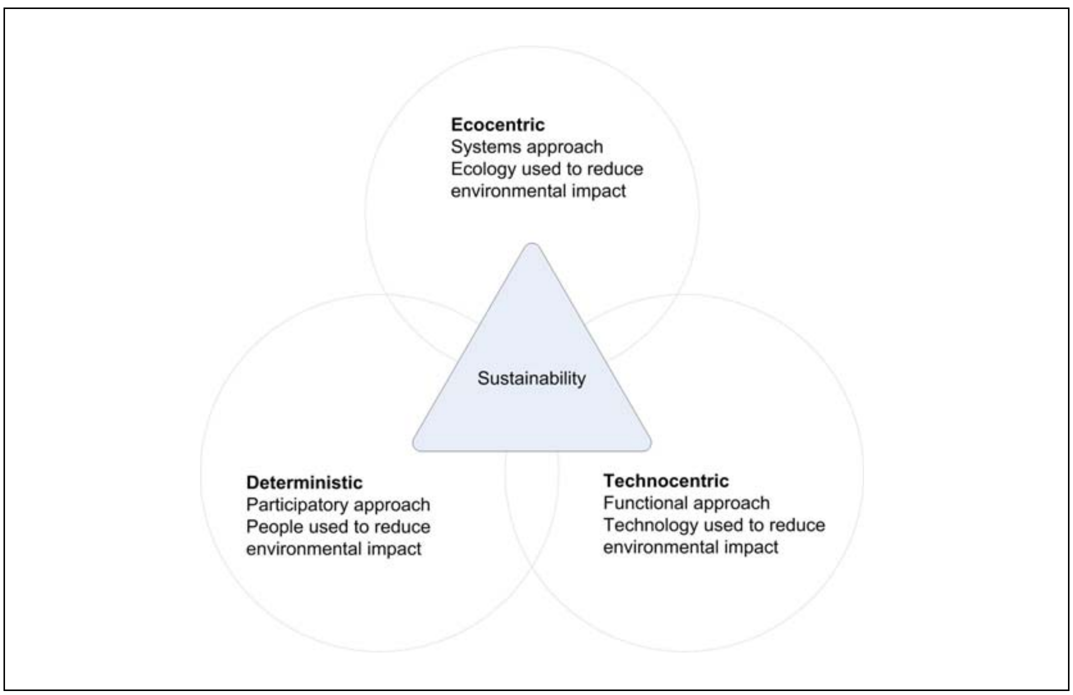

Figure 1 Philosophy

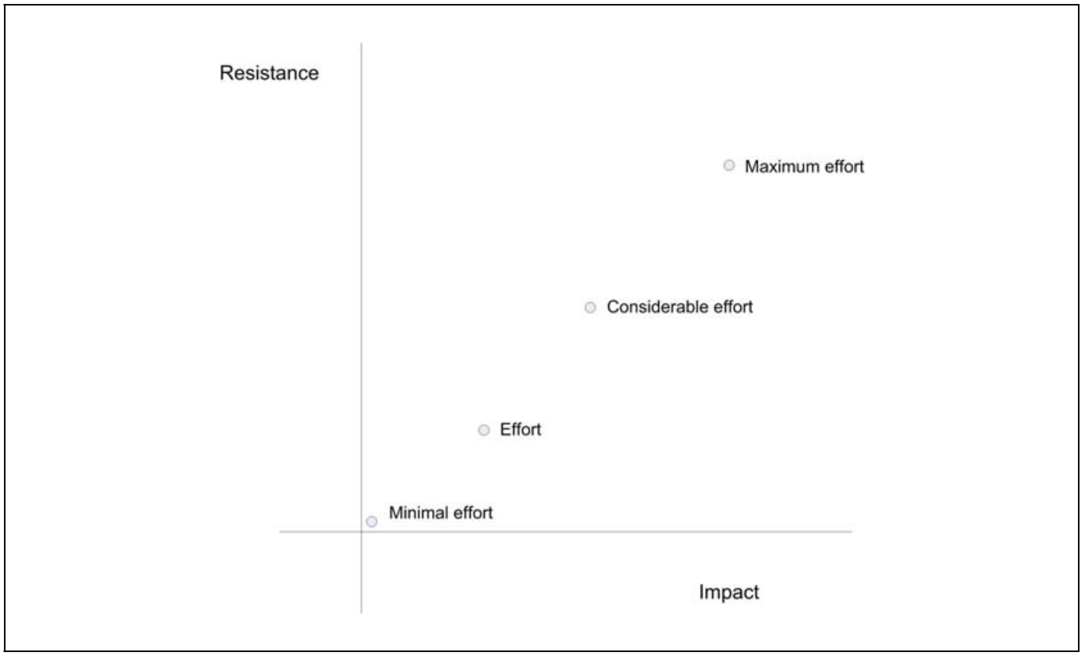

Figure 2 Profundity

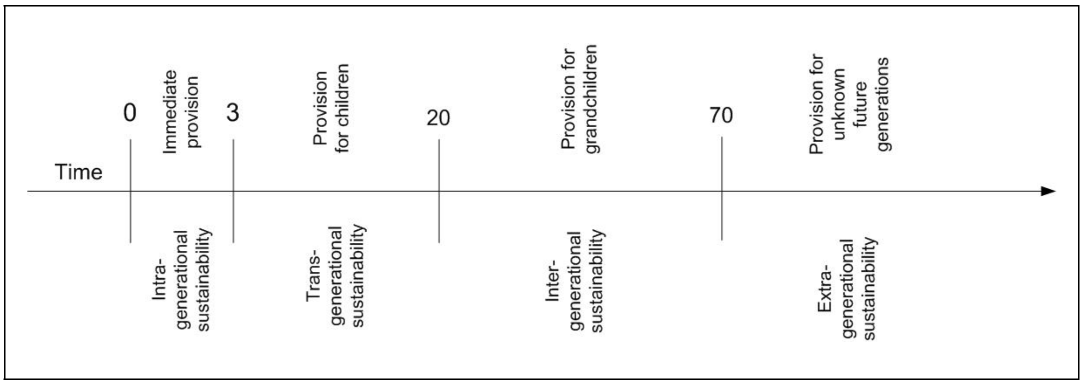

Figure 3 Futurity

Analysis in practice

Survey research in the retail sector had shown that of the methods available for environmental performance analysis, intuitive discursive measures were most commonly applied to design development in the early stages and value engineering in detailed design and tender stages. It could be assumed that this is true in commercial sectors too because they are led by similar constraints of firstly limited time and cost for design and secondly retailers and developers common greater interest in reducing capital cost and limited concern for long term revenue. A number of methods were identified as potentially beneficial in establishing good practice for sustainability in commercial design using simulated data;

Whole life costing was appropriate in very large and complex schemes where maintenance would be carried out by the investor (Lavender, 1990). Cost benefit analysis (Hanley and Spash, 1993) was more appropriate where project design life is less than ten years in retail fit-out and where cleaning and maintenance costs could not be identified either because they were carried out by nationally tendered contract cleaners or by staff members as part of their duties.

Resource reduction calculations, usually referred to in percentages, allow demonstration of reduction in primary utilities such as electricity, water, gas materials and output of waste. These are difficult to manage in a holistic manner in commercial development; each tenant must be responsible for their own resource management. Introduction of the calculation methods required in UK Building regulations Part L (2006) will lead to a better understanding of how resources are used in commercial development, and which are caused by the developers' building fabric or tenant installed plant.

Social Impact Analysis and weighted evaluation is difficult to develop in commercial projects due to the wide and unpredictable nature of stakeholders (Barde and Pearce 1991). It is easier to base design decisions on other impact assessments such as existing retailing in a town and vicinity, or published market research. In very broad terms commercial social benefit can be calculated by dividing the number of people who benefit as customers or visitors to the development against the number of people it employs.

Environmental Impact Assessment of elements and materials was useful if trying to make design decisions based on a specific list of criteria. These might include weighted analysis developed by the BRE (Woolley, 2000; Chem and Shiers, 1998). This is true regardless of the scale of the project, except when two similar products by different suppliers were being compared, it is necessary to make a detailed review of supplier information and base the design decision on ranking the clients preferred criteria as a paper exercise. An alternative method is balanced value multi criteria analysis which allows a flexible approach to product selection based on clients preferred weightings (Woolley and Bevan, 2006).

Multi criteria analysis methods have been developed by Langston and Ding (2001) for schools, and Nijcamp, Rietveld and Voogd (1990). Transferring these to commercial projects is possible with modifications. Social benefit is calculated by dividing number of people employed by the number who will use the development as customers. Environmental risk is calculated by assessing the amount of non-recycled waste generated throughout the life of the project. The resulting figure is a generally a fraction, but is meaningless unless it can be compared to other similar projects. It is more useful to optimise each coefficient independently and not loose them within an equation.

Risk Management

Having established that a number of factors can be used to asses different aspects of sustainability in a commercial development, and that that they were not being fully utilised, the next stage was to identify a mechanism for ensuring that these issues were considered and evaluated throughout the design and procurement stages. This was approached through taking a wide perspective of what had caused effective change in working practices in the UK construction industry. The introduction of the Health and Safety regulations in 1993 saw the wide scale introduction of design risk management, using the likelihood of a dangerous occurrence multiplied by the severity of an accident to assess a risk. This methodology was later adapted by the construction industry to identify a risk, offer a mitigation route and identify where the responsibility lay for ensuring the risk was managed. This is a readily comprehended format which is well known, transparent and easy to document. By adapting this process as a briefing tool against the risks posed by insufficiently addressing the issues of economic, social and environmental sustainability, it should be possible to clearly and openly manage CR policy, planning and building control issues through the crisis points identified earlier.

Design and Development
The design of the framework was developed using action research strategies over a period of more than a year. Whilst mostly required for mixed use urban projects the process also was used for other projects with a user led design development allowing faster feedback on the implementation of the framework.

3. IMPLEMENTATION

The framework matrix is completed as an Excel Spreadsheet for ease of transfer amongst the project team but can be frozen at specific points by means of a revision note and date. This process requires that first the design team obtain the client's brief, CR policy and sustainability policy. Specific to the brief and its location the design team identify risks to sustainability; these are outlined on the basic framework matrix in three groups for environmental, social and economic risks, but can be added to and subdivided to suit the specifics of the project. For each risk the design team must identify ranked responses to the risk of decreasing levels of profundity. They then identify conflicts and issues that may have a positive or negative impact or may affect the level of profundity that is possible. The design team must then with the client identify which responses will be adopted. These must then be individually assigned design checks of specific target measurement or criteria relevant to each response. These might include energy use kWh/m^2, percentage of energy to be obtained through micro-generation, material selection criteria, reduction targets in water use etc. They may use web based software or paper methods as deemed appropriate or preferred by individual consultants. Period of effect is defined to demonstrate the futurity of the mitigating strategy and the philosophy is identified to make clear if technology, people, climatic effects or ecology are depended on for the success of the strategy. During the course of the design and construction of the project, any changes are documented and residual risks identified at handover. Finally a responsible party is nominated for the management of the strategy in the long term.

The framework (Figure 4) requires that a responsible person is appointed to manage the matrix; this might be the architect or project manager. Involvement of the full design team is very important to the success of this method and any facilities management input that can be obtained from clients consultants such as insurers, planning consultants, anchor tenants or other stakeholder groups is also very helpful. The framework is updated as new decisions are made in the design development stages, reviewed in meetings and appended to minutes. Any changes should be documented and the party effecting the change noted. The framework supports the production of written sustainability statements for planning applications by describing each risk response. The document becomes part of the client requirement or tender documentation, thus ensuring that the contractor is committed to the responses it makes. It also informs the development of health and safety documentation and is central to the operations manual.

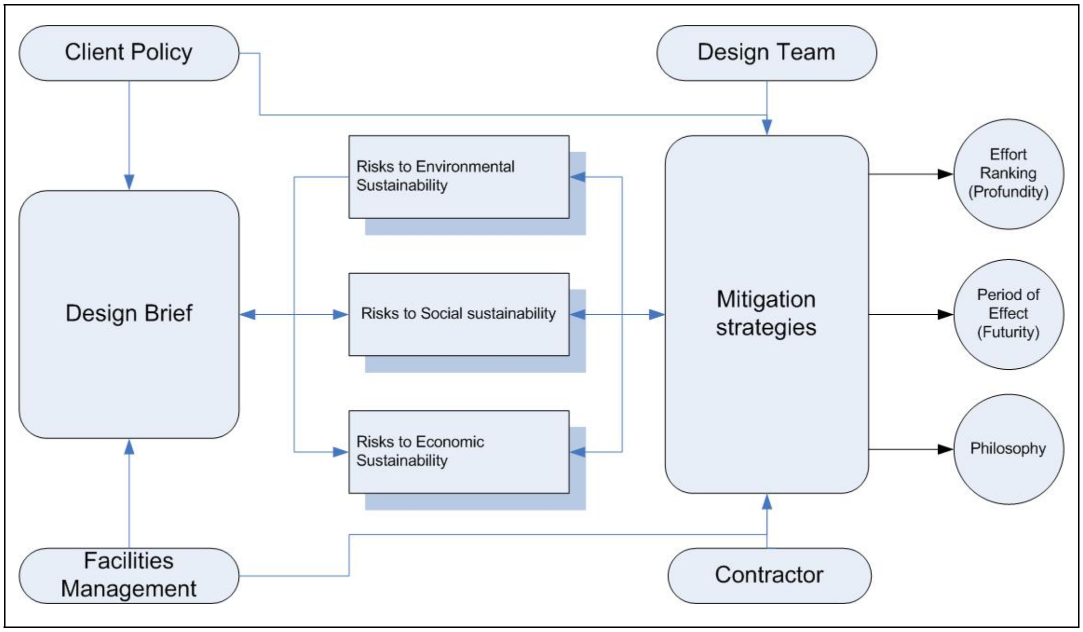

Figure 4 Sustainability Risk Management

Examples

Case study 1: Mixed use urban development scheme including large supermarket, housing, doctor's surgery, retail units and parking. The project offered an ideal opportunity for an industry leading CHP local wire network and district heating scheme with waste heat being used in the homes and surgery. Difficulties in leasing and investment arrangements would have required that the plant was under the control of the supermarket and this anchor tenant was not ready to take such a big step. The proactive solution of district heat recovered from the supermarket is still being investigated in this ongoing project.

Case study 2: Office refurbishment developed for occupier. This project involved the complete internal and external refurbishment of an existing office building. The initial risk identified was energy use, both in terms of carbon emissions and cost to the business. The levels of profundity identified were; passive: meet legislative requirements and fit conventional heating and cooling; Active: meet legislative requirements for new cladding u-values and fit conventional heating with mostly natural ventilation (stand alone cooling for major meeting rooms); Proactive: highly insulate the new cladding with high performance fixed glazing, mechanical ventilation, cooling and heating system with close facility management; and Industry Leader: as the active system with an on-site micro-generation scheme. The Proactive route was selected and a target energy consumption was set at 175kWh/m^2 to include small power for up to 250 workstations and ancillary services. This might have seemed an unconventional choice but observation of the client's management of existing air-conditioned offices had shown that windows were opened ineffectively and in an existing naturally ventilated office, high temperatures were endured to prevent difficulties with paper disturbance caused by open windows. The design was proven on completion to be 174kWh/m^2 or 20kg/CO_2/m^2/year however no base line was established prior to the design to demonstrate what energy saving that provides. Further monitoring and feedback will be carried out from commissioning as part of the facility management and CR reporting by the business that will occupy the building to observe comfort levels and energy use. This may result in roof mounted micro-generation being installed at a later stage.

Case study 3: Coastal Water Sports Centre. This project had already achieved planning permission when the client sought to improve the sustainability of the project to help with funding. The embodied energy of materials was identified as one of the risks and the proactive solution: to source materials locally where possible, use recycled materials and reduce material volumes was selected. The concrete substructure for this coastal project has to withstand occasional high tides, and needed to be very robust, the design of the formwork has maximised strength for minimum material volume, although, as the risk of salt attack was high, a high grade waterproof specification was required. External stone cladding was required by the planners, the local stone is too soft and nearby Victorian structures use Scottish granite. A new supply to match could not be sourced in the UK, the next nearest geographically was in Portugal, but it was discovered that most stone is taken to China for processing, therefore it was less damaging to obtain the stone from China than have it make two journeys around the world. The alternative was to re-dress granite taken from a nearby pier planned for demolition, whether this will occur it such a time to suit the programme of the new building remains to be seen.

Case Study 4: Department store. A major retailer has adopted a sustainability policy and is seeking initially to reduce energy use. Savings have been identified through a paper exercise using a hypothetical store with lighting design using low energy fittings to the lowest lux levels and LED spot lighting, resultant cooling load reduction and better management of door areas. This retailer has identified their ongoing needs from speculative developers to provide a shell which offers good day lighting, good opportunities for natural ventilation and heat recovery and ideally opportunities to collect roof rainwater, on-site micro-generation planned by the developer. They have identified that there is a considerable lag time between the design of the shell by a developer and their own input by as much as 5 years. In these circumstances, the legislative requirements that reflect a developer’s passive response to sustainability risks are already outdated.

4. RESPONSE

Clients

Once a client has accepted that they have a pivotal role in the development of their project sustainability strategy through the dissemination of their corporate responsibility policy they find it easy to expand the matrix format and adapt it to other projects. In one example a client is using the framework to write the policy and brief for future master planning projects.

It is difficult however for the matrix to make any contribution to a more sustainable building if the client has a passive response to responsibility, this will result in a development that merely meets current legislation. In this circumstance, the design team have an essential role to highlight potential risks inherent in the passive stance through planning difficulties, maintenance and utilities costs, public relations, imminent legislative changes and tax incentives.

Design Consultants

Approaching the management of sustainability as a risk evaluation and mitigation response has proved an effective way to clarify the objectives of the client's CR brief. Consultants are familiar with this form of working as it is transparent, easily digested and reflects the intuitive discursive design team pattern of problem solving that is typical of commercial development.

Contractors

The success of this framework in producing the sustainable development that the client sets out to provide is dependant largely on the procurement method and how the matrix is embedded in the documentation. It is very easy for the design team to maintain control when a traditional contract form is used, but management and design and build forms leave the contractor in a position to develop their own designs, use subcontractors and make substitutions. Providing that the contractor is made clear that the document forms part of the project requirements, it is still possible to maintain the quality of the solution. Perhaps more importantly, the contractor should be selected on their own performance and commitment towards sustainable business and the way they manage sub-contractors to do the same.

5. CONCLUSIONS

The framework provides a clear evaluation of how the client will achieve the aims set out in their sustainability policy and what targets they set out to achieve, part of CR reporting is to strive to improve on such targets with successive annual reporting. The link between the speculative commercial development and the tenant business using the same framework highlights the need for this approach. Developers must see that there is a need to look beyond the immediate sale of a development on completion or they may find that tenants cannot operate in the shells they are offering. One mixed use scheme that is currently in planning will have the same anchor tenant described in case study 4, this should provide the optimum opportunity to mitigate sustainability risks though design for all stakeholders by better communication. It must not be underestimated the role that planning authorities have in this process and an understanding of the loopholes created by insufficient conditioning of approvals must be noted.

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MANAGING HIGHWAYS MAINTENANCE PROJECTS: NEURAL NETWORKS VS. REGRESSION TECHNIQUES

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ABSTRACT

Allocating funds and other resources for highways maintenance projects is considered by highways agencies around the world as a challenging task due to several constraints such as time, budget, manpower, equipment, and other complex factors affecting their condition ratings. This calls for innovative priority systems to select and schedule highways for maintenance schemes. This paper investigates the development of neural nets and regression models for the priority ratings of bridge maintenance projects. The study utilizes a data set of 66 bridges provided by the British Highways Agency. The projects are evaluated according to risk assessment criteria, which are based upon four components: safety, functionality, sustainability and environmental impact. The findings prove that the ANNs outperform the MRA. The reasons behind these results are analysed. The advantages and disadvantages of the two approaches are compared as well.

Keywords: Artificial neural networks, Bridge risk assessment, Multiple regression analysis, Performance measurement

1. INTRODUCTION

Highways departments around the world have different systems for managing their infrastructure including bridges, roads and highways.. For instance, the British Highways Agency has rating criteria for bridge maintenance projects, which is determined in terms of the risk scores of bridge conditions. The risk score is an overall aggregation of bridge risks that are usually assessed against different criteria such as safety, functionality, sustainability and environment and characterized by risk ratings such as *High*, *Medium*, *Low* or *None*. The aggregation process involves a large number of subjective judgments of bridge experts. But there is no explicit functional relationship between risk score and risk ratings.

In order to determine the future maintenance priorities, mathematical models could be developed to predict the risk scores of bridge structures. Artificial neural networks (ANN) and multiple regression analysis (MRA) are different approaches which could be used for the assessment of risks for bridges maintenance schemes. This study compares their mechanisms and performances in modelling bridge maintenance projects and their risk information.

In different research areas and knowledge domains, numbers of studies were conducted to compare the performances of ANN models and traditional statistical models. For example, Cao et al. (2005) utilized ANNs to predict stock price movement and compared the predictive power of linear statistical models and neural networks. Their results showed that neural networks outperformed the linear models. Kumar (2005) compared regression and neural nets on a real life data and two simulated examples. Results revealed that regression was much better than neural networks for skewed data. Kim et al. (2004) examined the performance of three cost estimation models based on MRA, ANN and case-based reasoning (CBR). The ANN models achieved better results in short-term estimation, while the CBR models were more accurate in long-term estimation. Heiat (2002) compared neural networks and regression analysis for estimating software development efforts. Results indicated that neural networks produced improved performance over regression analysis. Alon et al. (2001) compared ANNs and traditional methods including Winters exponential smoothing, Box–Jenkins ARIMA model, and multivariate regression for forecasting aggregate retail sales. They found that ANNs fared favourably in relation to these traditional statistical methods. The ANN was also able to capture the dynamic nonlinear trend and seasonal patterns, as well as the interactions between them. Prybutok et al. (2000) compared the performance of different models for forecasting daily maximum ozone levels; and the study revealed that ANNs outperformed regression and Box–Jenkins ARIMA models.

Elhag and Boussabaine (2002) developed a variety of tender price estimation models using different types of ANNs with different parameters and input factors. Their research revealed that most of the neural networks parameters had a little impact on models' performances whereas the various sets of input factors had a significant effect. Baker and Richards (1999) compared ANNs and the regression model developed by the National Center for Education Statistics (NCES) for forecasting school expenditures in USA. ANN results ranged from comparable to superior with respect to the NCES model. Arditi and Tokdemir (1999) compared ANN and case-based reasoning (CBR) for predicting the outcome of construction litigation and discussed their advantages and disadvantages. It appeared that CBR was more flexible when the system was updated with new cases and had better explanation facilities than ANN. Desai et al. (1996) explored the ability of neural networks and traditional techniques such as linear discriminant analysis and logistic regression, in building credit scoring models. The findings indicated that neural networks offered a very promising avenue if the measure of performance was percentage of bad loans correctly classified. However, if the measure of performance was percentage of good and bad loans correctly classified, logistic regression models were comparable to the neural networks approach. Nguyen and Cripps (2001) compared the predictive performance of ANN and MRA for single family housing sales and found that ANN performed better than MRA when a moderate to large data sample size was used.

The paper is organized as follows: Section 2 briefly introduces the basic principles of ANN. Section 3 provides a description of bridge risks information. Section 4 examines the evaluation criteria for modelling performance. Sections 5 and 6 discuss the developments of the bridge risk assessments models using ANNs and MRA. Section 7 compares the performances of these models and their advantages and disadvantages. Finally conclusions are offered in Section 8.

2. BACKGROUND OF ANN

Neural computation is one of the inductive machine learning methodologies. It is most often used to learn, generalise and represent different types of knowledge. It extracts information from existing data by inductive learning. It is a fundamentally different approach to other information processing approaches. Algorithmic computing and expert systems are used in cases where the processing can be described as a known procedure or a set of known rules. Neural computation allows the development of information processing for which the rules and relationships are not available (Hecht-Nielson, 1990).

An ANN consists of many processing elements joined together as shown in Figure 1. PEs are usually organised into groups called layers or slabs. A typical ANN consists of a sequence of layers with full or random connections between successive layers. Typically, there would be an input layer where data is presented to the network; and an output layer which holds the response of the network for a given input. Layers in-between the input and output buffers are called hidden layers (Haykin, 1999).

There are different types of neural networks that have been developed during the last decade, and many more are expected to evolve in the near future. The abilities of neural networks include the following: to learn by examples; to be able to map nonlinear relationships; to adapt for changes in the operating conditions; to reasonably respond to incomplete and noisy data; and to generalise solutions for future situations.

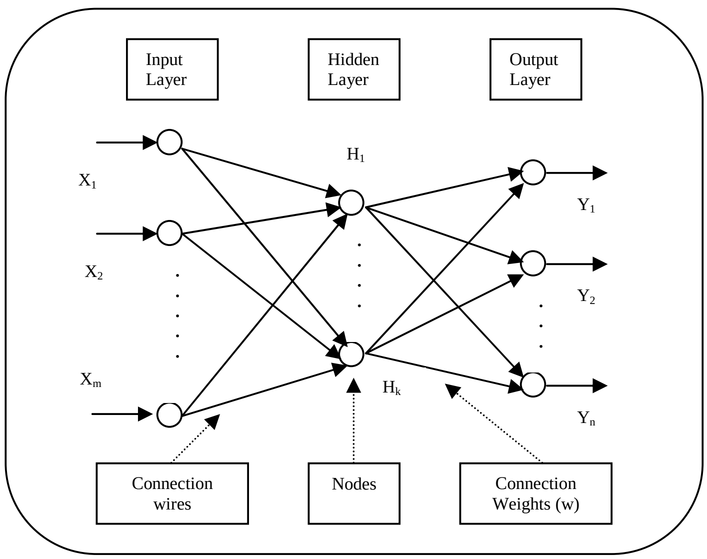

Figure 1: A Simple Artificial Neural Network Structure

3. DESCRIPTION OF DATA

The data set used in this study was provided by British Highways Agency, which evaluates bridge risks in terms of the following four criteria (British Highways Agency, 2004):

- Safety — safety of the public.
- Functionality — effects on the level of service/availability of the network for

use.

- Sustainability — sustainability of both expenditure and workload, where the aim is to reach a state of steady expenditure and workload, avoiding the built-up of a backlog of unavoidable, essential work by doing effective, targeted preventative maintenance, i.e. painting steelwork, silane of new concrete and preventative maintenance on all bridges in new/as new condition. Sustainability will also require the timely replacement of structures.
- Environment — effects on the environment, including the (aesthetic) appearance of the structures.

The magnitude of risk is described by ratings such as *High, Medium, Low or None*. The overall risk of a bridge structure is characterised by a risk score, which decides the maintenance priority of the bridge structure. The data used for developing the priority rating models comprises 66 bridge maintenance projects. If the risks of these 66 projects can be learned or fitted very well, then the risk score of any project can be well predicted.

The data input factors used to develop the bridge risk assessment models include: safety risk rating (SRR), functionality risk rating (FRR), sustainability risk rating (SUR) and environment risk rating (ERR); whereby the output factor is represented by the bridge risk score (RS). In developing the models all the qualitative risk ratings such as *High*, *Medium*, *Low* and *None* are transformed into numerical values 3, 2, 1 and 0, respectively.

4. PERFORMANCE EVALUATION CRITERIA

There are various statistical criteria, which are used to evaluate the performance of a model. These criteria include: the sum of squared error (SSE), mean square error (MSE), mean absolute error (MAE), root mean squared error (RMSE), mean absolute percentage error (MAPE), root mean square percentage error (RMSPE), correlation coefficient (R), Theil's inequality coefficient (U). Some of these such as RMSE, MAPE and R are the most widely used performance evaluation criteria and will be used in this study. A model with low RMSE and MAPE and high R is considered to be highly accurate. These criteria are defined as follows in Equations 1 to 3: (Elhag, 2004)

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(A_t - F_t)^2}\,, \tag{1}$$

$$MAPE = \frac{1}{N}\sum_{t=1}^{N}\left|\frac{A_t - F_t}{A_t}\right| \times 100\,, \tag{2}$$

$$R = \frac{\sum_{t=1}^{N}(A_t - \bar{A})(F_t - \bar{F})}{\sqrt{\sum_{t=1}^{n}(A_t - \bar{A})^2 \cdot \sum_{t=1}^{n}(F_t - \bar{F})^2}}\,, \tag{3}$$

where A_t and F_t are actual (desired) and fitted (predicted) values, respectively, and

$\bar{A}$ and $\bar{F}$ are their averages determined by Equation 4.

$$\bar{A} = \frac{1}{N}\sum_{t=1}^{N} A_t \text{ and}$$
$$\bar{F} = \frac{1}{N}\sum_{t=1}^{N} F_t \ . \qquad (4)$$

5. NEURAL NETWORK MODELS

The universal approximation theorem (Haykin 1999) shows that a neural network with a single hidden layer and sufficiently large number of neurons can in principle relate any given set of inputs to a set of outputs to an arbitrary degree of accuracy. The bridge risk assessment models, developed in this study, are based on the Back-propagation neural nets (Figure 2). The bridge risk assessment models were developed using NeuralWare Professional II/PLUS.

A trial-and-error method is performed to optimize the number of neurons in the hidden layer for these models. Table 1 shows the performance of BP-ANN varying with the number of neurons in the hidden layers. It is observed that the performance of BP-ANN is improved as the number of hidden neurons increases. However, too many neurons in the hidden layer may cause over-fitting problem, which results in the network learning and memorising the data very well, but lacking the ability to generalise. On the other hand, if the number of neurons in the hidden layer is not enough then the network may not be able to learn.

Criterion	**Number of neurons in the hidden layer**										
	2	3	4	5	6	7	8	9	10	11	12
MAPE	15%	13%	10%	16%	15%	8%	9%	7%	6%	6%	5%
RMSE	9	6	5	6	7	3	4	3	3	3	2
R	0.96	0.97	0.98	0.96	0.97	0.99	0.99	0.99	0.99	0.99	0.99

Table 1: Performance variations of BP-ANN models

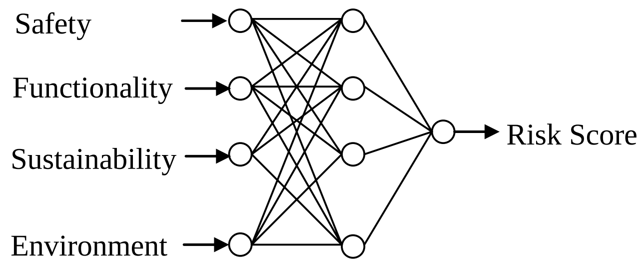

Figure 2: BP-ANN architecture for bridge risk assessment

6. REGRESSION ANALYSIS MODELS

The MRA models were developed using stepwise regression technique based on Equation 5. Table 2 shows the parameters and regression coefficients of the seven MRA models for bridge risk assessment. The performances of the seven MRA models are presented in Table 3, which reveals that MRA3 and MRA7 achieved better accuracies than the others.

$$RS = b_0 + b_1 \times SRR + b_2 \times FRR + b_3 \times SUR + b_4 \times ERR + \varepsilon \,. \quad (5)$$

Code	MRA Model
MRA1	RS = 29.124 + 19.729 SRR
MRA2	RS = 15.663 + 17.182 SRR + 9.846 SUR
MRA3	RS = 14.581 + 15.595 SRR + 3.979 FRR + 8.962 SUR
MRA4	RS = 32.733 SRR
MRA5	RS = 20.055 SRR + 14.590 SUR
MRA6	RS = 17.841 SRR + 4.934 FRR +13.086 SUR
MRA7	RS = 17.331 SRR + 4.877 FRR +11.877 SUR + 3.268 ERR

Table 2: MRA models for bridge risks assessment

Criterion	MRA1	MRA2	MRA3	MRA4	MRA5	MRA6	MRA7
MAPE	33%	23%	21%	40%	22%	20%	**17%**
RMSE	14	10	**9**	23	12	11	11
R	0.84	0.92	**0.94**	0.84	0.92	0.93	0.93

Table 3: Performances of the seven MRA models

7. COMPARISONS OF PERFORMANCES

The performances of the bridge risk score models developed by BP-ANN, and MRA are summarized in Table 4. The findings indicate that the BP-ANN model with four neurons in the hidden layer achieved much better accuracy than the MRA models. In fact, each of the BP-ANN models in Table 2 outperformed the MRA models. This is mainly attributed to the strong ability of the neural networks to map nonlinear relationships between the input factors and the bridge risk score.

Performance criterion	Models				
	BP-ANN	MRA3	MRA7	MRA8	MRA9
MAPE	10%	21%	17%	21%	20%
RMSE	5	9	11	9	12
R	0.98	0.94	0.93	0.94	0.93

Table 4: Performances of the bridge risk assessment models

It is noted that the MRA approach identified SRR as the most significant input factor for modelling bridge risk scores, followed by SUR and FRR. The ERR was identified as the least important factor. However, such priorities of inputs cannot be identified by any of the BP-ANN models because it is implemented like a black box.

Theoretically, a nonlinear MRA model might be able to better model the bridge risk data than a linear MRA model. However, in practice it is very hard to predefine an appropriate nonlinear function for the bridge risk problem. This study exploited different types of nonlinear functions such as exponential function, polynomial function, … etc. Nevertheless there were no significant improvements in the MRA models' performances.

8. CONCLUSIONS

This paper presented a comparative analysis for modelling bridge risks using neural networks and multiple regression analysis. In the study a variety of bridge risk assessment models were developed and their performance and accuracy were analysed and compared. The results revealed that neural network is particularly suitable for leaning and mapping nonlinear functional relationships between the input factors and the bridge risk score. The findings also showed that ANNs outperformed the MRA in modelling bridge risks. On the other hand, the regression technique was proved to be capable of explaining the parameters learned from the bridge maintenance projects and identifying the impact of each input factor on the risk score, whereas the neural networks have no such capabilities.

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PERCEPTION ON SUCCESS AND FAILURE FACTORS FOR CONSTRUCTION COLLABORATIVE RELATIONSHIPS

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ABSTRACT

Collaborative arrangements such as joint ventures, strategic alliances, project and strategic partnering, partnership (including public private partnerships, prime contracting) and outsourcing are increasingly being used in construction project developments with the intent that the construction project stakeholders will work together in an environment of trust and openness. Based on a UK wide postal questionnaire survey, the opinions of contractors were assessed on the factors that are responsible for the success and failure of collaborative relationships in construction development. The research shows that UK contractors are positive about collaboration and are engaged in collaborative relationships for construction developments. The five main factors identified (apart from senior management support and the relationship being perceived as very important to the partners) for successful construction collaboration are: commitment, trust, shared risk; responding to clients' needs; and good communication. The five main failure factors in order of significance are lack of trust; communication breakdown; lack of belief in the system; clash of organisational cultures; and unchanging attitudes. The main criteria that the respondents would want the success of collaborative relationships to be measured against are profitability (including cost/budget reduction), client satisfaction and creation of more collaborative relationships.

Keywords: joint venture, strategic alliance, partnering, partnership, success factor, failure factor, collaborative relationship, culture.

1. INTRODUCTION

Business collaborations are now prevalent across different business sectors. These have developed in various forms including joint ventures, strategic alliances, partnering, partnerships, outsourcing, etc. The early 90's saw the increase in collaboration between companies in the manufacturing industry. This arose from commercial pressures relating to increased competition, higher research and development (R & D) costs, increasing pace of product innovation and technological development and the increasing internationalisation of industries (Leverick and Littler, 1993). To stay not only in business but to remain competitive, manufacturing firms had to look at ways that would improve performance and profits. For many manufacturing firms this was achieved by using collaborative processes. In the summary report of their conference on 'Collaboration for Competitive advantage: the changing world of alliances and partnerships, Stiles (1995) identified the need that spurred collaboration across the world to include: increasing globalisation, competitiveness, risk and uncertainty within the business environment, businesses as diverse as insurances, airlines and computers are recognising the need to collaborate in order to survive. He noted that companies considering new market ventures or planning long-run research and development programmes are finding that collaboration offers the opportunity to spread the risks of this form of investment.

Crouse (1991) indicated the demand from customers has been responsible for the push for partnerships given that they have become more knowledgeable and are faced with more choices over a shorter period of time. In addition he argued that customers want the best solutions for the best price without being locked in with any one vendor. Consequently, the response to this demand by industry while at the same time meeting the objectives of getting products to market faster, increase market share, improve quality and service, improve productivity, reduce cost and improve profitability has brought about the need for partnerships. The survey by the Economic Intelligence Unit in 2003 (cited by Anslinger, 2004) noted that the main reason cited by Chief Executive Officers for increasing dependence on external relationships are the need for fast and low-cost expansion into new markets and greater control/influence of the customer relationship.

In the UK construction industry, two government reports have specifically addressed the need for change to improve the industry: the Latham report (1994) and the Egan report (1998). These reports have a recurring theme in that they both suggest the industry could achieve expected improvement through greater teamwork not only at site level and organisational level but also with clients and suppliers. Recommendations within these reports have led to an increasing use of collaborative arrangements such as long-term/strategic arrangements, partnering, joint venture, public private partnerships, prime contracting and supply chain management in order to improve the construction development process. However it may be anticipated that not all the collaborative relationships in construction developments will be successful. This paper therefore addresses the factors that may be responsible for the success (or failure) of construction collaborative relationships. The research that formed the basis for the paper replicated a survey undertaken on collaborative relationships in the manufacturing sector by Leverick and Littler (1993).

2. GENERAL OVERVIEW ON COLLABORATIVE RELATIONSHIPS AND SUCCESS FACTORS

Douma et al (2000) tackled collaborative relations from a strategic alliances angle and noted that due to the ever increasing pace of technological developments and access to new technologies, alliances have become a key success factor in many industries. In addition, they found that there is now a shift from ‘traditional’ cost driven alliances to a knowledge-intensive alliances, where inter-partner learning is a major objective. Spekman et al (1996) concluded from their study, based on in-depth interviews with managers on both sides of five strategic alliances, that successful alliances have their origin at the top of the organisation. Even those alliances of lesser stature and which are managed at lower levels within the organisation must have the blessing and support of the top management.

Brouthers et al (1995) identified 4Cs under which strategic alliances should be utilised; this they termed the major forces involved in helping assure success: complementary skills are offered by the partners, cooperative cultures exist between the firms; the firms have compatible goals; and commensurate levels of risk are involved. Medcof (1997) also identified different 4Cs for successful alliances: capability (are the prospective partners capable of carrying out their role in the alliance?); compatibility (are they compatible operationally); commitment (are they committed to the alliance and its strategic aims); control (are the control arrangements for the coordination of the alliance appropriate?). The conference report on collaboration by Stiles (1995) indicated that successful collaborative partnerships and strategic alliances need to be developed as part of the overall strategy of an organisation that requires initial identification of clear goals and objectives, and significant attention to the choice and type of partner.

Crouse (1991), on the power of partnerships, enumerated the clear advantages of a balanced partnership relationship: partnering provides the ability to leverage internal investments; focus on core competencies leverage core competencies of other organisations; reduce capital needs, broaden products offerings; gain access or faster entry to new markets; share scarce resources; spread risk and opportunity; improve quality and productivity; having access to alternative technologies; provide competition to in-house developers; use a larger talent pool and satisfy the customer.

Anglinger and Jenk (2004) identified five forms of alliances that have application to the various forms of collaborative relations: (1) invasive where the partners share a significant amount of technology, personnel and strategy and derive value from a true combination of perspectives and resources, often accompanied by co-location. However because partners objectives are varied, it is noted that it is harder to gauge success or monitor success hence this requires more elaborate governance and senior management involvement for this form of alliance to be successful. (2) Multi-function which encompasses multiple spots on the value chain and brings together R&D functions or development and market with the aim to maintain or build momentum for commercialisation, improve approval chances and speed time to market. (3) Multi-project which involves existence of multiple alliances within a single company to reduce transaction costs and give partners a first look at each other’s products or right of first refusal (4) Coopetition which involves cooperating with competitors with the benefit of sharing development costs, along with access to cross-pipeline expertise and reduce transaction costs (5) Networks which is a case of multiple partners grouped in a single alliance to access diverse technologies and skills, share costs, build market momentum and bundle related products into a full customer solution.

Douma et al (2000) are of the view that the need to cooperate is determined by pressure on continuity, market opportunities, time pressure or the number of alternative options (such as autonomous development or acquisitions). They identify the six drivers for strategic fit in collaboration: (i) that cooperation is only advisable when partners have a shared vision of future development within the industry in which an alliance will be formed, and of the impact that these developments will have on their individual positions; (ii) that precondition for strategic fit is compatibility of strategies; (iii) that the alliance partners will only be prepared to make concessions when the alliance is of strategic importance to them; (iv) a successful alliance requires mutual dependency; (v) any alliance should have added value for the partners and /or their customers and (vi) partners must carefully consider whether the market will accept that alliance.

Daulans et al (2003) noted that rather than strategic fit between the partners and the characteristics of alliance, the capacity which an organisation has built up in managing alliances (including alliance training, cross-alliance evaluation, use of alliance specialists) makes an important contribution towards enhancing alliance success. Sonnenbery (1992) identified ten principles of a solid partnership as follows: both partners gain from the relationship; each party should be treated with respect; promise only what can be delivered; specific objectives should be defined before the relationship is firmly established, striving for a long-term commitment is important to both parties; each side should take the tie to understand the other's culture; each side should develop champions of the relationship; line of communication should be kept open; the best decision is one made together and preserve the continuity of the relationship.

Lorange and Roos (1991) came up with two political considerations (stakeholder blessing and internal support) and two analytical considerations (strategic match and delineation of strategic plan) as the foundation of a successful strategic alliance). Shaughnesy (1995) on the other hand argued that the most important prerequisite for success in international joint ventures is that the parties should share the same objectives without ensuring that each partner's total objectives and goals match, which is to invite disaster. He therefore identified pre-contract partner training needs to look at five factors for managing successful collaborations: communication goals (comprises training in interpersonal relationships and conflict management); performance goals (shared goals are identified and developed); dispute resolution (consideration is given to the need for timely resolution of disputes); evaluation (both parties agree a continuing evaluation of the team's performance during the length of the contract); and commitment (to a partnering agreement that embodies the spirit of collaboration and which is separate from the venture contract). Spekman et al (1996) are of the view that successful collaborative relationship must implement blameless review processes at scheduled intervals to ensure that the relationship is on course despite those internal/eternal pressures which might affects its direction.

This review of previous publications has shown that collaborative relationships are used in many industries including manufacturing, retailing, construction and service sectors. Although, collaborative relationships can take different forms the literature review has drawn mainly from strategic alliance where this has been utilised to help assure success and complement skills. The review has show that some of the factors responsible for the use of collaboration in the recent times are access to new technologies, fierce competition, the need to focus on core business, risk sharing, and market opportunities. However, there are different factors that could be responsible for the success or failure of collaborative relationships. The success factors identified include top management support, complementarities of skills, cooperative culture, shared goals and objectives; etc. The extent to which these factors are relevant to collaborative relationships in the construction environment are explored in this current study.

3. RESEARCH METHOD

This paper presents UK contractors opinions on the success and failure factors of collaborative relationships and how the success should be measured. This is part of a questionnaire survey that sought UK contractor's opinions on the risks and rewards of collaboration in construction development. A four page questionnaire, accompanied by a covering letter, was sent to managing directors of sample firms. The letter indicated the objectives of the research and requested that the questionnaire should be completed by a senior member of staff involved in construction development in the firm. The questionnaire design was based on a combination of an extensive review of literature dealing with collaboration in construction, the researcher's general knowledge of collaboration in UK construction and Leverick F and Littler D (1993) survey on the manufacturing industry. The overall aim of the research was to establish whether collaboration can be used to improve the construction industry. The main limitation of the current study is that the research is based on the survey instrument derived from Leverick and Littler (1993) study. However, more recent literature on the collaborative relationships tend to suggest that the practice involved in collaborative relationships in terms of influencing factors have not changed much and that the factors identified by Leverick and Littler are still very much relevant in many industries where collaborative relationships have received continuous growth in usage. In an attempt to reflect on the validity of the current study the results were compared with Leverick and Littler findings. In addition, open ended questions were included for the respondents to supply missing gaps.

The questionnaire was divided into six sections exploring collaboration in construction. Contractors were asked their opinion on the reasons for collaboration in construction, the role of collaboration in construction and the risks of collaboration. The questionnaire also looked at success and failure factors in construction collaboration. The final section of the questionnaire looked at the use of information technology within construction collaboration. The questionnaire used the five point Linkert scale with '5' indicating "great extent" or "most important" and '1' indicating "insignificant extent" or "least important". The questionnaire was sent to 250 companies of which 63 responded giving a response rate of 25.2%. With the exception of two respondents, the questionnaire was completed by senior members of the industry. All the respondents firms have engaged in a form of collaborative relations involving various construction stakeholders (clients, other contractors, subcontractors, suppliers, manufacturers and consultants).

The respondents were split into two groups (SME's and Large) based on their number of employees, to determine whether their responses varied with size as part of the analysis. Watts (1980) highlights that the size of a company can be measured in terms of number of employees, net assets (capital employed), value added (net output) and Turnover. Table 1 shows a grouping of the firms based on number of employees according to the UK Department of Trade and Industry that categorises as Small Medium Enterprises (SMEs) the firms with less than 250 employees. The Table includes the number in each group, the mean number of employees and the standard deviation for each. Statistical analyses, based on Analysis of Variance (ANOVA) F statistics and associated probability values (p), were undertaken as presented in Tables 2 and 3 on the basis of the size of the companies (SME and Large) to show if the two groups share the same views on the success and failure factors. Where p is less than

0.05 it means that the two groups have different opinion on that particular factor, otherwise their views are similar.

Table 1: Employment

Group	Employees	Frequency	%	Mean	Std Dev.
SME	Less than 250	32	50.8	109.53	67.28
Large	Greater than 250	31	49.2	3873.84	9473.41
	Total	63	100	3983.87	9540.69

4. FACTORS RESPONSIBLE FOR SUCCESSFUL COLLABORATION IN CONSTRUCTION

Table 2 shows the contractor’s opinions on the factors responsible for successful collaboration. The most important factor is senior management’s close involvement in the collaboration process, followed by the relationship being perceived as very important to the partners coupled with the benefits between collaborators being perceived as 'evenly' distributed. These factors are generally rated higher by large contractors compared with the SMEs. The results corroborate a study by Bresnen and Marshall (2000) that found senior management support very vital in making a collaborative approach both credible and legitimate. In all cases, partnering or alliancing had been championed at the highest levels of the organisation and the general perception was that goal alignment and good relationships at these levels were crucial. Spekman et al (1996) noted the importance of senior management support as they bear responsibility for several key aspects of the alliance formulation process: they ensure that the alliance is tied to the strategic intent of the firm; and must drive the alliance vision down through the organisation. In support of this Anslinger (2004) emphasised that a successful alliance must take one of two forms of structure: have a strong structure with centralised leadership or provide clear rules for decision making.

For any collaborative arrangement to work, relationships between parties need to be good. Luck et al (1996) consider teambuilding within construction project companies essential for achieving performance improvement, and successful construction projects. Teambuilding is performed by co-ordination and integration of project organisations to increase productivity, efficiency, motivation, goal attainment, group dynamics and dispute minimisation (Kumaraswamy, 1996). The issue is that such teams become acquainted and familiar with those working around them. However, the temporary nature of construction projects and role ambiguity are barriers and constraints to such teambuilding in construction (Luck et al., 1996). Given the deficiency of the current practice Särkilahti (1996) has proposed that the performance of construction project organisations could be improved if the temporary nature of project organisations could be changed by entering into collaborative arrangements to encourage repeated working among a number of firms beyond the scope of one-off construction projects.

Generally, however, large contractors rated the reasons for successful collaboration in construction development higher than SME’s. The reason for this could be that large contractors tend to work in more collaborative arrangements than SME’s due to their work load and the complexity of projects they undertake. With the exception of ‘the relationship was perceived as being very important to the collaborators’ and ‘corporate systems and management style was flexible’ the ANOVA analysis shows, however, that the opinions of the SME and large contractors did not differ on each of the factors at the 5% significance level. The rating given to ‘corporate system and management style flexibility’ by SME was significantly higher than large contractors; this is probably because SME’s tend to be smaller partners or sub-contractors in the construction development process and therefore are more used to being managed than managing.

Table 2 Factors responsible for successful collaboration in construction.

Factor	**Overall**	**SME**	**Large**	**F Stat.**	**P-value**
Senior management were closely involved in the collaboration	4.063	4.031	4.097	0.063	0.803
The collaborative relationship was perceived as being very important to the collaborators	4.016	3.750	4.290	5.565	0.022
Benefits between collaborators were perceived as 'evenly' distributed	3.778	3.688	3.871	0.642	0.426
Corporate systems and management style was flexible	3.778	4.000	3.548	5.491	0.022
There was clear project planning with defined task milestones	3.714	3.688	3.742	0.056	0.814
A long term view of strategic benefits was taken	3.683	3.688	3.677	0.002	0.966
Adequate staff resources were made available to the collaborators	3.635	3.625	3.645	0.008	0.929
Sufficient time resources were made available to the collaboration	3.619	3.531	3.710	0.632	0.430
Sufficient budgetary resources were made available to the collaboration	3.603	3.688	3.516	0.662	0.419
Purely financial measures of progress in the collaboration were avoided	3.365	3.344	3.387	0.030	0.864
The product or concept being developed was highly innovative	2.778	2.781	2.774	0.001	0.980

The factors responsible for successful construction collaboration in the development process are similar to Leverick and Littler (1993) study into collaboration in the manufacturing industry. Both surveys rate the ‘importance of the relationship’ and ‘benefits being evenly distributed’ high in their responses. However the role of senior management in collaboration was not perceived to be a significant factor in the success of collaboration in the manufacturing industry. The reason for high importance of senior management support for collaborative relationships success in the construction industry compared with the manufacturing industry could be the nature of the construction industry: its renowned fragmented nature and therefore for collaboration to work in construction there needs to be effective communication between parties, with senior management taking control and responsibility for key decisions. The two factors rated lowest in both surveys for successful collaboration were ‘purely financial measures’ and ‘the product was innovative’. Generally the results of both surveys are similar which might suggest that the construction industry and manufacturing industry agree on what are needed for successful collaboration relationships.

The respondents were further asked open ended question to the identify factors that mostly contributed to success of collaboration in the construction environment. A high level of commitment and trust were the most frequently mentioned factors for successful collaboration. Other factors mentioned in an order of importance are shared risk; responding to clients needs; good communication; sufficient resources; improved efficiency; and understanding individual roles of the partners.

5. FACTORS RESPONSIBLE FOR UNSUCCESSFUL COLLABORATION IN CONSTRUCTION

Anglisger and Jenk (2004) reported the Accenture research that about half of all alliances fall well of expectations due to the following causes in order of importance: shift in partners strategic direction, senior management attention wanders; champions move on; lack of career path and shortage of staff; and clash of corporate cultures. Sconnenbery (1992) identified important reasons why partnerships fail as lack of commitment, cultural differences, poor management, poor communication, and failure of individual relationships (i.e. where individuals involved in the partnership lack interpersonal skills or personal chemistry may be missing). Table 3 shows the UK contractors' opinions on the factors that are responsible for unsuccessful collaboration. The most important factor is collaborating partners' failure to contribute to the partnership needs, goals and objectives as expected. This is followed by lack of trust between the collaborating partners and lack of frequent consultation between them.

Table 3: Factors responsible for unsuccessful collaboration in construction

Factor	Overall	SME	Large	F Stat.	P-value
The collaborating partners failed to contribute as expected in the partnership charter	4.016	3.813	4.226	3.704	0.059
There was little trust between the collaborating partners	3.952	3.844	4.065	0.708	0.403
There was a lack of frequent consultation between the collaborating partners	3.714	3.906	3.516	2.340	0.131
Little attention was given to the issues involved in the collaboration	3.571	3.750	3.387	1.936	0.169
Specific roles and responsibilities were not clearly defined	3.571	3.750	3.387	2.131	0.149
There was little consultation between the personnel involved in the collaboration	3.429	3.375	3.484	0.155	0.695
There was little previous experience of collaboration management	2.984	3.313	2.645	6.113	0.016
The construction development did not fit naturally with existing businesses	2.714	2.938	2.484	2.614	0.111

Lack of Trust was rated the second highest failure factor which supports Barlow et al. (1997) that relationships fail to work without trust. Lorange and Roos (1991) assert the reasons often emphasised for failure of collaborative relationship are "lack of trust" and "incompatible personal chemistry". Trust is said not only to reduce transaction costs, make possible the sharing of sensitive information, permit joint projects of various kinds, but it also provides a basis for expanded moral relations in business (Brenkert, 1998). Latham (1994) commented: "….disputes and conflicts have taken their toll on moral and team spirit. Defensive attitudes are commonplace…."

Latham's (1994) report attempts to re-build trust in the construction industry by advocating partnering. Co-operation among construction project participants requires mutual trust, commitment, involvement, common targets, good communication and joint problem solving (Marosszeky et al., 1997). According to Cooper et al. (1996a) the success of long-term co-operation is highly dependent on cultural and attitudinal factors displayed by the participants. In addition, the success is also dependent on the achievement of identifiable and sustainable performance improvements, and mutual benefits for all collaborating participants (Cooper et al., 1996b). A critical step towards collaboration in construction is to overcome the common culture of conflict, and adopt more ethical behaviour marked by honesty and integrity. Therefore, collaboration could be seen as a process of improving relationships, and a means for encouraging cultural shift from adversarial to non-adversarial behaviour (Hellard, 1995). Gambetta (1998) described reputations are a key to trust in relationships, reputations are expectations others hold of your likely behaviour in a partnering relationship; a partner with a 'good' reputation is more likely to be trusted.

Another failure factor that the contractors rated high was "a lack of consultation between partners". Poor design consultation/management is a primary factor that contributes to poor quality (Love et al, 1999) and time cost overruns in projects (Chan and Kumaraswamy, 1997). In a partnering relationship involving client, design and construction teams, such poor quality and time and cost overruns could emanate from lack of consultation and poor communication practices between the team members.

Undefined roles and responsibilities was the fifth highest contributing factor to unsuccessful collaboration. Collaboration requires clear understanding and distribution of responsibilities, authorities and roles. It requires adequate information flows and communication of these authorities and roles among the collaborating organisations and reliable access to the latest technological and management knowledge (Yashiro, 1996).

With the exception of the first two top failure factors, the SME contractors rated the reasons for unsuccessful collaboration in construction development higher than the large contractors. This is not unexpected as in practice, the smaller partners or sub-contractors (representing SMEs) tend to have subordinate roles in collaborating arrangements and are often ignored. Nonetheless, with the exception of 'the collaborating partners failed to contribute as expected' and 'there was little previous experience of collaboration management' the ANOVA analysis shows that the opinions of contractors did not differ on each of the factors at the 5% significance level.

Comparisons show that the factors responsible for unsuccessful construction collaboration are similar to the results from Leverick and Littler (1993) study into collaboration in the manufacturing industry. Both surveys rate 'failure to contribute as expected', 'lack of frequent consultation' and 'little trust' as the top three factors responsible for unsuccessful collaboration. The two factors rated lowest in both surveys for unsuccessful collaboration were ‘little experience’ and ‘did not fit within existing business’. The results of both surveys are similar which might suggest that the construction industry and manufacturing industry share similar views on the factors that do contribute to unsuccessful collaboration.

The respondents were asked an open ended question to identify the factors that most contribute to the failure of collaboration in construction project development. This generated many responses which are summarised in the order of significance from the highest to the lowest as: lack of trust; communication breakdown; lack of belief in the system; clash of organisational cultures; unchanging attitudes; lack of planning; varying financial objectives; lack of appreciation for contractual risks; client interference; clash of personalities; disputes not being resolved; and lack of senior management support. This might suggest that the major criteria by which respondents assessed failure of construction development collaborations is behavioural; these measures were mentioned by over half of the respondents as the major criteria for the failure of collaboration. Surprisingly though lack of senior management support was not mentioned as a major criteria for assessing collaboration failure given that this was listed as the top reason for successful collaboration (see Table 2).

6. MAJOR CRITERIA FOR ASSESSING THE SUCCESS OR FAILURE OF CONSTRUCTION DEVELOPMENT COLLABORATIONS

Sonnenbery (1992) argued that a good relationship should accomplish the goals, financial and otherwise that has been established; have ability to resolve conflicts as they arise, settle differences, and compromise when necessary and exhibit a clear pattern of growth and profitability overtime; all of which must be undertaken in an atmosphere of trust. Crouse (1991) noted that a balanced and complementary relationship should add to each company’s core competencies coupled with the partnership being structured to meet the needs of both parties. He argued how equities by the partners in each other businesses can be used as an intention by the parties to develop a long-term relationship.

Table 4: Criteria for success and failure of construction development collaborations

	% of respondents mentioning factor
Profit/revenue/commercial success/budget	88
Client satisfaction	60
Creating more collaboration partnerships	52
Commitment of managers	48
Improved quality of product	48
Improvement in efficiency	32
Benchmarking	24
Trust	20
Improved health and safety record	16
Improved communication	12
Gaining skills from partners	8
Industry KPI’s	8

The respondents were asked an open-ended question to identify the major criteria for assessing the success or failure of construction development collaborations. Table 4 shows that criteria identified with profit/revenue/commercial success/budget (i.e. financial consideration) being the most important.

Similar to Leverick and Littler (1993) survey, the major criteria by which respondents assessed the success of construction development collaborations was the profitability of the resulting construction development. Two other top factors for measuring success of collaborative relationships are client satisfaction and creation of more collaboration partnerships. Fifty two percent (52%) of respondents advocated assessing the success of collaborative relationships according to whether or not the collaboration led to more collaborations; again this is similar to the findings of Leverick and Littler (1993) survey.

The two factors rated lowest for successful collaboration by the respondents as shown in Tables 2 are financial (sufficient budgetary resources were made available to the collaboration and purely financial measures of progress in the collaboration were avoided). However, the most important criteria that the respondent identified in an open-ended question for assessing the failure or success of construction development is profit/revenue/commercial success/budget. This may appear contradictory; however, this tends to suggest that the most important criteria to measure the overall success of collaborative relationships (i.e. output of collaborative relationship) in construction development should be financial (prices/revenue/commercial success) but the day to day assessment of the relationship (i.e. input to collaborative relationships) should de-emphasis financial measures. Rather the factors (or inputs) such as top management support, importance perception of the relationship by all parties, partners equality, clear objectives, etc. should be regarded more important with the expectation that these should lead to overall financial benefits.

7. CONCLUSIONS

The literature searches included in the paper have shown that there is an abundance of new and existing thinking on how various forms of collaborative relationships are and should be used in the business environment. The current paper has identified the success and failure factors of collaboration within the construction environment. Collaborating relationships have been prescribed by various reports from the construction industry as an important tool for dealing with conflicts and adversarial relationships in the construction environment and for attaining and maintaining a competitive advantage. Stiles (1995) concluded that "During the life time of a partnership, key skills associated with relationship building, trust and flexibility need to be developed and applied. If done well, the benefits can be significant, not simply in respect of the current operation, but also in terms of learning that can be achieved and drawn upon in future collaborations." This is a major advantage that can come from collaboration.

However, while such relationships can pay off, it is important that collaborations are carefully considered to ensure that they fit into the business plans of the organisations that are considering entering into partnerships. The failure factors that the construction industry should consider carefully and address before entering into collaboration are possibilities of lack of trust; communication breakdown; lack of belief in the system; clash of organisational cultures; unchanging attitudes; lack of planning; varying financial objectives; lack of appreciation for contractual risks; client interference; clash of personalities; disputes not being resolved; and lack of senior management support. Some of the factors that are known to contribute to the success of partnerships in construction are a high level of commitment and trust, ability and willingness to shared risks amongst partners; responding to clients needs; good communication; sufficient resources; improved efficiency; and understanding individual roles of the partners.

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SUSTAINABLE PROCUREMENT: A CONTEMPORARY VIEW ON AUSTRALIAN PUBLIC PRIVATE PARTNERSHIPS (PPPs)

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ABSTRACT

The last two decades have seen the evolution of Public Private Partnerships (PPPs) as an alternative procurement method to traditional methods of delivering public infrastructure. Gaining significant popularity in the UK during the 1990's PPPs have gradually spread worldwide to become an accepted approach to infrastructure provision. In Australia, there would appear to be considerable growth potential for PPPs given that both the New South Wales and Victorian State Governments have recently developed policies to expand the application of PPPs to include social infrastructure, such as hospitals and schools. This growth potential has lead to an on-going debate on the nature of the bid requirements for social infrastructure PPPs, particularly in terms of the cost of bid preparation.

This paper maps the historical development of PPPs in Australia and describes a recently commenced research project which is investigating current approaches to the identification and allocation of risks during the bidding process of social PPPs with particular reference to the legal and financial (i.e. transaction) aspects. The primary objective of this research is to improve the process of risk identification and risk allocation for Public and Private Sector stakeholders in PPP bidding with the ultimate goal of minimising the transaction costs of the bidding process.

Key words: Public private partnership; economic infrastructure; social infrastructure; risk allocation; success factors; complexity index

1. INTRODUCTION

This paper describes a research project that is primarily concerned with the transaction costs of bidding for Public Private Partnership projects, particularly in terms of the process of risk identification and risk allocation. The research project is based on the *a priori* assumption that PPPs are integral part of the Australian procurement landscape to the extent that, to quote Duffield (2005 p. 5), "The Australian PPP industry can now be defined to be in its second generation of the modern era". This is not to say that PPPs are not highly contentious nor without their critics. For example, the recent publicity relating to the Cross City Tunnel in Sydney (Farrelly 2005; Mitchell 2005; Salusinszky 2006; Scott 2006) demonstrates the political risks involved when a high profile PPP incurs the publics' ire. Additionally Curnow et al (2005 pp. 39-42) have argued that the current costs of bidding for social PPP projects (as opposed to economic PPP projects) are unsustainable and that this is a critical issue which, if unresolved, will deter companies from entering into the PPP bidding process, particularly in terms of social projects such as schools and hospitals. Moreover at a very fundamental level some commentators such as Sheil (2003 p. 5) have raised ideological issues with the manner in which PPPs have been deployed in Australia and several writers including Sheil (2003), Davis (2005) and Spoephr *et al.* (2002) subscribe to the view that the use of the term Public Private Partnership is a deliberate attempt to mislead the public into accepting what is, in effect, privatization by stealth.

Whilst, as stated, this paper is primarily concerned with research which has the goal of minimizing the non-value added activities associated with the PPP bidding process, is useful to place this research in a historical context and also to make reference to the strong views currently being expressed in Australia by protagonists against PPPs.

2. PPPS: IDEOLOGICAL OBJECTIONS

As Hodge and Greve (2005) discuss in their introduction to 'The Challenge of Public-Private Partnerships' very large commitments are being made by governments with the private sector under the aegis PPPs. In Australia this will have amounted to 20 billion AUD from the period of 2003 to 2008. (Gray 2002; cited in Hodge and Greve 2005 p. 3). As may be expected, this scale of 'contracting out' has added considerable fuel to the emotive 'public versus private debate'. This debate is universal and has been going on from the time of Adam Smith's 'The Wealth of Nations'(1776). Australia with a much shorter historical exposure to institutional arrangements between governments and the private sector than say the UK has been, perhaps because of this reason, the source of some of the most recent vitriolic criticism of PPPs. Sheil (2003) is of the view that PPPs represent not simply privatization by stealth but "privatization plus stealth". Quiggin (2004 p. 1) presents a similar, if less forceful case in stating that "In most cases the PPP approach involves an inappropriate allocation of risk between the public and private sectors, an excessive cost of capital, and an inappropriate bundling of risk through the use of a single private partner (or consortium) rather than separate contracting for separate contracting for separate project stages. And expresses the view that "…the PFI/PPP approach should be adopted only in special cases."

Trenchant criticism of PPPs is not restricted to Australian commentators. For example Crouch (2003 p.2) presents the argument that "…corporations that are winning the contracts do not themselves have the experience of providing the services. Their core business is winning public contracts across a range of sectors". This is a recurring theme amongst critics of the PPP approach namely that the major private sector players' expertise lies primarily in the organization and winning of tender bids rather than undertaking the work.

The 'language' of PPPs is also a point of issue with its critics. Sheil (2003 p. 1), for example, cites Orwell's essay on Politics and the English Language in support of his proposition that political decay is connected with the decay of the language. The particular point at issue being the use, or from Sheil's point of view, the misuse of the word 'partnership' in PPPs and whether in fact the term 'Public Private Partnerships' has any meaning. In Sheil's view the slack usage of the PPP term by state governments is a deliberate attempt to obfuscate the real issues. Hodge and Greve (2005 p. 7), although by no means 'anti-PPP' cite Linder (1999) in describing PPPs as a 'grammar of multiple meanings' in which "The language of PPPs… is a game designed to 'cloud' other strategies and purposes."

Not withstanding the above quite fundamental objections to PPPs the balance of opinion would appear to be that PPPs are here to stay and are deeply embedded as part and parcel of government procurement strategies. In our view, accepting that PPPs are part of the contemporary procurement landscape is not an unreasonable position.

3. PPPS: AUSTRALIAN ORIGINS

It would appear that most Australian commentators such as Jones (2003), Duffield (2005), Malone (2005) Walker (2003), Jordan and Stillwell (2004) and Evans & Bowman (2005) subscribe to the view that PPPs are a natural progression from Build Own and Operate (BOO) contracts such as the Gateway Motorway and Bridge, Brisbane (BOO completed 1986) and Build Own Operate and Transfer contracts such as the Sydney Harbour Tunnel (BOOT completed 1992). Duffield (2005) has classified Australian PPPs into 'first' and 'second' generation with the release of the Victorian Government policy document 'Partnerships Victoria' in 2001 being the watershed between the 2 generations. Duffield contends that the first generation of PPPs was primarily motivated by the public sector gaining access to private capital and the transfer of near full project risks whereas in the second generation of PPPs state governments sought to retain direct control of 'core services' and to involve the private sector in amongst other things, value for money outcomes (Yates and Sashegyi 2001).

Table 1 is our summation of key events in the development of PPPs in Australia from the 1980's onwards and illustrates the first and the second generation divide.

Table 1: Key Events & Initiatives in the Development of PPPs in Australia

1980's	1990's 1ST GENERATION OF PPP'S	2001 to date 2ND GENERATION PPP's
1980's Pressure due to poor balance of trades, excessive high debt, government borrowing limit capped by loans council, poor fiscal management - Aust. Gov. seeks alternative methods for development without further reducing credit ratings	**1990's** Victoria gives lead with privatisation, outsourcing and BOO & BOOT Projects	**2001:** PPP manual 'Partnerships Victoria' released. Queensland 'Public Private Partnership (PPP) Policy' released in September 2001
1980-90's Australia governments embrace economic liberalism in order to improve efficiencies	**1996**: National Competition Policy, supported by Competition Principles Agreement endorsed by all Australian governments.	**2002:** NSW Government publishes a 'State Infrastructure Strategic Plan'; SA Government releases PPP Policy & establish PPP Unit in Treasury. WA releases 'Partnerships for Growth' was released as the Policies and Guidelines for Public Private Partnerships

1983: Australian dollar floated on international money markets - first step to deregulating the national economy	**1990's** Corporate liberalism emerges in government. An ideological shift towards government playing more of a managerial role. A number of privatizations & outsourcing take place across Australia.	**2002: I**ntergenerational report released with the Budget papers (Treasury 2002) warned that net government spending will need to rise by 5% of GDP by 2041-42 to fund the same standard of services & level of benefits.
1987: NY stock market crash - ripple effect in Aust. ends the speculation boom that had followed the deregulation of the economy.	**2000:** Airport Link Company collapses six months after Sydney's airport rail link is opened, becoming one of Australia's first PPP projects to fail.	**2003:** National PPP Forum held; Victoria 'Fitzgerald' review; NSW 'Parry Inquiry' recommends public debt used only when all other funding options have been fully explored.
1988: NSW first documented formal procedures & controls governing private sector participation.	**2000:** TAS. Government releases a policy statement, and guidelines, on private sector participation in the provision of public infrastructure	**2005:** Local Governments propose to use PPP model for a number of urban revitalisation projects, such as Parramatta, Liverpool in NSW.
		2006: NSW Parliamentary Inquiry into Cross City Tunnel & PPPs. NSW & Victoria announce continued use of PPPs as well as increase use of public debt to meet infrastructure shortfall.

4. RESEARCH APPROACH

Context

As part of this research a compilation was made of all PPP projects[1] from 1986 onwards undertaken to date in Australia. This compilation included all projects listed by Jones and Duffield together with (as far as is known) all PPP projects up to the May 2006. The data indicates (with a few exceptions) that the application of the PPP approach to hard social infrastructure PPPs is a relatively recent trend but one which is gathering momentum with many of the projects currently under consideration or in the pipeline in 2006 being for hard social PPP projects. Whether or not these projects progress to fruition will largely depend on the perceived risks and returns to the private sector. In this respect the research that we are undertaking is highly apposite.

Cost of bidding and bid price

Our research addresses two quite distinct questions. The first question is whether the cost-to-bid ratio is higher for social PPPs than economic PPPs and, if so, does this act as a deterrent to potential bidders? The second question addresses the issue of how bidders for social PPPs identify risks, opportunities/success factors and how these are built into the bid price. It important to distinguish between the two questions as problems can and do arise when the cost of bidding is confused with the bid price. There are difficult methodological issues associated with both questions.

[1] Argy *et al* (1999; cited in Grimsey and Lewis 2004 pp. 20-21) make the following useful distinctions between types of PPPs:

- hard economic infrastructure e.g. roads
- soft economic infrastructure e.g. financial institutions
- hard social infrastructure e.g. hospitals
- soft social infrastructure e.g. social security

The Cost of Bidding

Hughes et al (2006) describing a study on the cost of procurement in the construction industry, makes the statement that there is a "desperate need for robust data" in respect to tendering costs. Whilst it may appear to be a relatively straightforward matter to identify the costs of bidding for a specific project, in reality this is not the case. "Complexity of the data collection places significant hurdles in the way of those who wish to undertake research in this area. This is probably why so few attempts have been made at assessing these costs. The quantification of the costs of tendering that have already been reported in the literature tend to focus on the cost of estimating and bidding, and take no account of the relationship between the distinct stages of a project. Moreover, they are based on impressionistic estimates, rather than analysis of data. However, the fact that they range from 1% to 15% indicates a strong feeling that there is a lot of expenditure in this area, and it is difficult to quantify. Also there is the further conclusion that the value added by this expenditure is not clear" (Hughes et al, 2006). The authors comment on 'impressionistic estimates' is particularly interesting in the context of PPP bidding. Our own research is still at the data collection stage and the data has yet to be finalized and analysed. However we are beginning to appreciate the aptness of their term 'impressionistic estimating'. In addition to the difficulties associated in accurately allocating costs to a specific tender bid there is the added dimension of the commercially sensitive nature of the data surrounding PPP bidding and also the extended nature of the commercial relationships of a PPP consortium.

Bid Price

As previously discussed one of the primary objectives of this research is to explore how PPP consortiums allocate the costs of risks, opportunities and success factors in their bid price. Whilst a good deal of research has been conducted in the risk management field in terms of the risk measurement/ risk analysis part of the process, it would appear that often there is a mismatch between theory and practice. A survey of 123 respondent Australian companies and organisations by Yates and Sashegyi (2001) found that for many large projects:

- formal risk assessments were not undertaken,
- risks were not being allocated to the party best able to manage the risk,
- risk clauses were often varied from those in the standard form of contract,
- risks were being transferred to consultants and contractors which were impossible for them to manage,
- cost saving would have occurred if risks had been more efficiently allocated, and
- contractors, consultants and principals have widely different views on current risk allocation (procedures).

Whilst the above findings are not specific to PPPs they are generally indicative of the problems of risk allocation in major project and certainly come to the fore when a project fails to live up to stakeholder expectations.

Bowen and Edwards (2005) note that the prevailing view of risk as a negative concept is under challenge and describe an emerging school of thought in the form of 'opportunity management' where "one person's risk may be another's opportunity to profit". However Bowen and Edwards also note that whilst the notion of opportunity being the converse of risk is laudable, most risk management publications (including their own text) dwell on the aspects of risk as viewed in a negative rather than a positive context. Bowen and Edwards explain that “in opportunity management, the probability attaches not to the occurrence of a particular event leading to a consequence, but to the attainment of a particular outcome if a particular decision is made.” From a methodological point of view attempting to undertake a forensic investigation of the consequences of a particular set of decisions is fraught with difficult. However being able to identify specific factors which correlate to the project outcomes is a more achievable objective. For this, and other reasons we have determined to examine the positive aspects of risk through critical success factors.

Critical Success Factors

The concept of ‘Critical Success Factors’ (CSF) was developed by Rockart and the Sloan School of Management with the phrase first used in the context of information systems and project management (Rockart 1982). Morledge and Owen (1999) further developed the concept of CSF by identifying certain weaknesses associated with the practical application of Rockart’s method. They identified and attempted to address the perceived areas of weakness such as: subjectivity; bias; human inability to process complex information; time dependency; generalisation; and qualitative performance measures.

Research into CSF has been on-going for several decades although Sanvido *et al* (1992) maintain that the CSF approach has been largely ignored by the construction industry and establishing the factors that make construction projects successful has been particularly intractable. Recent research tends to take a relationship-based approach to the issue of CSF. For instance, Rowlinson (1999) states that critical success factors are those fundamental issues inherent in a project that must be maintained in order for team-working to take place in an efficient and effective manner. They require day-to-day attention and operate throughout the life of the project.

A number of authors have identified factors they consider critical to the success of project procurement under PPP or similar concepts. Table 2 lists the CSF factors for PPPs with author citation.

Table 2: CSF factors for PPPs with Author Citation

CSF	Citation
Appropriate and developed legal framework	Tiong (1995)
Financial capability and support	Tiong *et al* (1992)
Appropriate risk allocation	Grant (1996)
Political stability and support	Keong *et al* (1997)
Expertise	Salzmann and Mohamed (1999)
Local partner/s	Salzmann and Mohamed (1999)
Transparency	Jefferies *et al* (2002)
Appetite for competition	Jefferies (2003)
Tender cost reimbursement for loosing contractors	Jefferies (2003)
Commitment	Hardcastle *et al* (2005)
Developing a culture of partnership	Duffield (2005)

Success within the context of a PPP will mean different things to different stakeholders. They will have some common goals but will also have several project and long-term aims that are very different. We believe that this critical assessment is best dealt with through the use Critical Success Factor concept and, as previously stated, this is the methodology that we intend deploying in our research approach.

5. PRELIMINARY FINDINGS

The following initial findings were identified during the first round of data collection, i.e. workshops and interviews with key stakeholders in the PPP bidding process. This initial stage helped to identify the characteristics of social PPP projects in Australia and also map the development of these projects. These findings provide the foundations for the remainder of data collection and in particular the identification of CSF.

Characteristics of Social PPP Projects

Respondents generally agreed that hard social infrastructure projects (schools, hospitals) are characterised as being smaller in scale than economic infrastructure projects (motorways, bridges, tunnels etc.) and, by their very nature, also tend to be complex, particularly in terms of ongoing involvement with the community. Thus private sector bidders for social infrastructure PPP projects are often presented with a situation where the financial rewards are less and the operational demands are more complex than for economic PPP projects.

This round of data collection also identified that there is a strong body of opinion to support the contention that current social infrastructure projects in Australia are not true partnerships and there is a clear need to reduce the ‘tokenism’ of Australian PPPs. Interview participants put forward the view that the Public Sector needs to make PPPs more attractive to the Private Sector and clarify the identification of risk in order to transfer more responsibility to the Private Sector. This issue is supported by other recent industry criticism of PPPs concerning the ‘narrowness’ of the scope of work that is offered to the private sector.

PPP project costs relating to finance, building design, construction, maintenance and waste management amount to less than 15% of the total life cycle cost of the enterprise. As a result, the private sector may be deterred by the high transaction costs of PPPs, which offer only a marginal increase in scope of business opportunity. This is in stark contrast to opportunities that are available in the much lower cost-to-bid ratio of more traditional procurement models or in hard economic PPP projects where the revenue stream from, say, a freeway toll way has a substantial and clearly defined internal rate of return. Governments are looking for significant increases in efficiency through the PPP process, but no matter how well the 15% of the enterprise available to the private sector is organised, it is not going to make up for inefficient management in the remaining 85%. We have also received comments that support the view that a number of major construction contractors are either withdrawing from social PPP projects completely or are being highly selective due to the unattractiveness of the projects on offer.

6. CONCLUSIONS

As previously stated this paper is based on a research project which is still at a preliminary stage. Whilst the theoretical underpinning has been established, data collection is proving to be difficult, although not insurmountable. This is partly due to the commercially and politically sensitive nature of the data. Additionally the paper trail involved in tracking data is extensive. A PPP consortium is a temporary organisation with a complex network of players with competing goals and objectives, many of whom never get to see the complete picture. Inevitably the group operates under pressure, particularly the members of the SPV (Special Project Vehicle) who are the drivers of the bidding process. The private sector view which has been continuously reinforced in our workshop sessions is that social, as oppose to economic PPPs, are more complex with relatively higher bid costs. Another recurring theme has been the difficulty in developing a true partnership between the public and the private sector in bidding environments which are frequently adversarial. In an ideal situation 'success' would result in win-win situation with a successful outcome for all the stakeholders, whereas all too often success is regarded as victory for the public sector over the private sector or vice versa.

It is our view much of the negativity and adversarial environment which surrounds PPPs is due to a lack of transparency both in terms of the costs of bidding and in terms of identification of risk, opportunity and success factors. This research which will track, for the first time (at least at any rate in Australia), the transaction costs of bidding together with CSF and should assist, at least in part, in providing a better understanding between stakeholders in the PPP process.

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THE CULTURE OF PROJECT MANAGEMENT IMMATURITY IN PUBLIC SECTOR INFRASTRUCTURE ORGANIZATIONS - THE CASE OF WOB

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ABSTRACT

Public sector infrastructure organizations responsible for infrastructure development in South Africa, which include infrastructure departments, parastatal organizations and other statutory organizations qualify as project-oriented organizations (POO). Project management (PM) within their activities is considered to be a core competence and this competence has to be explicitly developed by these organizations. There are strong indications to suggest that these organizations' PM competencies leave a lot to be desired. On face value they purport to be fully fledged project oriented organizations and performing as mature PM organizations, while in reality they are enmeshed in the *culture of PM incompetence by default*. This paper reports on a study, which was carried out in one of the largest infrastructure department in South Africa. The focus is on one of the largest programmes managed by the department. In order to determine the department's PM maturity, an evaluation of the performance of the programme was carried out in relation to department's mandate. It is found that the programme in its current form could be described as a 'white elephant' and a programme, which does not have an appropriate organisation structure, appropriate and sufficient staff to carry its objectives. Generally, it is quite clear that the programme control system is very weak or non existent, hence the existence of sketchy standards, policies, procedures, decision rules, and reporting requirements to monitor and control its various initiatives – *PM immaturity characteristics seem to dominate the management of the programme and departmental managers responsible for the programme are not conscious of these immaturity characteristics*. There are strong indications to suggest that the department is still marking time at Level 1 of PM Maturity. Recommendations are made which will help the department to move up the ladder of PM Maturity and shed the culture of PM immaturity thus capable of managing the programme.

Keywords: Culture, infrastructure organisations**,** project management immaturity, public sector**,** project management competence

1. INTRODUCTION

South Africa is a country of 45 million people, classified as an upper middle income country by the World Bank and ranked 120 out of 177 countries on the United Nations Human Development Index (World Bank 2005 and 2005a). Classification and ranking provides a picture of a country with one of the most skewed economic set-up, where most of the very poor people are black and the majority rich are white. This gives a true reflection of the apartheid policies then before 1994. Furthermore, South Africa is by far the largest economy contributing in excess of 66 percent to the overall Gross Domestic Product (GDP) of the Southern Africa Development Community (SADC) region. The economy of South Africa experienced expansion in recent years fuelling a boom in the construction industry that is manifesting itself in the shortage of skills and construction material manufacturing constraints. Since 1994, the Department of Public Work (DPW) has championed a range of initiatives and has co-coordinated the development of a comprehensive construction industry development policy. Towards the end of 1995, the department generated a position paper entitled, *"Establishing an enabling environment to ensure that the activities of the reconstruction and development programme (RDP) and related initiatives by Government are realised in the construction and allied industries"* for consideration by Government. Early in 1996, the DPW was mandated by the government to lead the initiative in conjunction with all infrastructure government departments – South African infrastructure departments (SAIDs), which in addition to itself, include .the Department of Housing (DoH), Department of Local Government (DoLG), Department of Transport (DoT), and the Department of Water Affairs & Forestry (DWAF).

Through further research, the DPW produced a discussion document, which formed the basis for a round of consultation workshops with industry stakeholders, and this resulted in the formulation of a Green Paper (DPW 1997). The Green Paper was released for broad comment in November 1997. In line with the Green Paper proposals, an Inter-ministerial Task Team on Construction Industry Development was appointed by the DPW on behalf of the Infrastructure Departments. The task team was drawn from the private sector, organised labour and the public sector.

Following discussion on the Task Team's review of comments on the Green Paper, a White Paper (the Construction Industry Policy) was produced in 1999 (DPW 1999). The policy, which could be referred to as a South African Construction Industry development map, spells out its strategic aim as:

> *"…..to establish an enabling environment in which the objectives of reconstruction, development and growth are realised in the industry."*

The policy also spells out its vision as:

> *"…to promote stability, foster economic growth and international competitiveness, create sustainable employment, and to address historical imbalances as new industry capacity for industry development is generated."*

While the DPW was responsible for co-coordinating the development, monitoring and dissemination of Government policy for construction development, different departments are charged with the implementation of various programmes outlined in the policy. These programmes fall under the SAIDs.

From the foregoing, it is clear that infrastructure departments forming part of a broader public sector need to aim towards good practices in contributing to the South African construction industry and development in general. The human resource capacity issue makes the situation even more demanding. Between 1994 and 2001, the number of civil servants decreased from 1.2 to just over a million (CIDB 2004).

The resulting capacity constraints have significantly affected infrastructure departments such that almost 25% of these infrastructure departments procurement budget is now spent on private sector experts providing policy advice and project management services, but without internal capacity to manage these external consultants. The need for project management expertise within all infrastructure departments has become so fundamental in order to deal with an enormous responsibility of managing a huge number of programmes.

The number of projects falling under every infrastructure department as indicated in Table 1 is so huge that the only way to coordinate and deal with these projects under a high level of staff turnover and limited budgets is for the departments to be fully fledged project oriented organizations (POOs).

Table 1. Infrastructure Departments Programmes and Projects (2004/5)

Infrastructure Department	**Number of Programmes**	**Number of Projects (approx.)**
Department of Public Works (DPW)	5	35
Department of Housing (DoH)	6	31
Department of Local Government (DoLG)	6	18
Department of Transport (DoT)	6	30
Department of Water Affairs & Forestry (DWAF)	16	55

Source: www.gcis.gov.za/docs/annual/2005/pll.pdf

The South African government capacity constraints in infrastructure departments are not peculiar to South Africa. They seem to be common almost in all non-industrialized countries (Fay and Yepes 2003; Harris 2003; Parker and Kirkpatrick 2004). It is very important therefore to note that the findings reported in this paper could be used towards addressing capacity constraints in other non-industrialized countries.

As indicated in Table 1, South African infrastructure departments (SAIDs) are under pressure to improve performance in order to address developmental constraints facing the country. The fact that the SAIDs are structured along programmes and consequently projects, strongly suggest that they are project oriented departments or the success of these infrastructure departments (IDs) is contingent on being able to make predictions and commitments relative to their services and products. Their project management competence is fundamental to make this a reality. This Project management competence is extensively referred to as ‘project management maturity’ in various theory and practice literature (for example in Skulmonski and Ginger 2000; Broadman, Johnson 1995; Kaplan and Norton 1992; Lynch and Cross 1995). The need for the SAIDs to function fully as project oriented departments is one of the alternative ways to succeed. According to Schlichter (1999), project management (PM) has led a number of organizations to be more effective and efficient in delivery of their products and services, more accurate budgeting and scheduling, improved productivity, and improved customer relationships. All these are fundamental if the SAIDs are to meet their mission and vision.

Going through the SAIDs Annual reports, it is clear that Florac, Robert and Carleton's (1997) questions are forming the framework of each and every report. Every infrastructure department seems to ask Florac, Robert and Carleton's (1997) questions:

> *"Are we achieving the results we desire?" "Are we meeting our customer's success criteria?" and "Are we achieving our desired return on investment?"*

But how do they (the SAIDs) know if their management approaches are appropriate and will consequently lead projects to meeting set objectives embodied in their policy mandate? A project management competence or maturity assessment can provide the basis to evaluate progress in pursuit of best-in-class project management status.

According to the CIDB (2004) public sector capacity is a key constraint to the realization of investment potential, delivery of infrastructure and industry's sustainable development. It argues that as a largest single industry client, the public sector is dispersed and spans all three spheres of government and this challenge can only be met with a systematic management approach. Looking at the public sector business set-up of SAIDs, which is organized in programmes and consequently into projects as indicated in Table 1, there is no doubt that these public sector POOs must embrace their core competence in order to have a sound systematic management approach. Core competences as defined by Prahalad and Hamel (1990) and Hamel (1994) are an organisation's *fundamental capabilities, an integration of skills that are competitively unique*. This means that these capabilities are difficult to imitate. The core competences enable the organization to deliver a fundamental customer/or stakeholder benefit and therefore contribute to the long-term survival of the organization. Embracing core competencies therefore, means adopting a ***PM maturity culture.*** The salient question to be asked at this point is: *What is a PM maturity culture?*

This paper aims to answer this question by presenting survey results from a case study of a major national programme being managed by one of the South African infrastructure departments (SAIDs). In order to maintain the department's anonymity it is referred to in this paper as WOB. The management of the programme (which will be referred to as KProg) is scrutinized in order to establish the ministry's PM maturity culture. In order to determine WOB's PM maturity culture, an evaluation of the performance of the KProg was carried out in relation to WOB's mandate. A clear reflection is made on KProg's original intent of advancing the transformation process of the construction industry and diversifying its shareholding structure.

This paper is organized as follows. First, a theory and practice of PM competence culture review and the purpose of this paper are presented. Then, the key results of the Case Study are presented and discussed. These results are also compared with previous results presented in the theory and practice review. Finally, the paper concludes with a brief summary of the salient findings and some of their implications.

2. PM MATURITY CULTURE – THEORY AND PRACTICE

According to Seymour and Fellows (1999), culture is acknowledged to be rooted in people's minds – their ideas, beliefs and values. They argue that belief lie at the core and become hierarchical – *ordered into a value structure which underpins behaviours, thereby creating the other manifestation of culture*. The principal argument of this paper regarding ***''PM maturity culture'*** accepts this argument, and adopts the definition of culture based on developments of 'culture' definition since the middle of the 20th Century as argued by Barthorpe, Duncan and Miller (1999). Since the primary focus of this paper is on construction industry practices, the arguments discussed in this paper are based on organisational culture definition, by Kroeber and Kluckhohn (1952) and Hofstede (1980).

According to Kroeber and Kluckhohn (1952), organisational culture describes:

> *"….patterns, explicit and implicit of and for behaviour acquired and transmitted by symbols, constituting the distinctive achievement of human groups, including their embodiment in artifacts; the essential-core of culture and consists of traditional (i.e. historically derived and selected) ideas and especially their attached values; culture-systems may, on the one hand, be considered as products of action, on the other as conditioning elements of future action."*

Hofstede (1980) adds another dimension of distinction between members of the organisation, by defining organisational culture as:

> *"….the collective programming of the mind which distinguishes the members of one category of people from another."*

From the above two definitions, it could bed argued that officials in SAIDs are not free to act in ways which they perceive to be most beneficial in managing programmes and consequently their respective projects. Constraints are imposed to yield a decision environment of bounded rationality (Simon, 1960). This, according to Seymour and Fellows (1999), is through the particular situation and norms of behaviour – both explicit (pressures from stakeholders, government procedures, departmental organisational set-up, law) and implicit (moral codes etc.) – there are strong indications to suggest that the culture of 'PM immaturity' has taken root due to various pressures originating from stakeholders and government's enormous challenge of trying to deliver various services within a very short space of time.

According to Dinsmore (1999), an organization's project maturity level:

> *"…is a measure of its effectiveness in delivering projects (or programmes – author's emphasis)"*

Strengthening Dinsmore's (1999) definition, Gareis and Huemann (2000) define PM competence as:

"…the ability to perform the project management process efficiently."

Gareis and Huemann (2000) further argue that the PM competence relates to specific PM tasks to be fulfilled, and it exists if there is PM knowledge as well as PM experience. In the POO, PM competences can be differentiated for individuals, for project teams and for the organization.

From the foregoing, it is fair to say that the *PM maturity culture of an organization is primarily determined by establishing how PM competent an organization is*. When you refer to PM competence, you are at the same time referring to PM maturity culture. At present, the best way of assessing an organization PM maturity culture or PM competence level is through PM competence models.

Existing PM competence models (PM maturity models) or assessment approaches are based on the Carnegie-Mellon University Capability Maturity Model (CMM) for software development, prepared in conjunction with the Software Engineering Institute (SEI). Details of this model are described elsewhere (Humphrey 1989; Paulk, Curtis and Chrissis 1991). According to Gareis and Huemann (2000), during the late 1990s several specific PM competence models to describe and measure the organizational PM competence were developed (Ibbs and Kwak 1997; Goldsmith 1997; Fincher and Levin 1997; Hartmann 1998). Most of these are based on the Project Management Institute (PMI) Guide to the Project Management Body of Knowledge (PMBOK). Dinsmore (1999)and Gareis and Huemann (2000)argue that traditional competence models use four to five steps to describe and measure the competence to perform a specific in an organization. The scale usually used is initial, repeatable, defined, managed and optimized according to the SEICMM (Paulk, Curtis and Chrissis 1991) or initial, repeatable, managed, distributed and sustained (Bolles 2002). Bolles's (2002) levels have been adopted for this study as indicated in Table 2.

Table 2. PM maturity culture characteristics

Stage	Characteristics
Initial (I)	No formal methodology for managing projects; projects are managed ad-hoc and success is not repeatable; no formal training and education exists; projects are typically late and over budget if completed; no review process; no project authorization process; and project risk assessment is nonexistent.
Repeatable (II)	POO structure is established at some levels; standard methodology is created and distributed; PM fundamentals are provided at all levels; project portfolio management has been implemented; 25-50% of project deliveries are successful.
Managed (III)	POO structure is established enterprise-wide; PM qualification programme is in place; internal intranet is used extensively for all PM functions; virtual and real-time project status reporting is common; PM education and training is a requirement at all levels; 50-75% of project deliveries are successful.
Distributed (IV)	Principles of a learning organization are a norm; executives and managers PM qualified; all project managers are required to complete internal/certification programme; 75-95% of project deliveries are successful.
Sustained (V)	Management by projects is an organization philosophy; executives and managers PM qualified; all project managers are required to complete internal/certification programme; 99% of project deliveries are successful.

Source: Bolles (2002)

Although retaining the traditional competence model as indicated in Table 2, this study has added 'the spider's web' principles, developed by the 'Projektmanagement Group' in Vienna, where PM sub processes are considered in the study in order to clearly understand how WOB is organized and specifically on how her PM processes relate to managing KProg. Details of the Vienna model are described in detail elsewhere (Gareis and Huemann 1998).

From the background information described above, it is fair to argue that the success of SAIDs is contingent on being able to make predictions and commitments relative to its services and products. Consequently, PM maturity culture is of interest to PM professionals at an infrastructure department level like WOB since having a PM maturity culture is viewed as one that is having a conducive environment to move on the maturity ladder from Level I to higher levels in order to meet its commitments in terms of its services and products (for example in managing KProg).

In the process of maturing (embracing the PM maturity culture) across maturity levels indicated in Table 2, Bolles (2002) argues that organizations and individuals either gain or lose ground, but *they never stand still*. But w hen an organization shows characteristics of not losing or gaining ground, then it is considered to be in a *stand still position and it is considered to embrace a PM immaturity culture.* But this conclusion needs to be qualified by looking at *the type of organization and its support base.* For public organizations with an appropriate support base from the government like the SAIDs, remaining within levels I and II without gaining ground beyond Level II is considered to be in a *PM immaturity culture zone*. Based on this argument it could be said that if a public organization shows movements (gaining or losing) between Level II and Level V, but without moving below Level II or showing signs of standing still in Level II, then it is considered to embrace a *PM maturity culture*. This interpretation of maturity culture will be used in the study to determine where WOB stands between two extreme points of *'mature culture' and 'immature culture'* by analyzing its performance in managing KProg.

When analyzing *'mature culture' and 'immature culture'* in those organizations which are supposed to be project-oriented organizations (POO) like the SAIDs, it is important to remember that maturity or immaturity in PM is not just required by individuals, but also by project teams and organizations. Hence these have to correlate (Gareis and Huemann 2000). The PM maturity culture of individuals performing project roles, such as project sponsor, programme manager, project manager or project team member, have to be in accordance with the PM maturity culture of the organization as a whole. The PM maturity culture of individuals, project teams and organization can be described, measured and further developed through determining PM maturity levels shown in Table 2. Since PM is considered as a core competence in strengthening the PM maturity culture in a POO, this competence has to be explicitly developed by the organization.

A Project Oriented Organization (POO) –the characteristics

In order for an organization to qualify as a POO, which is a condition for the need to embrace a *PM maturity culture*, an organization should have the following characteristics (Gareis and Huemann (2000) : management by projects must be an organizational strategy; adoption of temporary organizations for the performance of complex processes; it must manage a portfolio of different project types; it must have specific permanent organizations to provide integrative functions; it must apply a 'new management paradigm'; it must have an explicit project management culture; and it must perceive itself to be project oriented.

Based on the above seven characteristics, it is important that a POO must consider projects as tool to perform complex projects and as strategic options for organizational design. Furthermore, it is important to note that management by project is the organizational strategy of organizations dealing with an increasingly **complex environment**. This **environment** is affected by a number of forces originating from the project itself, the organization sponsoring the project, and organizations involved in project implementation, the sector or industry relevant to the service or product resulting from the project, forces from the country/economy and forces coming from the world environment on economics, politics and other social pressures. In the process of balancing project parameters (quality-Q; Cost-C; schedule-S; utility-U) within health and safety (H&S) and environmental (E) requirements, the stakeholders' requirements are addressed. This complex environment is described in Figure 1.

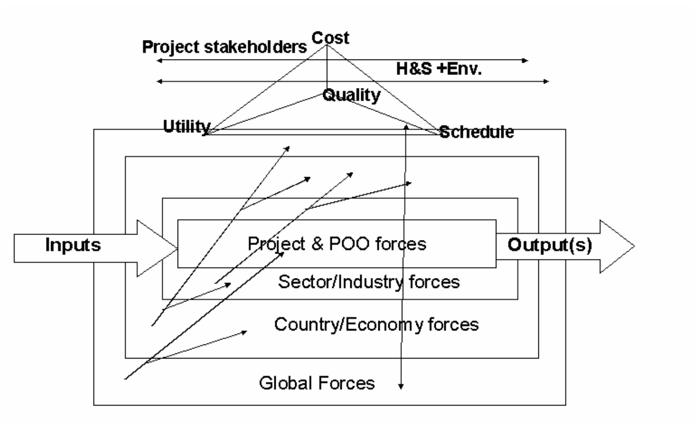

Figure 1

By applying management by projects, the organization will be able to embrace a *PM maturity culture* and sail through the forces (Gareis and Huemann 2000), indicated in Figure 1 and pursue the following objectives: Organisational differentiation and decentralization of management responsibility; Quality planning, control and assurance by project team work and holistic project definitions; Goal orientation and personnel development; and Organisation of organisational learning by projects. In order to embrace PM good practices, the POO is characterized by the existence of an explicit ***PM maturity culture***, such as *a set of PM-related values, norms and procedures.* (Dinsmore 1999; Gareis and Huemann 2000).
In conclusion, a review of theory and practice suggests that *a PM maturity culture* is not just required by individuals in a POO like WOB, but also by project teams and by organizations. A review suggests also that PM is a core competence of a POO and this competence has to be explicitly developed by the organization.

3. CASE STUDY DATA

In order to have representative data on *PM maturity culture* in SAIDs, an intensive scrutiny was made on the 5 SAIDs PM portfolio (see Table 1), both from the scale of work they are involved in and the importance of their activities across the country (looking at 3 tiers of the public sector – *local authority, provincial and national*). The department – WOB was thus identified as the most fulfilling of the two criteria.

Within WOB, a similar criteria to the one used to select a focus department was used, but focusing on identifying a single programme, which has depth in terms of what is supposed to be accomplished (scale of work) and the position of the programme when looked at across the three levels of the public sector (across local authority, provincial and national – looking at the programme boundaries). KProg was identified as the largest programme within WOB and across other SAIDs based on the criteria.

In this research a thorough literature review (theory and practice) in KProg primary business area was carried out. Structured interviews based on a questionnaire (33 questions) were carried out to KProg clients identified from existing KProg database. The sample was randomly chosen from a total of 3817 KProg clients and consisted of 458 clients, about 12% of the clients on the KProg client database. The survey included questions on *the general background of the respondents and their projects, as well questions on their formal skills in the types of businesses they were involved in, their organizations profiles, duration in the business, types of projects they were involved in, geographical area operation, level of business involvement, problems facing them and their businesses, their sources of finance, and their evaluation of KProg performance* (including reasons behind their dissatisfaction).

Structured interviews were carried out also with regional KProg managers (39 questions). The survey included questions on *KProg development from its inception to its current phase, achievements (on KProg objectives and tools used to meet them), processes used in monitoring their clients* (including updating of KProg database), *their assessment of WOB as the KProg parent department on the extent to which it has succeeded in accessing clients across the country* (more in rural areas), *appropriateness of existing documentation in managing clients, performance of their clients, policy on client relations management, client complaint procedures and training of clients*.

Other relevant National WOB key officers were interviewed through structured open-ended questions (between 13 -19 questions depending on the relevance of the question). Questions were focused on *the relationship between KProg and other programmes within WOB, processes in addressing KProg clients, and the ideal strategies to improve KProg*.

Another set of structured interviews were carried out with senior officers of two randomly selected institutions (1 private and 1 public) offering financial support to KProg clients (13 questions). Questions focused on *their policy on the support of KProg clients and tools used to measure success of their support to KProg clients*.

A one day KProg clients' organizations workshop, where 13 randomly selected representatives of KProg clients organizations drawn from all over the country attended. The original intention of the workshop was to supplement the questionnaire based interviews to KProg clients described above by reviewing the various objectives of KProg and assess whether it was meeting these objectives, its strengths and weaknesses, problems hindering it from fulfilling its mission and possible solutions to those problems. To this end a series of issues aligned with the programme was complied and an interactive process planned which it was hoped would yield valuable input. Participants however objected to what they called '*a piecemeal review of KProg'* and its performance, likening it to *rearranging deck chairs on the Titanic*. In the unanimous opinion of the participants, the programme had been overtaken by events and they preferred a strategic, comprehensive evaluation, which they hoped would lead to a major overhaul.

Research Method

Although structured interviews and a workshop were used in this research survey to deal with respondents within the research territory, the foundation of the study was focused on conducting a qualitative research – *through a case study*. Following in Priest, Roberts and Wood's (2002a and b) foot steps, it is important to note that one of the most challenging aspects of conducting qualitative research lies in the analysis of the data. Furthermore, the author was confronted with the challenge of satisfying the *'quantitative research believers'* who strongly argue that quantitative research is the only reliable approach and the *'case study skeptics'* who feel that case studies do not provide an appropriate base towards reliable findings. The *'quantitative research believers'* and part of the *'case study skeptics'* will feel comfortable that the author has intensively used structured questionnaires to collect data. Another section of '*case study skeptics'* will still know how a case study and one case study for that matter can represent a study on 5 SAIDs. The strengths of one case study representing five SAIDs have been dealt with above and the only issue to be argued here is the strength of using the case study method for this research project.

The case study method has a long and respected history in the social sciences. Yin (1994), for example, points to the classic case studies by Whyte (1943) on the 'Cornerville' community and Allison (1971) on the Cuban missile crisis. There have also been seminal examples of case research within the management literature. Gibb and Wilkins (1991), for example cite Blau's (1955), Gouldner's (1954) and Dalton's (1959) work on bureaucracy. According to Perren and Ram (2004), the philosophy and implications of the case-study method have received considerable attention in the methodological literature (e.g. Eisenhardt 1989, 1991; Gibb and Wilkins 1991; Ragin and Becker 1992; Stake 1994; Gomm, Hammersley and Foster 2000) and there are a number of standard texts on the approach (e.g. Stake 1995; Yin 1994). Based on these findings, which are widely accepted across the world (Perren and Ram 2004), the author feels strongly that the method used in this study is sound and the way in which it was selected is balanced. Furthermore, three different approaches were used to analyse and interpret data. These are: *grounded theory analysis, content analysis, and narrative analysis.* In order to remain focused to the letter of these approaches, Priest, Roberts and Wood's (2002a and b) principles were followed closely.

Survey Findings

KProg clients survey results

The following responses were obtained from a questionnaire survey of a randomly selected sample of KProg clients. In many of the questions the responses do not total 438 as some respondent chose not to answer the question.

- *Company profile: type of firm*

The most popular type of firm for the respondents was the closed corporation, followed by sole proprietorships. Partnerships trust firms; private limited firms and non-profit organisations were not popular. Surprisingly, given the reported small nature of KProg client firms, Close corporations outnumbered sole proprietorships by almost 7.5 to 1.

- *Geographical area of operation*

This question aimed at identifying the geographical scope of operations of the firm, and the responses were categorised according to whether the KProg clients indicated they carried out jobs in and out of the country, anywhere within the country, within a number of provinces, in only one province, within a city or municipality or within a district or region. The results show that most of the KProg clients have a provincial scope of operations, with 82% of them carrying out works within one province. Only one KProg client carried out work out of the country, in Botswana.

- *Main problems faced by KProg clients*

KProg clients ranked 'lack of steady work opportunities' as the biggest problem facing them, followed by 'slow progress payments', 'credit and cash flow problems', 'complicated tendering procedures', and the 'lack of financial and managerial skills'. The 'lack of technical skills' and the 'lack of experience' were not seen as significant.

- *Managerial skills and training required*

The skill or training KProg clients would like to acquire most to help them in their businesses (Table 5) are tendering skills, identified by 223 KProg clients (51%), financial management skills (51%) and project management skills (50%).

- *Evaluation of KProg on the basis of expectations*

Most KProg clients either agreed with or disagreed with the assessments of KProg, with few adopting a neutral stance as indicated in Table 3. Opinion was generally split between those who assessed KProg favourably and those who saw it in unfavourable light. It can be concluded that KProg performs poorly in facilitating its clients to access credit facilities, and in facilitating KProg clients to acquire knowledge in competitive estimating techniques and business management. It is seen more favourably in facilitating KProg clients to access training and has best reviews in providing work opportunities and mobilising support nationally for KProg clients. Overall, however, opinion is divided as to KProg's performance.

Table 3 Assessment of KProg's performance

			Percentage of clients		KProg
Statements	**Fully met with my expectations**	**Nearly met with my expectations**	**Neutral**	**Some what**	**Not at all**
Through the WOB, KProg is providing work opportunities and mobilising support nationally for its clients	42	9	10	4	35
KProg is facilitating for its clients to access credit facilities	26	3	5	3	63
KProg is facilitating for its clients to access training	43	5	4	3	45
KProg is facilitating its clients to acquire knowledge in competitive estimating techniques and business management	36	4	6	2	52

- *Satisfaction with the administration of KProg*

The largest group, 41%, considered themselves very satisfied with the administration of KProg, 10% 'quite satisfied', 15% saw KProg 's performance as just 'Satisfactory' 1% were 'Somewhat dissatisfied', and 32% were 'Very dissatisfied'.

- *Overall assessment of KProg (its long-term usefulness)*

KProg is seen as an excellent tool for long-term business success by 28 % of KProg clients; and as beneficial by 15% of them. Eighteen percent are neutral, 19% see its performance as a along term tool as fair and 23% as poor. These figures show a fairly even split between positive and negative views on KProg.

- *KProg database as a tool for KProg clients' assessment*

Almost half (48%) the respondents interviewed were very satisfied with the database as a tool for their assessment, monitoring and management. This is a favourable review considering that only 22 % were 'somewhat dissatisfied' to 'very dissatisfied' with the database. Similar reasons were advanced for dissatisfaction with the database as are advanced for the overall assessment of KProg.

- *Help Desk Facilitator ability to provide advice and assistance*

The Help Desk Facilitator was viewed as 'very satisfactory' by 54% of the respondents, as 'quite satisfactory' by 10%. Its performance was seen as 'somewhat unsatisfactory' by 2% and very unsatisfactory' by 16 % of the respondents. Though in the minority this is still a significant number, nonetheless.

Workshop with KProg clients' organisations

The original intention of the workshop was to review the various objectives of the KProg and assess whether it was meeting these objectives, its strengths and weaknesses, problems hindering it from fulfilling its mission and possible solutions to those problems. To this end a series of issues aligned with the programme was complied and an interactive process planned which it was hoped would yield valuable input. Participants however objected to what they referred to as 'a piecemeal review of KProg' and its performance, likening it to rearranging deck chairs on the Titanic. In the unanimous opinion of the participants they felt that the programme had been overtaken by events and they preferred a strategic, comprehensive evaluation, which they hoped would lead to what is called 'a major overhaul'.

While acknowledging the need for KProg as an intervention to level the playing ground in SACI, participants had numerous criticisms of the programme. These ranged from KProg in ability to build on the strengths of the existing emerging clients, its inability to bring the KProg clients organisations on board 'ab initio', to KProg's little emphasis on the need to develop KProg clients and pull them from whatever their entry level was to an exit level predetermined where they could then be independent of KProg.

Summary of findings: regional officers responsible for KProg

The managers identified KProg major weakness as the blanket acceptance of every client who had applied without physically visiting the client business office to check and verify information and capacity. There was no limit to number of clients entering the programme, little or no attempt at a screening process and no focus so the targeted market became too broad. This created problems later on in terms of poor KProg client performance and client dissatisfaction. Other issues included KProg mechanism for monitoring clients, which was either poor or non-existent and the vagueness of KProg mandate, and

4. CONCLUSIONS

The results of this study described above provide a strong indication to show that WOB does not seem to have the ability to make predictions and commitments relative to its services. There are strong indications to suggest based on the department's premiere programme (KProg) management that WOB does not possess sufficient skills and abilities to manage its programme as a POO. *On the PM Maturity culture level, it seems to have* remained within levels I and II. Level I characteristics are more dominant to WOB. Although the PM maturity culture evolves over time as the organisation's PM maturity increases, WOB's progress for the last 7 years, suggest otherwise. During this period it seems to have lost more from Level II and stagnated at Level I (see Table 2). The *PM immaturity culture* seems to dominate *its business.* Under these circumstances, the position of WOB need to be re-assessed and re-organisation of its framework in order to embrace a PM maturity culture.

According to this study, which could be described as mirror for other SAIDs, it seems fair to conclude that government m departments responsible for infrastructure seem to have good intentions and basic ideas on how to deal with implementation of various responsibilities within their mandate. The choice to organise around projects is an appropriate one, but the choice needs to be supported by other requirements in order to deliver their projects. For these public sector organisations to benefit from this choice of organising around projects (becoming true POO), they need to fully embrace the *PM maturity culture* as a dominant culture, where individual and team learning have to be organized. Instruments for the further embracing of the *PM maturity culture* have to be differentiated for *individuals, teams* and *the organisation* as a whole.

For WOB and other infrastructure departments in non-industrialized countries the lesson to be learnt from this study is that organizing around programmes and projects (as project oriented organization – POO) is an appropriate way of fulfilling their mandate under conditions of high staff turnover and limited budgets. But being able to function as a POO and fulfil the department/ministry's mandate and move smoothly to higher levels of the *PM maturity culture* ladder, requires the creation of an environment for successful projects or 'building project management centre of excellence'. While the details in terms of the required methodologies, tools and training for an appropriate POO are found elsewhere (e.g. in Bolles 2002; Graham and Englund 2004), a brief process (in 7 steps) is given here (Graham and Englund 2004) as: *1st step: Developing a senior management support*: breaking people out of their old unit/section management habits and instil practices that support project management; *2nd step: Developing a structure for independent input; 3rd step: Developing a process for project selection; 4th step: Developing upper manager's abilities in managing project managers; 5th step: Establishing a project manager's development programme; 6th step: Making project management a career position;* and *7th step: Developing a project learning organisation.* Going through these steps will help the organisation to focus on the organisational framework and be able to identify project management process gaps among other issues discussed above contributing to PM immaturity.

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MACRO LEVEL FACTORS AFFECTING THE CONSTRUCTION PROCUREMENT SELECTION: A MULTI CRITERIA MODEL

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ABSTRACT

Construction project procurement systems practiced in the industry have been subjected to changes resulting in many newly developed procurement systems that could be used to meet contemporary requirements of the clients. In dealing which procurement system to apply, there is a need to take into consideration various factors before any practical decisions can be made. Because, the wrong selection of construction procurement approach usually leads to project failure or general client's dissatisfaction. Therefore, a systematic approach for the selection of the most appropriate system is essential to aid the clients to achieve their ultimate project goals, thus to ensure best value for their money. The results of the panel data analysis carried out among major construction organizations in Sri Lanka clearly highlight the dominance of Measure and Pay method throughout the period concerned. Government as a major client and the regulator neglected the development of alternative procurement methods. This paper presents a multi criteria construction procurement selection model developed for Sri Lankan construction industry. Four rounds of Delphi survey were conducted to investigate the most important factors at macro level and their level of influence on various construction procurement systems. Based on the Delphi survey results, a multi criteria selection model was developed. In addition, few interviews were conducted with selected industry experts in the view of interpreting the suitability of the model for use by clients and their consultants. The results indicate that procurement selection procedure could be improved by developing a structured procedure based on a set of relevant selection criteria. Clients should establish a set of appropriate selection criteria based on their ultimate requirements & distinctive characteristics, project characteristics and external environment.

Keywords: Construction industry, Procurement selection, Selection criteria, Sri Lanka

1. INTRODUCTION

Construction procurement system is the organizational framework adopted by the client for the management of design and construction of a project. With the introduction of new and innovative ways of construction, many new and alternative procurement systems have been developed over the past decades. These systems could be used to meet contemporary requirements of the clients. Different procurement systems are used for different projects and the correct choice may help to avoid problems and be the key to the attainment of project specific goals. Procurement selection therefore received much attention from researchers in recent past. They strived to develop a systematic approach for procurement selection (NEDO 1985;

Skitmore and Mardson, 1988; Masterman, 1992; Chan *et al*., 2001; Cheung *et al*., 2001; Luu *et al*., 2003).

From the clients' point of view, there are probably only three basic criteria which include cost, time and quality**.** Hence, traditional procurement selection processes result in clients prioritising the basic criteria of Time, Cost, and Quality (Seeley, 1997). The lack of structured procedures, based on good information, for the selection of construction procurement system sometimes inhabit the opportunity for client to choose a procurement option in a fully informed manner (Luu *et al*., 2003). Despite the difficulties associated with selecting a procurement system, it has been suggested that the main influencing factors in procurement selection are determined by the level of client's experience (Masterman and Gamesn, 1994). Further, the selection criteria for a project procurement system may vary with the type of clients as experience dictates that different types of client bodies have different objectives to be secured through procurement.

Each project in the industry has its own characteristics and the project to be success the procurement method must address the technical features of the project alongside the client's and contractor's needs. The selection of suitable procurement method is critical to the success of any project. Kumaraswamy and Dissanayake (1998) have concluded that the most appropriate procurement system must necessarily depend on the project scenario or project profile that can be derived from contextual conditions such as external factors related to projects. Therefore, it is very much important to investigate and analyze the influencing factors affecting the selection of a procurement method in a dynamic construction environment. As far as Sri Lankan construction industry is concerned, the use of alternative procurement systems are less compared to other developing countries and therefore, there is a need to explore new ways of delivering construction projects. This paper presents a multi criteria selection model developed in the context of Sri Lankan construction industry.

2. PROCUREMENT SELECTION

Several previous studies have identified number of factors influencing the selection of procurement system in construction. They have focussed on selection factors in terms of Client characteristics (Moshini,1993; Masderman and Gameson,1994; Molenaar,1999), Project requirements (Gordon ,1994; Ambrose and Tucker ,1999; Rowlinson,1999) and External environment (Walker ,1989; Hughes,1989; Sheath *et al.*,1994; Alhazmi and McCaffer ,2000;Kumaraswami and Dissanayake,2001). Outcomes of the previous studies related to procurement selection revels that some important parameters have been neglected at macro level. A list of predominant procurement selection parameters have been identified by the Luu *et al.,* (2003) under the categories of client characteristics and objectives, Project characteristics and external environment. Clients' requirements will ultimately be influenced by the context in which they operate and this implies that the selection of procurement system may also be governed by the predominant environment. The external environment is a structure of several other systems such as economics, politics, finance, legal, technology, etc. The selection process is an open system which receives information from its environment, transforms and returns as an output to the environment (Mcdomott and Rowlinson, 1999). From the synthesis of the outcome of past studies, overall factors affecting the procurement selection can be grouped under three main criteria. The Figure 1 portrays the conceptual framework developed based on the project's environments which determine the selection criteria.

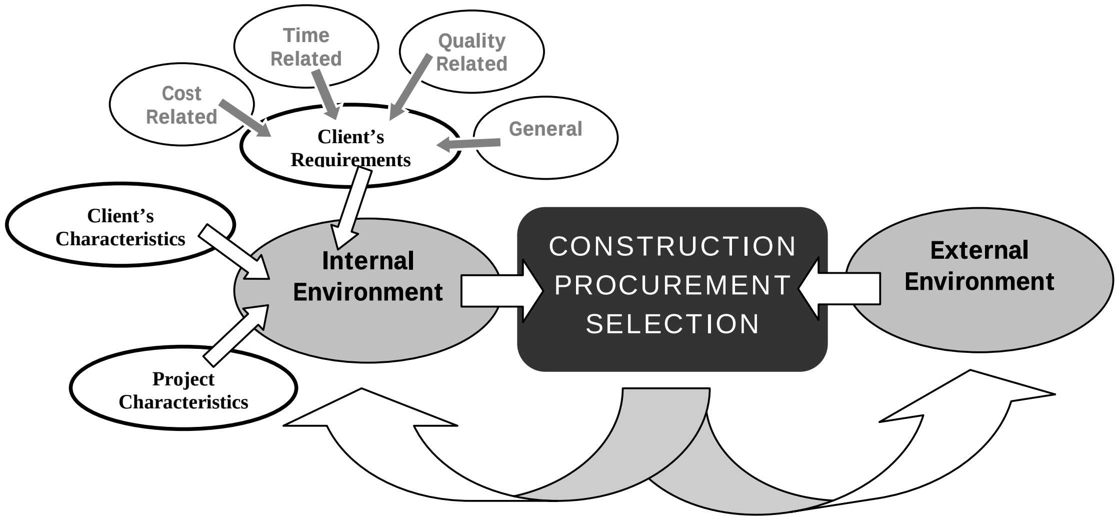

Figure 1 – Conceptual framework for the determination of selection criteria.

There have been several models developed with the intention of facilitating the selection of suitable procurement system for a particular project. Among the various models, Multi Attribute Utility Technique (MAUT) received the greatest attention. Chang and Ive (2002) discussed some of the inherent problems of using MAUT for procurement selection. One of strongest criticisms was the selection of procurement variables. The other is the utility value developed through opinions of industry experts. Particularly they are critical about the subjective nature of assigning values to procurement selection parameters to obtain mean utility values. Chan *et al.* (2001) used Delphi Method and Cheung *et al.* (2001) used Analytical Hierarchy Process to reduce the subjectivity of arriving at the utility values. Luu *et al.* (2003) on the other hand used 34 parameters against 8-10 used by other researchers to develop an acceptable model. However, these models use opinion to arrive at the most suitable procurement method for a project. Another pertinent question is that, in reality does the client or client's consultant use a structured model for procurement selection?

According to Masterman (1992) the practice of procurement selection is rather unstructured and ad hock. This observation is of course very true for a developing country like Sri Lanka (Shiyamini et al, 2005). In this context, this study examines the overall factors affecting the selection of procurement system in Sri Lanka. It differs from most of the related research on procurement selection in two respects. First, the study focuses on the past trend of procurement use in Sri Lanka. The factors that led to the use of a particular set of procurement methods and its change over time gave an ex-post picture of the parameters affecting procurement selection. One of the features of this paper is the use of this empirical data to explore procurement selection criteria. Second, most studies have employed a large number of variables in procurement selection. However, in reality whether such a large number of variables considered in procurement selection is doubtful.

3. METHODOLOGY

The use of Multi Attribute Decision Analysis has been considered the foremost technique for examining client needs and weighting of preferences from experts for each procurement (Chan *et al.,* 2001), but the major difficulty with these selection systems lies in the lack of consensus among the experts on the utility factors. To overcome above deficiencies, the Delphi technique was adopted. Delphi method is a highly formalized method of communication that is designed to extract the maximum amount of unbiased information from a panel of experts. Chan *et al.* (2000) has proved that the Delphi method is a powerful and appropriate technique for deriving objective opinions in a rather subjective area such as the Multi Attribute Methodology for selection of procurement system. Therefore, Delphi technique has been used to derive the expert opinion in this study. The success of the Delphi method principally depends on the careful selection of the panel of experts. In order to meet all stipulated requirements and to increase efficiency of the outcomes, the sample size was selected to have upper limit of the reliable sample size (15- 35) of the Delphi technique. Thirty five (35) members of panel represent wide distribution of professionals from several disciplines including Project Management, Quantity Surveying, and Engineering from consultant & contractor organizations both in public and private sectors. The Purposive selective sampling has been used as the appropriate sampling method for this research, because the information obtained from experts required in depth knowledge and sound experience on various procurement options. A group of experts, who have relevant working experience in the field of construction management and procurement selection, were selected to get the opinion on selection criteria and their level of influence on various procurement systems in construction. The following Table 1 gives the profile of the experts involved in the survey.

Table 1: Profile of the experts

Category	**No**
Project Director	8
Project Manager/Manager Contracts	6
Project Engineer/Civil Engineer	2
Chief/Senior Quantity surveyor	5
Quantity Surveyor	14
Total	**35**

The Table 2 presents the formats of Delphi survey carried out in four rounds and briefly introduces the data evaluation techniques used to analyse the data collected from the survey.

Table 2 : Summary of Delphi survey and Data analysis

	Round 1	**Round 2**	**Round 3**	**Round 4**
Instrument	Questionnaire 1	Questionnaire 2	Questionnaire 3	Questionnaire 4
Data base for Questionnaire	Literature review	Results from round one and literature	Results from round two subject to factor analysis	Results from round three
Duration	Two weeks	Eight weeks	Four weeks	Five weeks
Number of experts selected	35	35	35	35
Number of experts responded	35	31	26	23
Findings	Identification of factors affecting the selection of procurement system in terms of main three criteria	Level of importance of each factor identified in round one	Utility values for each selection factor obtained from round two against various procurement systems	Re-assessed utility values for each selection factor against various procurement systems
Data Analysis		Calculation of Percentage, weighted mean, standard deviation, Severity index, Coefficient of variation and factor analysis for identified significant factors	Calculation of average utility values, concordance coefficient (w) and related level of significance	Calculation of average utility values, concordance coefficient (w), percentage improvements of utility values and level of significance.

4. MAIN FINDINGS AND DISCUSSION

This section discusses the results of four rounds of Delphi survey which targeted to establish a set of exclusive selection criteria based on Sri Lankan context. Factors were studied and analysed in terms of client requirements & characteristics, project characteristics and external environment. Clients' requirements were focussed on cost, time, quality and other general aspects which affect the procurement system selection. The following Table 3 summarizes the overall factors derived from the review of literature and Delphi round one.

In the second round of Delphi, level of importance of each factor was considered. All together, 25 clients' requirements out of 34, 11 project characteristics out of 13 and 14 external environmental factors out of 19 were identified as significant factors. As some of these significant factors are interrelated, they were consolidated using factor analysis. The results of factor analysis brought nine factor categories of clients' requirements, six factor categories of project characteristics and five categories external environmental factors. Third round targeted to derive the utility values for each factor extracted from factor analysis against a wide range of various procurement systems used in the industry.

Table 3: Macro level factors affecting the selection of procurement system

SELECTION CRITERIA	
CLIENTS' REQUIREMENTS	**PROJECT CHARACTERISTICS**
Cost Related Factors • Capital cost • Maintenance cost • Prequalification and tendering cost • Financial risk • Price competition • Completion within the budget **Time Related Factors** • Planning and designing time • Tendering and evaluation time • Construction time • The early start of the project • Speed of construction • Time overruns • Quick response to clients new requirements (extra work and variations) • Maximizing of activities interfacing • Stage completion **Quality Related Factors** • Design reliability • Aesthetic appearance of the building • Workmanship • Functionality (suitability for the intended users) • Design innovation **General Needs** • Allocation of responsibility • Professional team performance • Parties involvements • Accountability • Transparency • Safety requirements • Corporation and motivation • Existing building operation • Familiarity (Client's awareness of construction procurement system) • Tender evaluation criteria • Clear express of end user's requirements • Flexibility • Consultants' attitude towards clients • Types of client	• Project type • Project size • Project cost • Degree of flexibility • Degree of complexity • Time constrains • Payment method • Integration of design and construction • Project funding method • Project site location • Site risk factors • Construction method • Degree of innovative technology involvement **EXTERNAL ENVIRONMENT** • Market's competitiveness • Government as a policy maker • Government as a major client • Regulatory feasibility • Technological feasibility • Source of finance for the project • Experienced contractor availability • Education of builders • Economic condition of the country • Availability of material • Information Technology • Influence of Intuitional bodies • Natural disaster • Industrial actions • Socio cultural differences • Goodwill of the contractor • Environmental issues • Civil war condition • Objections from neighbours / public

The questionnaire used in fourth round comprised with the average utility values derived from 25 experts for each factors against various procurement systems. The respondents were asked to reconsider the results of round three in order to improve the consistency of the results. There were 23 out of 25 questionnaires received in the fourth round and they were considered for the analysis at the end of fourth round. The consistency of the experts' utility values was subject to Kendall coefficient of concordance analysis using SPSS package. The results were summarized and compared separately for clients' requirements, project characteristics and external environmental factors. The following section discuses the outcomes of the Kendall coefficient of concordance analysis separately for each selection criteria.

Clients' Requirements

Utility values of all nine factors were sufficiently consistent at 0.05 level of significance or smaller. Further, concordance coefficient (w) ranges between 0.08 - 0.46 for certain factors such as Risk management, Time availability & Predictability, Accountability, Quality of works, and Responsibility & Parties involvement, indicate less strong agreement among experts during Delphi round three. The concordance coefficient ranges between 0.59 - 0.74 for the factors such as Price certainty, Price competition, Flexibility for changes and Familiarity indicate the strong agreement among experts at the fourth round of Delphi. The concordance analysis shows (Refer Table 4) that the consistency of the experts' ranking for procurement systems against each factor has improved over the succeeding round. The coefficient of concordance for all the factors (except for Time availability and Predictability) has improved from 28% to 174.84%. In this round, nine factors were considered sufficiently consistent compared to third round. The results show that the experts had overcome the difficulty in assessing the factors such as Responsibility & Parties involvement, since the significance improved lesser than 0.05.(α reduced from 0.7075 to 0.0399 in the successive rounds). Therefore, it can be concluded that all nine factors significantly influence the procurement selection practices in Sri Lankan context.

Table 4: Comparison of Concordance Coefficient of the utility values – Clients' Requirements

Selection Factors Clients' Requirements		**Concordance of Coefficient (W)**			**Significance Level**	
		Round 03	**Round 04**	**% Improvement**	**Round 03**	**Round 04**
1	Risk management	0.1440	0.1855	28.82%	0.0000	0.0000
2	Time availability and Predictability	0.2548	0.2548	0.00%	0.0000	0.0000
3	Price Certainty	0.3068	0.6229	103.02%	0.0000	0.0000
4	Price Competition	0.2812	0.5931	110.93%	0.0000	0.0000
5	Accountability	0.2188	0.4661	113.04%	0.0000	0.0000
6	Flexibility for Changes	0.3271	0.6508	98.96%	0.0000	0.0000
7	Quality of Work	0.1464	0.4024	174.84%	0.0000	0.0000
8	Responsibility and Parties Involvement	0.0293	0.0807	175.17%	0.7075	0.0399
9	Familiarity	0.4789	0.7397	54.45%	0.0000	0.0000

Project Characteristics

Utility values of all six factors were sufficiently consistent at 0.05 level of significance or smaller. Further, concordance coefficient (w) ranges between 0.29 - 0.38 for all six factors indicate less strong agreement among experts during Delphi round three.The concordance analysis shows (Refer Table 5) that the consistency of the experts' ranking for procurement systems against each factor has improved over the successive round. The coefficient of concordance for all six factors improved from 154.64% to 581.644%. In this round, six factors were considered sufficiently consistent compared to previous round. The results shows that the experts had overcome the difficulty in assessing the factor such as Project type, since the significance improved lesser than 0.05 (α reduced from 0.2613 to 0.0000 in the successive rounds).

Table 5: Comparison of Concordance Coefficient of the utility values - Project characteristics

Selection Factors Project Characteristics		**Concordance of Coefficient (W)**			**Significance Level**	
		Round 03	**Round 04**	**% Improvement**	**Round 03**	**Round 04**
1	Project Cost and Funding method	0.1527	0.3827	150.64%	0.0000	0.0000
2	Project Complexity	0.0952	0.3092	224.90%	0.0061	0.0000
3	Project Type	0.0491	0.3346	581.05%	0.2613	0.0000
4	Time Constrains	0.0814	0.3382	315.30%	0.0215	0.0000
5	Degree of Flexibility	0.1380	0.3558	157.94%	0.0001	0.0000
	Payment Modality	0.1025	0.2978	190.70%	0.0030	0.0000

External Environment

With respect to the external environment, utility values of all five factors were sufficiently consistent at 0.05 level of significance or smaller. The socio cultural suitability shows the higher level of significance as the concordance coefficient has improved at round four. Economic condition and the fiscal policy have also subject to changes from 0.041 to the 0.012 which indicates the increased level of significance. The significance level of Technology, Regulatory environment and Market condition for the project were increased to the maximum from the 0.011 and 0.001 respectively.

On the other hand, the correlation between the experts regarding the external environmental factors has also been increased. This indicates that the respondents got closer to the opinion of the factors regarding the procurement selection. Significant change occurred for the socio cultural suitability from 0.049 to 0.135. The following change has taken place for technology from 0.089 to 0.172 followed by regulatory environment, market condition and the economic condition & the fiscal policy. These external environmental factors have either direct or indirect influence on the selection and use of the procurement systems. Therefore, in assessing the suitability of a procurement system, the underplaying relationships of external environment need to be considered to avoid the consequences in decision making.

Table 6: Comparison of Concordance Coefficient of the utility values – External Environment

Selection Factors External Environment		Concordance of Coefficient (W)			Significance Level	
		Round 03	**Round 04**	**% Improvement**	**Round 03**	**Round 04**
1	Market competition	0.105	0.160	52.38%	0.001	0.000
2	Economic condition and the fiscal policy	0.074	0.096	29.73%	0.041	0.012
3	Technology	0.089	0.172	93.26%	0.110	0.000
4	Socio cultural suitability	0.049	0.135	175.51%	0.258	0.021
5	Regulatory environment	0.089	0.147	65.17%	0.011	0.000

5. CONCLUSIONS

An exclusive set of multiple decisive factors in terms of main three criteria: Clients' requirements & objectives, Project characteristics and External Environment, have been identified as being generally adequate for the procurement selection and there is a reasonable consensus on utility values for each procurement system. This study has used Delphi technique to ensure that the consensus is reached for the utility values provided by the panel of experts/practitioners from the industry. The synthesis of the outcome of the survey demonstrates intensely that there is a significant improvement in the consistency of the utility values over the successive Delphi rounds.

The combination of the results of all four rounds revealed 20 significant factors. As some factors are interrelated, factor analysis was performed to consolidate the related factors from each main criterion. All together 9 factor categories of clients' requirement, 6 factor categories of project characteristics and 5 categories of external environmental factors were derived. Among the nine factors of clients' requirements; the price certainty, price competition, flexibility for changes, familiarity, accountability and quality of work have higher concordance of coefficient and sufficient level of utility values leading to significant influence on all procurement systems. Other three factors also influence the procurement selection; since those factors have satisfactory utility values even though have lesser concordance of coefficient. All these factors should provide a starting point for the selection process. Six factors of project characteristics have satisfactory utility level even though they have lesser concordance of coefficient. From this study it was found that all identified factors in terms of clients' requirements and project characteristics have greater level of influence on procurement selection. The importance and interrelationships of identified significant factors and the utility values provide a good background for the development of procurement selection criteria for any kind of project scenario. In addition to the clients' requirements and project characteristics, factors from external environment also have the significance influence on selection process. Selection of appropriate procurement system is not a simple task. But the procurement selection procedure could be improved by developing a structured procedure based on a set of relevant selection criteria. Clients should establish a set of appropriate selection criteria based on their ultimate requirements & distinctive characteristics, project characteristics and external environment. The selection criteria should be logically derived from project's internal and external environment.

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E-PROCUREMENT: AN ASSESSMENT OF UK PRACTICE IN CONSTRUCTION

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ABSTRACT

As long as companies have been trading in the construction sector, they have sought to improve efficiency and effectiveness in their operations and services to stakeholders. The utilisation of e-procurement in other industrial sectors has, for some time, been widespread, but to date is considered a relatively new phenomenon in construction. However, what e-procurement strives to achieve is far from new. E-procurement is an important step towards development of the extended enterprise where the supply chain becomes a continuous and uninterrupted process of extending from buyer through seller partners in a bid to increase efficiency and reduce costs and time-scales.

The work carried out as part of this research looks at the e-procurement mechanism in construction with consideration of its technological utilisation. Additionally, the viability of various e-procurement systems in the UK construction industry is considered together with the benefits, potential barriers and risks involved. The work also includes an industry survey which reveals there is still limited adoption of e-procurement within UK construction. It is evident that the majority of companies are adopting a 'wait and see' approach to its utilisation. However, the study also identifies that e-procurement is currently the fastest growing area of e-business. Further consideration is also given to e-procurement implementation and recommendations are provided on e-procurement best practice for the construction sector.

Keywords: best practice, e-procurement, implementation, supply chain

1. INTRODUCTION

With the rapid evolution of IT and its applications, numerous opportunities exist for considering the impact of IT on purchasing and supply management in addition to technological use. Moreover, there is a risk that organisations who fail to realise the potential of any new technology may jeopardize their future operations, competitiveness and profitability. Whilst new technology mainly affects day-to-day operations, it is important to introduce and adopt a strategic perspective to understand its true potential. E-procurement is the key element of e-commerce which focuses on electronic automation of process to satisfy internal demand with external sources. Research suggests that the UK is rapidly embracing e-commerce (Chaffey, 2004). This relates to a communication perspective; the delivery of information, product/services or payment by electronic means, and a business process perspective through the application of technology towards the automation of business transactions and workflows. In doing so, it should enable cost cutting and increased speed and quality of service delivery. It should also provide the opportunity for buying and selling of products and information online (Chaffey, 2004). Moreover, better information should be made available about products, prices and suppliers to help ensure that departments and agencies secure the most appropriate transactions (Oughton, 2005). The objectives of the research were to identify the various e-procurement systems in the UK construction industry, together with the benefits, barriers and risks of implementation, and to make recommendations on how to apply and adopt a best practice approach to e-procurement utilisation.

2. E-PROCUREMENT TECHNOLOGIES

Most organisations are primarily using e-procurement technologies to acquire non-core supplies, including office products, computer and related equipment, and maintenance, repair and operating expenses (MRO). However, Davila, Gupta and Palmer (2002) indicate a likely trend towards integrating e-procurement technologies into core business processes as more companies use them to purchase inventory, services and capital goods. Tonkin (2003) considers that e-procurement is simply those aspects of the procurement function supported by various forms of electronic communication. Its use in both the public and private sectors takes many forms including: electronic data interchange (EDI), e-MRO (maintenance, repair and operation), enterprise resource planning, web-based enterprise resource planning, e-sourcing, e-tendering, e-reverse auctioning, e-auction for disposals, e-informing and e-collaboration. However, Oughton (2005) suggests e-procurement tools broadly relate to two aspects of procurement: sourcing activity, and transactional purchasing. E-procurement can therefore be considered as a collective term for a range of technologies that can be used to automate the internal and external processes associated with sourcing and buying (IDeA, 2004).

3. E-PROCUREMENT IN THE CONSTRUCTION INDUSTRY

Regardless of the current strategy of a company, the overall consensus is that e-procurement technologies will become an important management tool to enhance the performance of supply chains. Existing legacy systems built around these processes and e-procurement technologies would need to be integrated with production-related systems such as materials requirement systems (MRP), scheduling, inventory, costing systems, and performance reporting systems. E-procurement technologies would also need to ‘talk’ to suppliers’ systems to automate the ordering process, and to customers’ systems to ease the functioning of the supply chain. (Davila, et al. 2002). In the construction industry, current e-procurement technologies are still in their developmental infancy and a dominant design is still unavailable. However, moving these technologies to core business processes, such as inventory management and capital goods acquisition is still a challenging proposition facing construction (Davila, et al. 2002).

4. E-PROCUREMENT BENEFITS, BARRIERS AND RISK

E-procurement has recently drawn great attention and has been adopted by an increasing number of private and public organisations. Vaiday, et al. (2002) emphasise the transparency benefits of e-procurement which can provide subsequent benefits to construction organisations. This includes the elimination of manual processes to free up the time of procurement personnel, thereby allowing them to accomplish more strategic aspects of procurement, such as managing relationships with suppliers. The tangible benefits of e-procurement consist of the benefits that are required to deliver enhanced shareholder value and thus gain approval, such as price savings and process cost reduction (Eakin, 2003; BuyIT, 2002). Thus tangible benefits could be identified as reduction in purchase price and improved process efficiencies, in addition to reduction in overhead costs and process costs (BuyIT, 2002; DPWS, 2002; IDeA, 2004; Turban et al, 2004; Chaffey, 2004). Coupled with these benefits includes intangibles such as improved information, communication, collaboration and knowledge management, in addition to improved commercial relationships with suppliers and high visibility of suppliers' performance (BuyIT, 2002; DPWS, 2002; IDeA, 2004; Chatterjee, 2005).

However, there are many identified barriers and risks that make construction organisations fear the adoption of e-procurement solutions, and different construction organisations may consider different issues as the reasons not to embrace the technology. In essence, barriers can be identified as technical barriers, market barriers and organisational barriers.

Innovation & Information Consultants (2004) consider technological barriers represent obstacles to the adoption of e-procurement due to technological factors such as lack of high-speed connections and software incompatibility. The most frequently cited technological barriers include problems of integrating e-procurement with internal solutions and difficulties encountered in obtaining high speed access and download capabilities. This also includes adaptation requirements of existing systems (Hellman and Gadde, 1996) and issues regarding security (Cunningham and Froschl, 1996).

Market barriers include those barriers that are external to the firm, and are driven by market forces of supply and demand. This would also include relationship-related implementation barriers related to the purchasing and marketing strategies pursued by the companies involved.

Organisational barriers may present challenges where e-procurement, brings about and makes possible the transformation of an organisation's structure. Additionally, issues such as organisational culture and the importance of understanding organisational goals, self interest of employees and human behaviours are all important considerations (Stoner and Freeman, 1992).

5. INDUSTRY SURVEY AND DATA ANALYSIS

In order to assess the current climate with e-procurement and its influence on construction a questionnaire survey was carried out with 100 UK organisations randomly selected from across the construction industry. These included 30 client organisations, 25 contracting firms, 15 supplier organisations and 30 construction consultancies. From these 100 companies, a total of 30 recipients responded to the questionnaire. A breakdown of these respondents into the various categories is shown in Table 1.

Category	*Respondents*			
	Number have adopted e-procurement	***Number have not adopted e-procurement***	***Total (Group)***	***Total Number (Category)***
Public Main Contractor	0	3	3	14
Private Main Contractor	**4**	7	11	
Public Sub-Contractor	**1**	0	1	5
Private Sub-Contractor	**1**	3	4	
Public Council	**2**	3	5	5
Private Consultant	0	2	2	2
Private Supplier	0	2	2	2
Client	**1**	0	1	1
Private Specialist	0	1	1	1
Total	**9**	**21**	**30**	**30**

Table 1 e-procurement in Respondents' Organisations

While the questionnaire survey covered various aspects of e-procurement, the main focus was on the current practice of e-procurement in construction. Table 2 shows the number of e-procurement technologies used by respondents' organisations to automate the internal and external processes associated with sourcing and buying. A symbol legend is provided to identify the category of respondent.

e-Procurement Technologies			***Respondents***										
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**F/T**	**%**
Controlling	***Sourcing***	***e-Tendering***			♣	•	♥	♥		♥	♠	6/9	67
		e-Auctioning	♦	♦				♥				3/9	44
	Managing	***Contract Management***					♥				♠	2/9	11
		Spend Analysis	♦	♦				♥				3/9	33
	Invoicing	***e-Invoicing***		♦				♥				2/9	22
Purchasing	***Cataloguing***	***e-Catalogues/Content Management***	♦	♦	♣			♥	♥	♥	♠	7/9	78
	Purchasing	***e-Purchasing***	♦	♦	♣		♥	♥	♥	♥	♠	8/9	89
		e-Marketplace	♦	♦	♣					♥		3/9	33
		Supplier Websites	♦					♥	♥		♠	4/9	44
	Paying	***Banker Automated Clearing Service***	♦	♦		•	♥	♥				5/9	56
		P-Cards	♦	♦	♣			♥		♥	♠	6/9	67

♦ = Public Council, ♣ =Public Sub-Contractor, • = Private Sub-Contractor, ♥ = Private Main-Contractor, ♠ = Private Client, **F/T** = Frequency over Total, **%** = Percentage

Table 2 e-procurement technologies adopted by respondents' organisations

The table illustrates that 89% of respondents used online buying processes, from the creation of the requisition through to payment of the suppliers, e-tendering (67%), e-catalogues (78%) and purchase cards (P-cards) (67%). However, e-auctions, another main component of e-procurement, did not feature highly in the survey. Only 33% of the respondents have currently carried out purchasing negotiations via the internet. The information shows low respondents' rate on adoption of on-line bidding, primarily because of the apparent focus on price rather than quality or value.

Table 3 shows the reasons considered by respondents' organisations in connection with e-procurement systems. Process efficiencies and cost saving were the most common reasons considered by organisations entered into e-procurement.

1= Very Unlikely, 2= Unlikely, 3= Less Common, 4= Common, 5= Most Common								
Reasons	**Factors**					***Mean***		***Rank***
	1	**2**	**3**	**4**	**5**			
Process Efficiencies	0	1	0	1	**7**	**4.56**		1
Cost Saving	0	0	1	3	**5**	**4.44**		2
Time Saving	0	0	0	**6**	3	**4.33**		3
Value for money	0	0	3	**5**	1	**3.78**		4
Automatic workflows	0	0	**5**	4	0	**3.44**		5
Greater Quality	1	3	**4**	1	0	**2.56**		6
Development of e-Procurement Software	0	**6**	3	0	0	**2.33**		7
Market Tendency	4	0	**4**	1	0	**2.22**		8
Reaction to Recession	3	**6**	0	0	0	**1.67**		9
Total	8	16	20	**21**	16	**3.26**		
	81							

Table 3 Reasons considered by respondents' organisation to enter an e-procurement system

Items of cost reduction	**Respondent**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**F/T**	**%**
Cost of expenditure on goods/services related directly to the production/service delivery	♦	♦	♣		♥	♥	♥			6/9	67
Cost of non-production goods/ services	♦	♦		•	♥	♥			♠	5/9	56
Cost of operational purchasing activities	♦	♦	♣		♥	♥		♥	♠	7/9	78
Cost of tactical procurement activities						♥	♥			2/9	22
Cost of Strategic procurement activities										0/9	0
Internal benefits from investment in particular inter-organisational relationships									♠	1/9	11
Contribution of investments in particular inter-organisational relationships to revenues		♦					♥		♠	3/9	33
Cost of Overheads		♦	♣	•	♥	♥	♥	♥	♠	7/9	78
♦ = Public Council, ♣ =Public Sub-Contractor, • = Private Sub-Contractor, ♥ = Private Main-Contractor, ♠ = Private Client, **F/T** = Frequency over Total, **%** = Percentage											

Table 4 Items of cost reduction by the respondents' organisations through e-procurement

Table 4 shows the items of cost reduction achieved by the respondents' organisation through e-procurement. The majority were able to achieve cost reduction, particularly in the cost of operational purchasing activities (78%) (e.g. requisitioning, ordering, expediting and administrative support), cost of overheads (78%), followed by the cost of expenditure on goods/services related directly to the production/services delivery (67%) and the cost of non-production goods/services (56%). The information also shows there were no replies in the cost of strategic procurement activities and only one company had realised internal benefits from investment in particular inter-organisational relationships.

Table 5 shows items of time reduction achieved by the respondents' organisations through e-procurement. All had experienced the time reduction in paperwork and administration and 56% achieved time reductions spend in operational purchasing activities. Once again, no replies were received on the benefits from time reduction in strategic procurement activities. In comparison with the Table 4, the majority of current users indicated their organisations encouraged the cost reduction more than time reduction through e-procurement.

Items of cost reduction	Respondent										
	1	2	3	4	5	6	7	8	9	F/T	%
Time spend on goods/services related directly to the production/service delivery					♥		♥			2/9	22
Time spend on non-production goods/ services					♥			♥	♠	3/9	33
Time of operational purchasing activities	♦	♦			♥	♥			♠	5/9	56
Time of tactical procurement activities					♥	♥				2/9	22
Time of Strategic procurement activities										0/9	0
Time of paperwork and administration	♦	♦	♣	•	♥	♥	♥	♥	♠	9/9	100

♦ = Public Council, ♣ =Public Sub-Contractor, • = Private Sub-Contractor, ♥ = Private Main-Contractor, ♠ = Private Client, **F/T** = Frequency over Total, **%** = Percentage

Table 5 Items of time reduction by the respondents' organisations through e-procurement

Table 6 focuses on qualitative benefits that accrue from adopting e-procurement. These benefits are expected to accelerate the rate of adoption of e-procurement once the uncertainties that remain are reduced to levels that encourage significant resource commitments. The table also shows all of the e-procurement benefits for organisations on reduction of purchase price, process efficiencies and reduction of process costs.

Table 7 shows potential barriers and risks that respondents perceive with e-procurement implementation in their organisations. The majority of respondents indicated the important potential barriers which related to information overload and security, as well as human factors.

Table 8 indicates the strategies organisations are planning in the future. Four of the e-procurement users had been fully involved in e-procurement, two organisations had made large investments, but the remaining three were taking a 'wait and see' approach to the automation of internal and external processes associated with sourcing and buying.

1=Very Unlikely 2=Unlikely 3=Less Common 4=Common 5=Most Common								
e-Procurement Benefits	**Scale**					***Mean***		***Rank***
	1	**2**	**3**	**4**	**5**			
Reduced purchase price	0	2	4	10	**14**	4.20		1

Process efficiencies	0	1	3	**16**	10	4.17		2
Reduced process costs	0	3	3	11	**13**	4.13		3
Simplified process/less paperwork	0	3	5	**15**	7	3.87		4
Demonstration of best value/transparency	0	8	**10**	4	8	3.40		5
Speed of procurement process	0	7	**12**	7	4	3.27		6
Better Management information	0	5	**13**	9	3	3.33		7
Control of maverick spend via frameworks	0	6	**12**	8	4	3.33		8
Pre spend approval	2	6	9	**11**	2	3.17		9
Better monitoring of suppliers + projects	3	7	8	**9**	3	3.07		10
Commitment accounting	2	8	**12**	8	0	2.87		11
Reduction in errors	4	**9**	7	7	3	2.87		12
Better delivery of targets	1	11	**13**	4	1	2.77		13
Better engagement of suppliers	3	9	**11**	6	1	2.77		14
Access to wider range of suppliers	2	**15**	7	5	1	2.60		15
Total	17	100	129	**130**	74	3.32		16

Table 6 Benefits that respondents perceive has/will give to their organizations

Among the organisations adopting e-procurement the majority seemed more directed towards e-purchasing (89%), e-tendering (67%), e-catalogues (78%) and p-cards (67%). However, e-auctions, another main component of e-procurement, did not generate a high response. Only 33% of the respondents have had or were currently carrying out purchasing negotiations via the internet. It is important, therefore, to consider, in depth, the issues surrounding e-procurement best practice. This ought to encourage the adoption of e-procurement in order to obtain the maximum benefits available. It would also aid construction organisations who are planning to adopt e-procurement in the future and minimise the possible barriers and risks involved.

6. A BEST PRACTICE APPROACH

The research findings from the industry survey have highlighted several requirements. E-procurement requires a carefully planned strategy, clear objectives and thorough preparation coupled with adequate resources and budgets. This is in addition to a realistic allocation of time in order to realise returns. Moving to e-procurement is a strategic decision. The research findings would also support DPWS (2002) in the requirements of organisational needs. These include:

- e-procurement should be consistent with overall corporate and business objectives
- e-procurement needs to be an integrated part of the business plan and asset investment plan of an organisation, and
- organisations require the resources to meet any new demand that e-procurement generates including the re-engineering of business processes.

1=Very Unlikely 2=Unlikely 3=Less Common 4=Common 5=Most Common								
e-Procurement Barriers and Risks	**Scale**					***Mean***		***Rank***
	1	2	3	4	5			
Information overload	1	2	7	**13**	7	3.77		1
IT issues/existing systems not up to it/security	1	4	7	**12**	6	3.60		2
Staff management in change / cultural issues	3	2	7	**12**	6	3.53		3
Supplier readiness/lack of support for them	0	6	**11**	5	7	3.47		4

Trust	3	2	9	**12**	4	3.40		6
Time to implement changes	1	4	10	**13**	2	3.37		5
Training costs	2	7	7	**10**	4	3.23		7
Size of company	1	7	**12**	5	5	3.20		8
Too many market places/choosing the right system	0	7	**15**	5	3	3.13		9
Keeping small local suppliers involved to protect local economy	1	8	**11**	8	2	3.07		10
Feedback to smaller companies	0	6	**18**	5	1	3.03		11
Lack of accurate management info	1	7	**13**	8	1	3.03		12
Policy issues	2	6	**13**	8	1	3.00		13
Competing projects	2	7	**12**	8	1	2.97		14
Resource/ budget issues	1	**11**	9	6	3	2.97		15
Too few good companies	2	7	**14**	6	1	2.90		16
Problems with errors in tenders	3	**11**	7	6	3	2.83		17
Inaccurate info from suppliers	3	**13**	6	6	2	2.70		18
Total	27	117	**188**	149	59	***3.18***		

Table 7 Potential barriers and risks that respondents perceive with e-procurement implementation to their organisations

	Respondents				
	e-Procurement Adopter	***%***	***Non e-Procurement Adopter***	***%***	***Total***
Yes to all	4	13	3	10	7
Sizeable Investment	2	7	0	0	2
Investing selectively until best e-procurement model identify	2	7	0	0	2
Aware development, but not committing resources	1	3	11	37	12
Totally not apply	0	0	7	23	7
Total	9	30	21	70	30

Table 8 Strategies that respondent organisations are adopting towards e-procurement in their future plans

Although the adoption of e-procurement has rapidly increased in recent years, companies face different challenges associated with the advent and use of e-procurement (Puschmann and Alt, 2005). It is difficult, however, to define what a best practice e-procurement implementation should be. E-procurement is about enhancing collaboration, streamlining processes, controlling cost, and enhancing information exchange within and across organisational boundaries. The different needs of an enterprise require assessment in terms of capabilities and constraints, in addition to the coordination of supply chains and organisational structures.

7. CONCLUSIONS

E-procurement technologies will become an important element in the management of supply chains in the future. The findings from the research have indicated that e-procurement solutions and applications are still in their infancy and construction organisations are currently experiencing development issues, which can be expected with the implementation of new technologies and change initiatives.

The results of the industry survey have also identified e-procurement benefits such as reduction of purchase price, process efficiencies and reduction of process costs. Additionally, IT change, culture, cost, and time issues were the identified barriers and risks which mostly concerned organisations. The traditional paper based approach still remains in wide use with the construction sector, and organisations still preferred to use hard copy communications to deliver resource purchasing information. However, the trend towards using other media for communication to transfer resource purchasing information has risen in the UK construction industry. This demonstrates an encouraging move towards e-procurement and its increased adoption in the future.

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DESIGNING PERFORMING ARTS BUILDINGS FOR STAKEHOLDERS AND USERS: A FRESH PERSPECTIVE

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ABSTRACT

In the UK more than £ 1 billion of public funding has been spent through the Arts Council of England (ACE) on arts capital projects including a number of new and refurbished performing arts buildings, many with high visual impact and iconic architecture. Performing arts buildings are considered complex and unique due to strict requirements for meeting exacting technical demands and also the necessity to respond to various and sometimes conflicting needs of clients and stakeholders. This paper aims to explore the attributes contributing to the delivery of 'better' environments for performing arts buildings. Particular attention is given to the stakeholders and users of such buildings as guidelines from the design, construction and architectural agencies are inconsistent and some indicate potential problems of insufficient consultancy at the pre-design stage. This paper aims to report an AHRC funded project, currently underway which consists of an in-depth methodology of multiple case studies of performing arts projects in the UK constructed or refurbished since 1999. The nature and involvement of stakeholders and users in the early stages of the design process are discussed from a fresh perspective leading to the conceptualisation of a stakeholder model. This information is considered crucial to inform the development of more responsive spaces and successful projects that embody the mission, goals and objectives of the arts organisations.

Keywords: design, performing arts, stakeholders, users.

1. INTRODUCTION

In the UK, the government initiative to increase the investment in the arts industry through arts capital projects from 1995 onwards has helped to improve existing facilities or develop new ones. About £1.4 billion of public funding has been spent by the Arts Council of England (ACE) Lottery Fund on the arts, much of it on building construction (Stetter, 2002). However, the design and construction of arts buildings, such as theatres for instance, have been considered peculiar compared to other types of buildings (Earl, 1998). Moreover, construction of the arts buildings have been considered complex and unique due to strict requirements for meeting exacting technical demands and also the necessity to respond to various and sometimes conflicting needs of artists and performers, managerial staff, funding organisations, and the general public (Strong, 1990; Mulryne and Shewring, 1995; Appleton, 1996). Despite the existence of these conflicting stakeholders' needs, many of these publicly funded arts buildings were aiming for high visual impact and iconic architecture. A recent investigation has reported that many of the publicly funded capital arts projects examined have received or been nominated for architectural design awards (NAO, 2003). In the context of the iconic architectures, the role of designers have been regarded more dominant (Jencks, 2005) whilst in general circumstances, the design and management practice have not been well attuned to addressing the issues important to one of the stakeholders, the building users (Kernohan *et al*, 1992). Thus, the gaps between the end users/the designers, and between the end users/the clients indicated by Zeisel (1984), are potentially amplified within iconic building projects.

The official guidance for applying the lottery grant for arts capital projects required evidences of the main user groups and funders supporting attitudes towards the project and also the involvement of artists and crafts people, and also consultation with others such as public arts agencies (ACE, 1998). The long and well established project model in the UK construction industry by the Royal Institute of British Architect (RIBA, 1967) prescribes the designer to elicit all necessary information, including user study, during its stage B (i.e. feasibility study). The Commission for Architecture and Built Environment (CABE, 2002) recommend the clients of capital arts projects to conduct consultation during the pre-design phase with the stakeholders, i.e. people inside (staff, board members, artists) and outside (existing or potential audience, local community, funders) the client organisation who have a practical role or looser interest in the project. Even though most guidance are prescribing involvement of the building users, particularly in the earlier phase of the project, there appears to be a varying degree of involvement in the project and failure to specify who the users are, potentially leading to confusion for inexperienced arts organisations.

In light of this, the research is set to investigate the most appropriate practices to enable a ‘better’ environment in order to deliver excellent buildings for the performing arts. This is intended to be achieved by investigating and analysing selected buildings for the performing arts (i.e. by multiple case studies) that have been briefed, designed and procured in the relatively recent past (i.e. 1999 onwards). This ongoing research project, entitled DeDEPA (Designing Dynamic Buildings for the Performing Arts), is funded by the Arts and Humanities Research Council (AHRC). This paper aims to discuss the nature and involvement of stakeholders and users of capital arts projects in the early stages of the design process from a fresh perspective leading to the conceptualisation of a stakeholder model which is crucial to deliver performing arts buildings to inform the development of more responsive spaces and successful projects that embody the mission, goals and objectives of the arts organisations.

2. A FRESH PERSPECTIVE ON PERFORMING ARTS BUILDINGS

In general, it has been considered crucial for clients to know why they want a construction and what they want it to do to support their organisations (Pollington, 2004). In their ‘Client Guide for Arts Capital Programme Projects’, CABE (2002) have mentioned several ‘indicators’ of good design, one of which is the fitness-for-purpose of the resultant building. Based on this, the paper intends to have a fresh perspective (i.e. a start over) of rethinking the nature of performing arts buildings from the fitness-for-purpose point of view. The original purpose of having a performing arts building is reviewed and used as the centre of the perspective.

Essentially, the performing arts are concerned with a space for a live performance experienced by an audience within a set period of time where the space is defined by specific technical and spatial demands and requires a conducive atmosphere for both audience and performer (Appleton, 1996). Even though there are other ways for the audiences to experience the performing arts, including the more active and participatory forms, the audiences are normally regarded as attending the performances (McCarthy *et al*, 2001). Although the purpose of having the arts buildings may vary due to the nature of the client organisations (i.e. local government, commercial sector, private trust, and so on), the performing arts buildings discussed in here are concentrated to the ones that eligible to apply for capital funding to the ACE, i.e. focusing on artistic activities (ACE, 1998). Thus, a performing arts building can be considered to be built ultimately to accommodate live performances conducted by the performers and watched by the audiences. Following this, it can be understood that there are three major elements involved in an artistic performance, namely the audience, performer, and the performing arts space. The relationship among them has been considered on interaction based, in the sense that there are 'energies' that automatically resonate back and forth between the audiences, performers and performing environment during a live performance (Daniel, 2000). Indicating further interaction between the performers, audiences and the performing space, in theatre performances, it is argued that through the body and person of the performers, all the contributing systems of meaning (i.e. visual, vocal, spatial, fictional) are activated (McAuley 2000). From the theatre performers' point of view, the performing spaces have been considered strongly affecting their performances (Daldry, 1996) whilst the performers' interaction with the audiences have been considered essential for theatrical events to exist (Mackintosh, 1993). In music performances, the audio signals and performers' body movement have been considered important to convey the intended emotions (i.e. happiness, sadness, and anger) to the audiences (Dahl and Friberg, 2003). Thus, performers' movement have been considered a sufficiently significant part of a music event (Van Zile, 1988). From the performers' point of view, the number and type of their co-performers and audiences can substantially affect their performances (Jackson and Latane, 1981) whilst at the same time, the performers also rely on the acoustics of the performing spaces to act as mechanical amplifiers, which, by their architectural design, capture the sounds of voices and instruments, and impose resonances, reflections and absorption that 'colour' the sounds (Oliveros, 1995). Hence, it can be concluded that there is a coherent interaction among the performers, audience, and performing arts space.

Furthermore, performing arts have long been considered as an event rather than an object (Hinkle, 1979). Thus, the 'object' is the particular experience triggered by the performers and experienced by the audience whilst the 'arts' itself occurs only at the moment of experience (Ronen, 1977). This experience of performance is unique due to the fact that it can not be saved, recorded, documented or represented in other ways; otherwise, it will become something different (Phelan, 1993). In terms of theatre performances, the possibility for something goes wrong in the live show, of community and of shared experience felt at a successful theatrical occasion have been considered the factor that distinguishes live theatre from other others such as cinema (Mackintosh, 1993). However, there has been some concern regarding the loosening connection between the performers and their audiences in a live performance (Blau, 1990). The rehearsal activities, for instance, does not generally concern itself with the audience and focusing only on the arts interpretation of the scripts / choreographers / directors /

conductors from the performers' side (Guthrie, 1960). Prendergast (2004) has criticised that much talk of audience in the performing arts mainly concern development, ticket sales and number of 'bums in seats' and has called for more discussions on the audience's presence and response in an authentic and aesthetic consideration in a more meaningful way. After all, the audiences have expressed their willingness to engage with the arts performances, letting their perceptions to be manipulated, and communicate them with the most intimate detail of their life experiences (Bennett, 1997). Thus, the experience should be perceived from both the performers' point of view to express their artistic interpretations of the works and also from their audiences' point of view to experience the artistic event.

However, it has also been argued that the works created by the authors/composers are aesthetically complete, and the performers function is to make these aesthetic objects available to audiences to perceive and appreciate (Thom, 1993). Thus, even the artistic event is experienced by both (performers and audience) and the performers are expressing their artistic interpretation of the works, the final intention of the performers is to create the experience for the audience. Relating this to the coherent interaction among the performers, audience, and the performing arts space previously discussed, it can be inferred that the performing arts space should be designed to achieve this final purpose, namely the creation of the experience for the audience (including to support and inspire the performers to express their artistic interpretation of the work, leading to the creation of the experience for the audience). Emphasising on the audience experience, a more holistic view of the experience has been considered important. Appleton (1996) asserted that the experience of attending a performance in a performing arts building by members of an audience is not restricted to the time spent in the auditorium and has prescribed several needs to be satisfied including matters related to the information available about the performances (such as programme, cost of attendance), travel time and method, ease of parking or convenience of public transport, quality of entrance, foyer, cloakroom, toilets, auditorium (such as. seats, view, acoustic), and associated activities (such as eating, drinking, shops). In addition to this, the exterior of a performing arts venue, such as a theatre, has been considered important to attract the audience (McNamara, 1974) and even to start the audience experience (Sporre, 1993). Thus, in the context of experience creation, the coherent interaction exists among the performers, audience, and the whole performing arts building. Figure 1 illustrates this coherent interaction in terms of the experience creation. The diagram demonstrates how the arts building in its entirety accommodates the performers and audience and facilitates various interactions. Even though the main interaction was between the performers and the audience, other interactions exist, i.e. interactions among the performers, interaction among the audience, interaction between the performers and the building, and the interaction between the audience and the building.

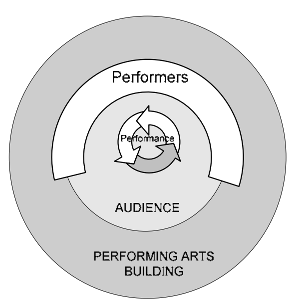

Figure 1. The coherent interaction of experience creation

3. STAKEHOLDERS AND USERS

As discussed, most guidance for designing and delivering performing arts buildings prescribe involvement of the building/end users, particularly in the earlier phase of the project. The main argument is that the best products and services result from a good understanding of the psychological needs and desires of the people who will use them (Sener and Van Rompuy, 2005). Thus, failure to engage end users in the process may resulted in the loss of an important stimulus to creative process whilst the client may be left with long-term dissatisfaction amongst the people they wish to support through the built solution being developed (Barrett and Stanley, 1999). However, it turns out that defining the building/end users and the stakeholders may not be a simple task after all as many views from different perspectives exist. The basic model of construction project stakeholders consisting three parties, (i.e. client, designer, and contractor) has no longer perceived adequate due to the complexity of modern buildings that have made it difficult for a single designer, contractor, or specialist to provide the spectrum of skills needed and also the fragmentation of construction process intensified by economic forces (Walker and Greenwood, 2002). The project stakeholders have been defined as those parties that will incur a direct benefit or loss as the result of the project (Winch, 2002). Following this definition, the stakeholders of a project were subdivided into two major categories, namely internal (including demand and supply sides) and external (including private and public sides). The Commission for Architecture and Built Environment (CABE, 2002) view the stakeholders need to be consulted as people inside (staff, board members, artists) and outside (existing or potential audience, local community, funders) the client organisation who have a practical role or looser interest in the project. Newcombe (2003) asserted that project stakeholders are groups or individuals who have a stake in, or expectation of, the project's performance and include clients, project managers, designers, subcontractors, suppliers, funding bodies, users and the community at large. Thus, the definition of project stakeholders of construction projects has been expanded to include the internal, external, primary and secondary project stakeholders.

Extending the view to incorporate building management as well as building design, the stakeholders can be subdivided into two main groups, namely the providers and the users of the facilities (Kernohan *et al*, 1992). The term 'providers' refers to individuals or groups with a close connection to a building or other facility, but without a presumptive right of use to that facility, including makers, traders, landlord/lessees, and maintainers. The term 'users' refers to individuals or groups with a presumed right to use the facility, including occupants, visitors, and owners. Taking into account the fresh perspective on performing arts buildings explained in previous section (i.e. the ultimate purpose of the performing arts buildings in the context of experience creation), the ongoing discussion on stakeholders (including the importance of user involvement as discussed above), the stakeholders of a performing arts building project are generally grouped according to the framework explained above, i.e. the providers and the users of the performing arts building. Subsequent sub-sections discuss each of the stakeholders group in more details.

The Providers

The term 'providers' represents the supply side of the building project and refers to individuals or groups with a close connection to a building or other facility, but without a presumptive right of use to that facility, including makers, traders, landlord/lessees, and maintainers. Makers group include architects and other designers, suppliers, builders and construction team. In the context of performing arts building, the makers group may also include an independent project manager individual/firm involved from the early stage of the project depending on the arts organisations' expertise and the procurement route (CABE, 2002; CIOB, 2002).

Trader groups include the people who financed, buy and sell buildings (e.g. investors, developers, real estate agents, property advisers). In the context of performing arts buildings discussed in here, it can be assumed that there is no trader group involved as the guidance from the ACE (1998) made it clear that the funding are available for capital expenditure, i.e. funding spent on the purchase, improvement, restoration, construction or creation of an asset with intention of using it on a continuing basis of the arts organisation's activities and is not intended for sale in the ordinary course of the arts organisation's activities.

Landlord and lessees group include owner, owner's agent, tenant organisations and facilities managers. In the context of the performing arts buildings discussed in this paper, the landlord/lessees are normally non-profit organisations such as local authorities, public sector agencies, registered charities, education institutes, or any other organisations which can not distribute profits in which the performing arts buildings will be used for the benefit of the wider public and focusing on arts activities (ACE, 1998).

Maintainers group include building managers, cleaners, maintenance contractors and staff who provide services usually direct to the owner or tenant organisation. Thus, the maintainers group may be considered both providers and users (Kernohan *et al*, 1992). In the context of the performing arts buildings discussed in this paper, the maintainers group is more likely to be a part of the performing arts organisations even though in several larger venues, it may also includes external maintenance contractors and/or service providers.

The Users

The term 'users' represent the demand side of the building project and refers to individuals or groups with a presumed right to use the facility, including occupants, visitors, and owners. Occupants are basically people or groups who hold temporary or permanent rights of ownership or tenancy over the building. In the context of performing arts buildings discussed in this paper, the occupant group is the performing arts organisation itself. This includes the administrative and technical staff and their executives, board members, artistic staff (performers) and their executive(s). This stakeholder group is usually regarded as the client. However, as the term clients have been considered a singular term that often intended to encapsulate a complex consortium of stakeholders whose opinions and factual requirements need to be consolidated into a single consensus view (RIAS, 2004), and may cause confusion, this stakeholder group is labelled as occupants group in this paper for clarity.

Visitors are temporary occupants who are using the buildings in a less regular basis and spend less time in the building and yet have been considered valuable for consultation. In the context of performing arts buildings discussed in this paper, the visitors group includes the existing and potential audience (those who visit the building for a performance or to experience a live artistic event), local community and other member of general public with interest on the building, such as friends groups, school children and/or the academic community for instance. A concrete example of this will be the Unicorn Theatre project in London that had been involving a class of primary school students in designing the new children theatre (Magee, 2005).

Owners are individuals or bodies with a financial interest in the facilities and may or may not be the occupants of the facilities/buildings. However, in the context of performing arts building discussed in this paper, the owners group overlaps the landlord and lessees group and will not be considered as a separate group.

Project Stakeholder Model

Based on the ongoing discussions on the fresh perspective of performing arts buildings and their project stakeholders explained above, a model of project stakeholders can be developed. Thus, it is argued that the design and delivery of performing arts building should be focused on the original purpose of constructing the building at the first place, namely the creation of the experiences for their audiences. The stakeholders identified in this paper need to be involved in the design and delivery of performing arts buildings with the original purpose of constructing the buildings in mind. Other purposes, such as higher visual impacts or iconic architecture, may be considered as added values to and should only support the creation of experience for the audience instead of overshadowing it. Figure 2 illustrates the project stakeholder model for performing arts buildings. There are two major group of stakeholder in the model, namely the providers and the users. The Providers consists of the Makers (architects, PM, Builders, suppliers, and so on) and the Landlord/Owner. The Users consists of Occupants (mainly the arts organisation) and Visitors. At the heart of the project stakeholder model is the original purpose of constructing the building and developing the model, i.e. the creation of the experience.

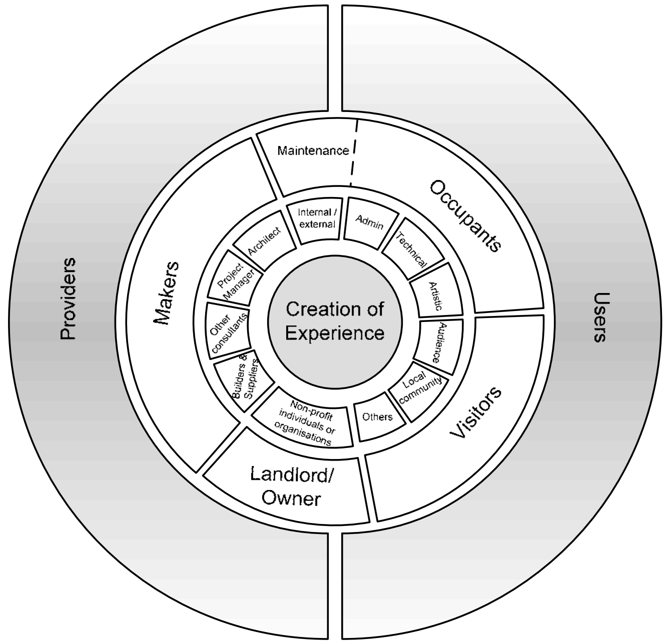

Figure 2. The project stakeholder model for performing arts buildings

4. DISCUSSION AND FURTHER RESEARCH

The design and construction of performing arts buildings have been considered peculiar, complex, and unique compared to other types of buildings due to strict requirements for meeting exacting technical demands and also the necessity to respond to various and sometimes conflicting needs of their stakeholders. Despite the existence of these conflicting stakeholders' needs, many of these publicly funded arts buildings were aiming for high visual impact and iconic architecture in which the role of designers are more dominant whilst the design and management practice generally have not been well attuned to addressing the day-to-day issues important to one of the building users. Thus, there is a danger that the gaps between the end users/the designers, and also between the end users/the clients are amplified within iconic building projects. In attempt to shed a light in the matter and to investigate the most appropriate practices to enable a 'better' environment in order to deliver excellent buildings for the performing arts, a research was set to investigate and analyse selected buildings for the performing arts (i.e. by multiple case studies) that have been briefed, designed and procured in the relatively recent past (i.e. 1999 onwards). This ongoing research project, entitled DeDEPA (Designing Dynamic Buildings for the Performing Arts), is funded by the Arts and Humanities Research Council (AHRC). As an integral part of the research project, this paper discusses the nature and involvement of stakeholders and users of capital arts projects in the design and delivery process from a fresh perspective. The discussion was started by analysing the ultimate purpose of constructing performing arts buildings. First it was established the coherent interaction among the three elements, namely performers, audience, and performance spaces in creating experiences in a live artistic event. Moreover, the nature of the experience has been explored as an event in which the performers express their artistic interpretation of the works whilst the audience experiencing the artistic event. Further study demonstrated that this performers' expression of their interpretation of the works is eventually intended to create the experience for the audiences. In relation to the experience creation, a holistic view expands the coherent interaction to the performers, audience, and the whole building.

Inspired by such interaction and the newly established purpose of constructing performing arts buildings, the discussion was extended to establish the appropriate stakeholders to be involved in the design and delivery of such buildings. Thus, it is argued that the design and delivery of performing arts building should be focused on the original purpose of constructing the building at the first place, namely the creation of the experiences for their audiences. Taking into account the importance of building/end users in the building design and management, a framework from other study was used to conceptualise and develop a stakeholder model for performing arts buildings. The stakeholders included in the model should ideally be involved in the design and delivery of performing arts buildings with the original purpose of constructing the buildings in mind. Other purposes, such as higher visual impacts or iconic architecture, may be considered as adding value to and should only support the creation of experience for the audience instead of overshadowing it. The development of the stakeholder model is considered crucial for the research to provide a direction and platform to inform the development of more responsive spaces and successful performing arts projects that embody the mission, goals and objectives of the arts organisations. The fresh perspective approach was also expected to stimulate a new way of thinking, particularly in the built environment field to take a ‘pause’ for a while in pre-design stage to re-think and re-formulate carefully the original purpose of constructing the building in the first place and identify the appropriate stakeholders (in achieving that purpose) to be properly consulted.

Further research involves data collection through interviews with stakeholders from various case studies that have been identified earlier in the research project. At the moment of preparing this paper, the data collection from three different performing arts projects in England that received public funding through ACE for the multiple case study approach is on progress. The involvement of different stakeholders in those three case study projects is examined (with particular focus on the building/end users) and compared with the ideal stakeholder model presented in this paper. Findings are expected to enable the formulation of the most appropriate practices to enable a ‘better’ environment in order to deliver excellent buildings for the performing arts.

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LATE AND NON-PAYMENT ISSUES IN THE MALAYSIAN CONSTRUCTION INDUSTRY – CONTRACTORS' PERSPECTIVE

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ABSTRACT

To eliminate poor payment practices and to assist continuous uninterrupted construction, some countries have drawn up construction-specific statutory payment security acts/legislations. This paper presents findings of a research conducted amongst Malaysian contractors with the aims to identify the main factors, effects and reactions to late and non-payment issues, and to identify ways to sustain the payment flows in the Malaysian construction industry. The research focused on contractual payments from the employer (government or private) to the contractors. The main factors for late and non-payment in the construction industry identified from the study include: delay in certification, paymaster's poor financial management, local culture/attitude, paymaster's failure to implement good governance in business, underpayment of certified amounts by the paymaster and the use of 'pay when paid' clauses in contracts. The research findings show that late and non-payment can create cash flow problems, stress and financial hardship on the contractors and that some reactions to late and non-payment adopted by the contractors may have adverse effects on their own businesses. Amongst the most appropriate solutions to overcome the problem of late and non-payment faced by local contractors include: a right to regular periodic payment, a right to a defined time frame for payment and a right to a speedy dispute resolution mechanism.

Keywords: construction, contractors, late and non-payment, payments act

1. INTRODUCTION

Malaysia has set its vision to be a fully developed nation by 2020. During the President's & CEO's Roundtable Discussion (2004), the construction industry has set its own vision to be 'among the best in the world' by 2015 and to achieve this vision, the issues of payment has been identified as one of the priority areas in the construction industry. The practice of efficient and timely payment in construction projects is a major factor that can contribute to a project's success. A smooth cash flow brings an effective delivery, on time and within budget so that projects can be completed within the planned time and with acceptance of quality (CIOB, 2004). Payment issues in the construction industry are considered a factor of significant concern to all the players in the industry. A survey of the payment performance has shown that construction industry, in particular, is prone to late-payment culture (Johnston, 1999).

Late and non-payment will cause severe cash flow problems especially to contractors. In view of such problems, Ameer Ali (2005) urges 'everyone in the construction industry pays all appropriate amounts due in a timely manner.' Abdul-Rahman and Berawi (2002) found that top management of construction companies in Malaysia confirmed that financial problem is the main cause of delay in addition to manpower shortage.

It was reported that about 16,000 of the Grade G1[*] contractors were on the brink of bankruptcy when several umbrella contractors failed to pay them for rural roads they had built, despite the government having paid the umbrella contractors in full (Suhaini, 2005). The failure to pay can be attributed to an attitudinal problem which, if commonly accepted by the industry or society in general, can become a culture of a particular industry. Elsewhere, Nicholas (2005) mentioned of a stern warning from a credit manager indicating that small companies faced the greatest risks from the late payment culture in the United Kingdom. The same report pointed out that 1.6% of income was lost because of late payment and that the average payment time in the United Kingdom was about 17.4 days late.

According to Murdoch and Hughes (1996), 'it is not uncommon to find that a contractor or sub-contractor who has not been paid what is due threatens to suspend work under the contract until payment is made'. It must however be noted that without a clear contractual right to suspend the works, the contractor is not entitled to do so even though the employer has failed to pay him within the time stipulated in the contract. In this respect, if the contractor suspends the work the courts may find him guilty of repudiating the contract.

According to Kennedy (2005) 'payment, not unexpectedly, has always been the main subject of disputes'. It has to be noted that the construction payment blues have domino effects on the payment chain of a construction project (Davis Langdon & Seah Consultancy, 2003). For instance, the late payment due to the contractor by the employer will also delay the payment due to the sub-contractor or suppliers who are bound in contract with him. Due to these circumstances, late and non-payment can possibly lead to a formal dispute resolution. According to Bob (2005), in order to recover payment for over the past few years 'the claimant was forced to commence arbitration or litigation' and 'those processes are very costly and take a long time.'

Due to late and non-payment problems, some countries like United Kingdom, Singapore, New Zealand and some states in Australia, e.g. New South Wales, have already legislated their construction specific statutory payment security regime. These legislations purposely enact provisions to address issues on prompt payment in the construction industry to eliminate poor payment practices and smoothen the contractor's cash flow (Lip, 2005; Ameer Ali, 2005).

Acts and the respective countries and states, which enacted them to address the problem of late and non-payment, are listed as follows:

- Housing Grants, Construction and Regeneration Act 1996 – United Kingdom

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[*] Contractors under the Construction Industry Development Board of Malaysia categorization who are eligible for tendering projects not exceeding RM100,000.00.

- Building and Construction Industry Security of Payment Act 1999 (NSW) - New South Wales, Australia
- Building and Construction Industry Security of Payment Act 2002 (VIC) - Victoria, Australia
- Building and Construction Industry Payments Act 2004 (QLD) - Queensland, Australia
- Construction Contracts Act 2002 - New Zealand
- Building and Construction Security of Payments Act 2004 - Singapore

Due to the lack of research on the issues of late and non-payment in the Malaysian construction industry, a study was conducted to identify the problems and effects of late and non-payments in the construction industry. The research was conducted in a timely manner when the local Construction Industry and Development Board was also seeking pointers on payment issues. This paper presents results of a study on late and non-payment issues facing the Malaysian contractors. Another portion of the study, that describes the same issue facing consultants, is presented elsewhere (CIDB, 2006)

2. OBJECTIVES OF RESEARCH

The main purpose of the study is to identify current problems in relation to late and non-payment issues encountered by contractors in the Malaysian construction industry. It also looked into the effects of late and non-payment with the aims to identify the possible solutions to resolve the issues of late and non-payment, which could effectively create "a win-win situation" for all the parties involved. Common methods or responses adopted by the parties in dealing with these issues will be identified to illustrate the effects they have on the parties. The findings of this study is useful for the introduction of a legislation called the Construction Payments Act or Security of Building Payment Act as already found in many advanced countries.

3. RESEARCH METHODOLOGY

The principal method used for the study was the use of a questionnaire survey. The survey was conducted to coincide with the Construction Industry Development Board's plan to incorporate the survey's outcomes in the Cabinet Paper which includes the Construction Industry Payment and Adjudication Bill 2006 which is targeted for submission to the Ministry of Works of Malaysia in March 2006. Considering the fact that a short time period was given, pilot study and interview sessions were not conducted for the purpose of data collection and the only method seems viable were the literature survey that leads and the questionnaire survey. The questionnaire was designed according to the objectives of research by reviewing literature dealing with late and non-payments and other relevant topics. It has been designed to be brief, concise and straightforward to encourage a high response rate from the potential respondents. The respondents just have to contribute their views and opinions by selecting the appropriate answer or giving short answers to the questions. The sources of literature review include relevant case law, books, journals, magazines, dissertations and seminar proceedings, as well as materials published by the Construction Industry Development Board (CIDB), the Malaysian Institute of

Architects (PAM), the Institution of Surveyors (ISM) and the Public Works Department (JKR).

The review of literature has provided useful information on the causes, effects, reactions and possible solutions related to the issues of late and non-payment in the global construction industries.

Target Respondents

A questionnaire survey was conducted on the contractors. The criteria for the selection of respondents were established and 6,000 active contractors from Grade G1 through G7 were randomly selected using the Construction Industry Development Board of Malaysia database. Of the 6000 fielded questionnaires, 333 replies were received, which represents a response rate of around 5.6%. The low response rate may have been contributed to the short response period given to respondents or simply because the prospective respondents were not interested in providing feedbacks.

Questionnaire Structure

The questions in the questionnaire were set to three types of answering methods, namely: rating-based, selective-based and open-based formats. For the rating-based questions, the statements were devised to measure the respondents' opinions by registering them on a four-point scale ranging from "never to very frequent" and "not serious to very serious." The selective-based questions only required respondents to tick the appropriate box or boxes in the questionnaire. The open-ended questions allowed respondents to record down their answers to the questions. Findings of the survey were analyzed to provide a better understanding of the issues of late and non-payment in the Malaysian construction industry. The Statistical Package for the Social Sciences (SPSS) was used to handle the statistical calculations.

4. THE SURVEY RESULTS

The findings of this survey are categorized into two main types of problems associated with late and non-payments in government and private funded projects. Analysis of the completed and returned questionnaire shows that 62.8% (147) of the contractors reported that they have experienced late payment situation in government funded projects whilst 65.4% (178) of the respondents affirmed the same situation in private funded projects. With regard to non-payment, about 24.1% (48) and 44.8% (111) of the respondents pointed out that they have not been paid for the works executed involving government and private clients, respectively since January 2000. Other findings from the questionnaire survey are presented under appropriate headings as follow.

Causes of Late and Non-Payment

Based on Figure 1, some general observations may be made. For the purposes of these observations five most frequent causes of late payment were *"Delay in certification," "Paymaster's poor financial management*," *"Local culture/attitude*," "*Paymaster's failure to implement good governance in business"* and "*Underpayment of certified amounts by the paymaster*" with their overall means of 1.826, 1.734, 1.63 and 1.565, respectively. Figure 2, shows the responses on the question about the causes of non-payment. Based on Figure 2, five most frequent causes of non-payment were

“Paymaster’s poor financial management,” “Paymaster's failure to implement good governance in business,” “Delay in certification,” “The use of ‘pay when paid’ clauses in contracts” and *“Local culture/attitude”* with their overall means of 1.896, 1.848, 1.768, 1.672 and 1.632, respectively. In the questionnaire, the score of three (3) represents the largest scale and zero (0) represents the least.

Respondents have specified additional causes of late/non-payment in addition to the ones listed in the questionnaire which include corrupt practice among consultants, pending on VO approval, money used up for other purpose, paymaster's ill intention of not paying when works are completed, consultant's working culture/attitude, main contractor lack of professionalism and economic slow down.

Effects of Late and Non-Payment

Respondents were also asked to rate the effects of late payment based on the extensive list given. A further analysis of the effects of late payment revealed that, three most grave effects of late payment based on Figure 3 were *“Create cash flow problems,” “Create stress on contractors”* and *“Creates financial hardship”* with their overall means of 2.377, 2.185 and 2.135, respectively.

Meanwhile, the three most prevalent effects of non-payment based on Figure 4 were *“Create cash flow problems,” “Creates financial hardship”* and *“Create stress on contractors”* with their overall means as 2.546, 2.454 and 2.40, respectively.

Additional effects of late or non-payment specified by respondents include: create accounting problem & tax computation, poor perception of industry players, affect the overall growth of a company, suppliers’ require cash purchase/LC/bank guarantees - heavy cash flow for the main contractor to operate, bad image to the government, affect quality of end products and possibility of sabotage by sub-contractor’s workers who have not been paid as a result of the chain effect, and results in delay and LAD.

Reactions to Late and Non-Payment in Government-Funded Projects

Figure 5 illustrates that the three most preferred reactions by the respondents when experiencing a late payment situation with government paymasters were *“Plead with employer for payment even after due date,” “Ignore and follow up with another claim the following month”* and *“Slow down works”*, with overall means of 2.049, 1.648 and 1.337, respectively.

Figure 6 indicates that the three most common reactions to non-payment in government-funded projects are: *“Plead with employer for payment even after due date,” “Slow down works”* and *“Ignore and follow up with another claim the following month”* with their overall means of 2.197, 1.724 and 1.651, respectively.

Additional reactions specified by contractors who encountered late/non-payment problem in government-funded projects are: find other source of fund, reschedule work to help developer ease their cash flow, mutual discussions with employers, giving discount to employer, and employment of stricter controls due to lack of trust.

Reactions to Late and Non-Payment in Private Funded Projects

In this question, respondents were asked to identify prevalent reactions when they face a late payment situation involving private clients. Based on Figure 7, three most frequent reactions in dealing with late payment problem in private funded projects are: *"Plead with employer for payment even after due date," "Ignore and follow up with another claim the following month"* and *"Slow down works*", with their overall means of 1.844, 1.688 and 1.068, respectively.

Figure 8 shows the responses to the question on how respondents' would react when they encountered with non-payment situation in private funded projects. The results show that the three most prevalent reactions when dealing with non-payment scenario in private funded projects are to: "*Plead with employer for payment even after due date," "Ignore and follow up with another claim the following month"* and *"Slow down works*".

Possible Solutions for Late Payment or Non-Payment Issues

This question asked the respondents about the probable solutions to overcome the problem of late and non-payment faced by local contractors either main contractors or sub-contractors. The three most possible solutions to counteract the payment problems based on Figure 9 are *"A right to regular periodic payment," "A right to a defined time frame for payment"* and *"A right to a speedy dispute resolution mechanism, for example, Adjudication,"* with their overall means of 3.72, 3.695 and 3.509, respectively. For this question, four is the largest scale and one is the least. Interestingly, the overall nine possible solutions in the questionnaire were all given a high score of importance as the least score was even as high as 3.147 as shown in Figure 9. Other solutions to late or non-payment situation provided by respondents are listed as follows: setting up of a commission to investigate errant paymasters, payment guarantee, restructuring work progress proportionate to payment's entitlement, amending the existing PAM or JKR contract, strictly follow milestones for payment, formation of an appropriate body to look into contractors' payment woes, issuance of advanced payment for contracts with a value > 5 million Malaysian Ringgit, and suspension of irresponsible main contractors' licenses with the CIDB.

5. CONCLUSIONS

Findings from the questionnaire survey indicate that more than 60% of the local contractors have experienced late problem may it be in government funded projects or private funded projects. As for non-payment, about 24.1% (48) and 44.8% (111) of the contractors reported that out that they have not been paid for the works executed involving government and private clients respectively, since January 2000.

The results of the study indicate that the most frequent causes of late and non-payment include: paymaster's poor financial management, paymaster's failure to implement good governance in business and local culture/attitude. The authors feel that it is necessary for employer's financial capacity and credit rating be made transparent to facilitate contractors in choosing the right employers and to increase chances of the latter getting paid. As the respondents felt that local culture or attitude is one of the frequent causes of late and non-payment, it is recommended that contractors consider this problem as a major risk that has a high probability of occurrence and account for it when completing estimates for tender.

The survey results indicate that the three most serious effects of late and non-payment are “Create cash flow problems”, “Create stress on contractors” and “Creates financial hardship”. It is anticipated that late or non-payment most likely will cause undue financial stress on the contractors and this would have a devastating knock-on effect down the contractual payment chain.

The results of study also show that some reactions to late and non-payment taken by the contractors may have adverse effects on their own businesses. For instance, contractors may not be able to justify their claims if they purposely “Slow down works” due to late or non-payment problem as the contractors could be treated as repudiating the contract in the event if there is no such right available in the contract.
Most of the respondent contractors agreed that a mechanism for avoiding or reducing this problem need to be taken in the form of contractual or statutory rights with the overall mean of 3.72. This study indicates that the three most possible solutions of payment problems are “a right to regular periodic payment”, “a right to a defined time frame for payment” and “a right to a speedy dispute resolution mechanism, for example, adjudication”. It is perhaps timely for Malaysia to consider introducing its own legislation on the Payment and Adjudication Act. Nevertheless, introduction of such an act cannot be regarded as a panacea for all ills, rather it must be regarded a means to an end. Professional bodies and government agencies should study and amend the existing standard forms of contract to provide protection and, promote balance allocation of risk and fair contract to all related parties. Promptness of submitting, processing, issuing interim payment certificates and honouring the certificates are extremely important issues in relation to progress payment claims. Perhaps, an increased sense of professionalism in construction industry could overcome some of the problems related to late and non-payment issues. Another crucial issue that needs to be addressed in why and how to change the sometimes lackadaisical attitude on payment issues in the construction industry.

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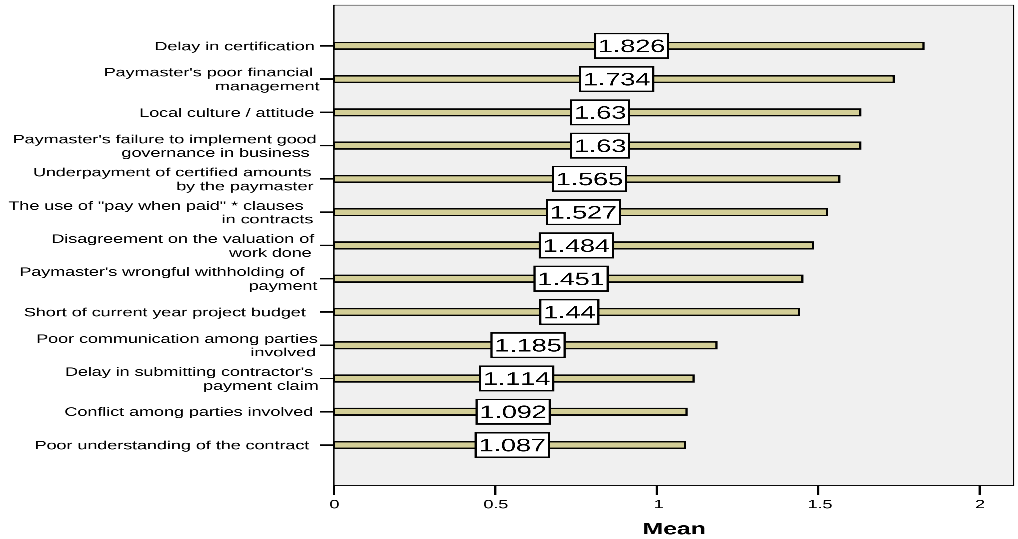

Figure 1: Causes of Late Payment for Contractors

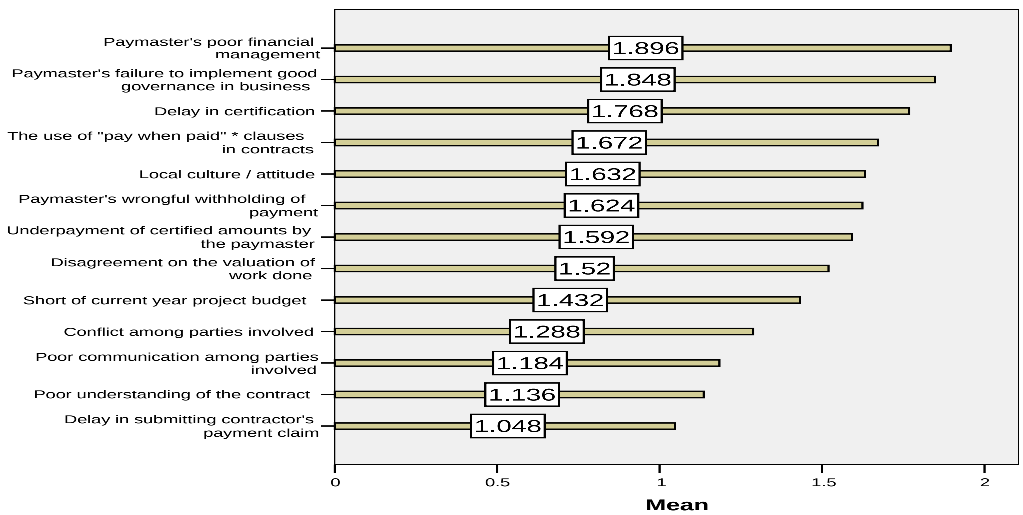

Figure 2: Causes of Non-Payment for Contractors

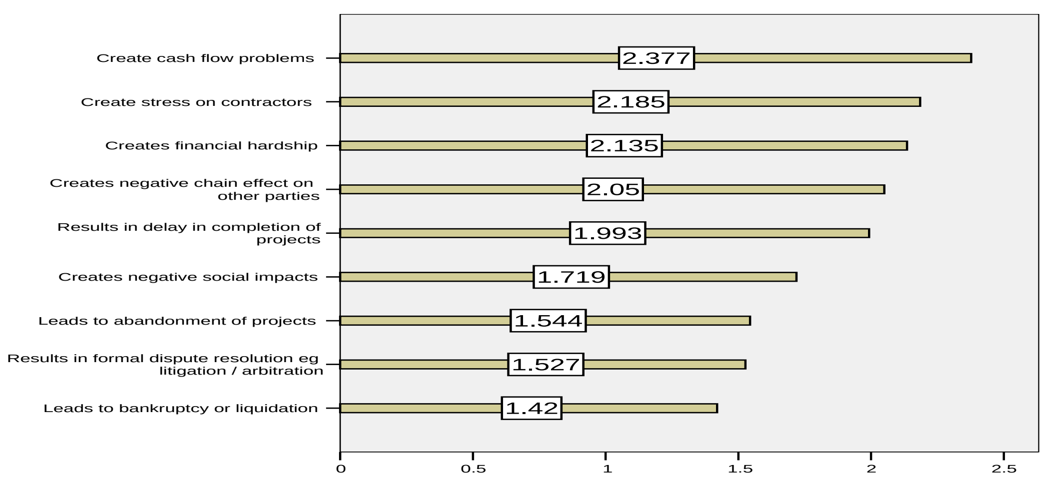

Figure 3: Effects of Late Payment to Contractors

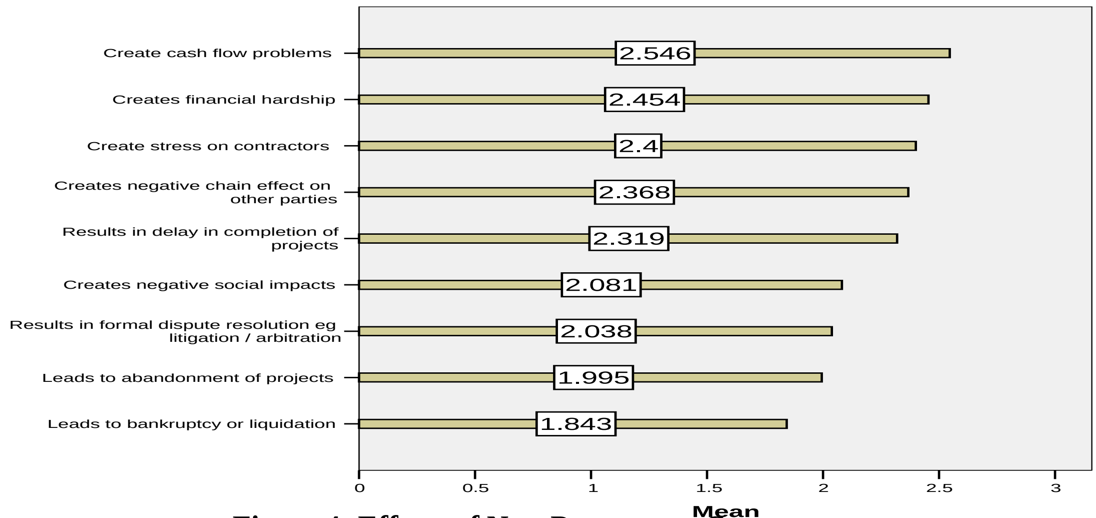

Figure 4: Effects of Non-Payment to Contractors

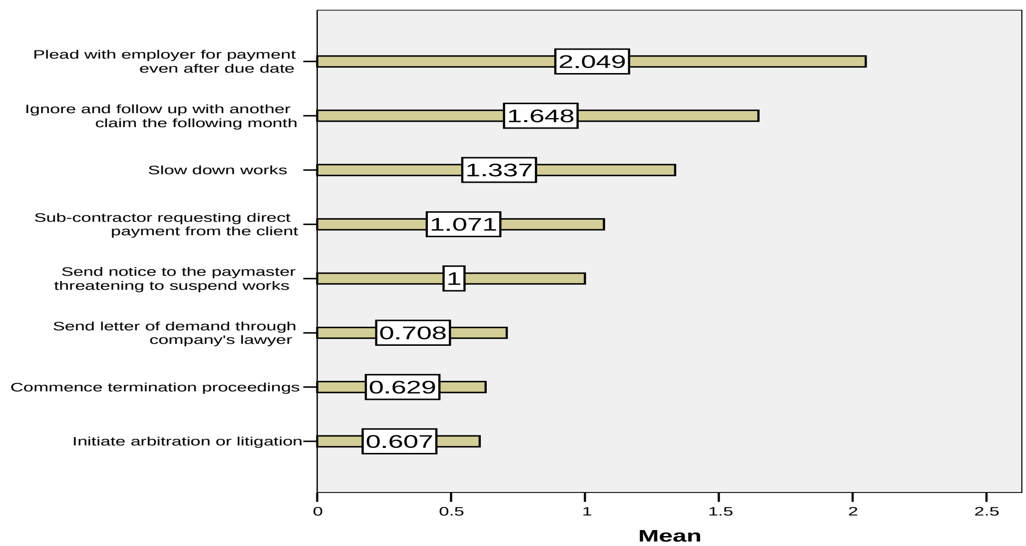

Figure 5: Contractors’ Reactions to Late Payment in Government Funded Projects

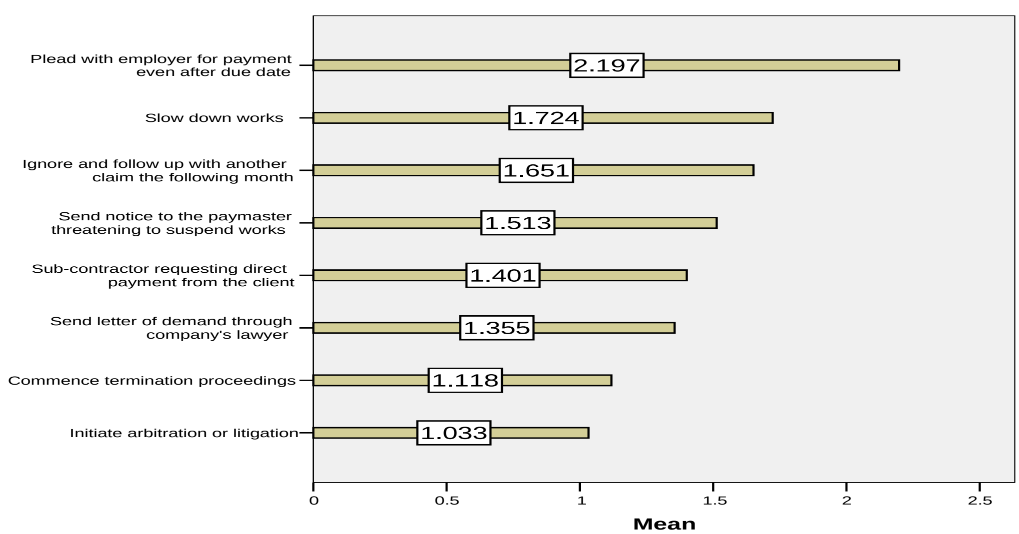

Figure 6: Contractors’ Reactions to Non-Payment in Government Funded Projects

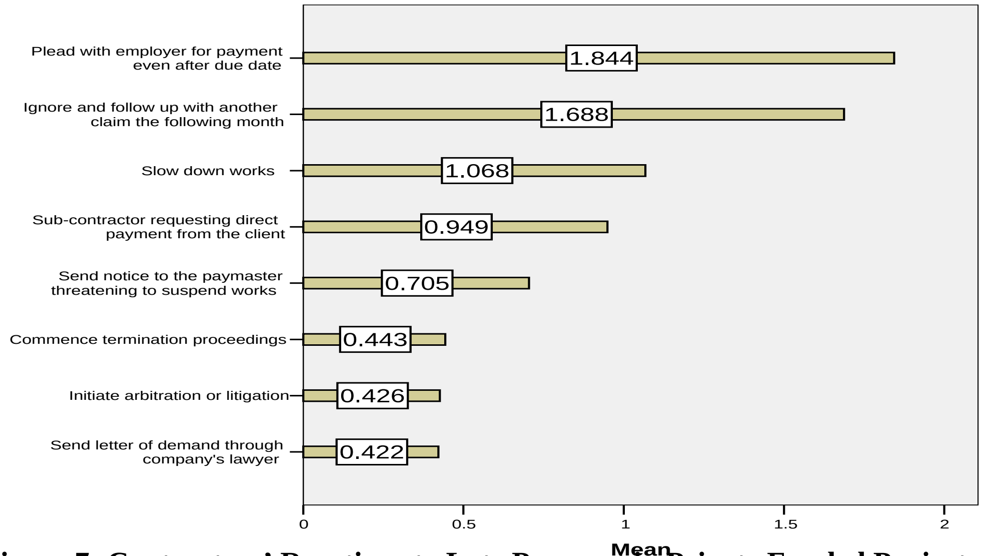

Figure 7: Contractors' Reactions to Late Payment in Private Funded Projects

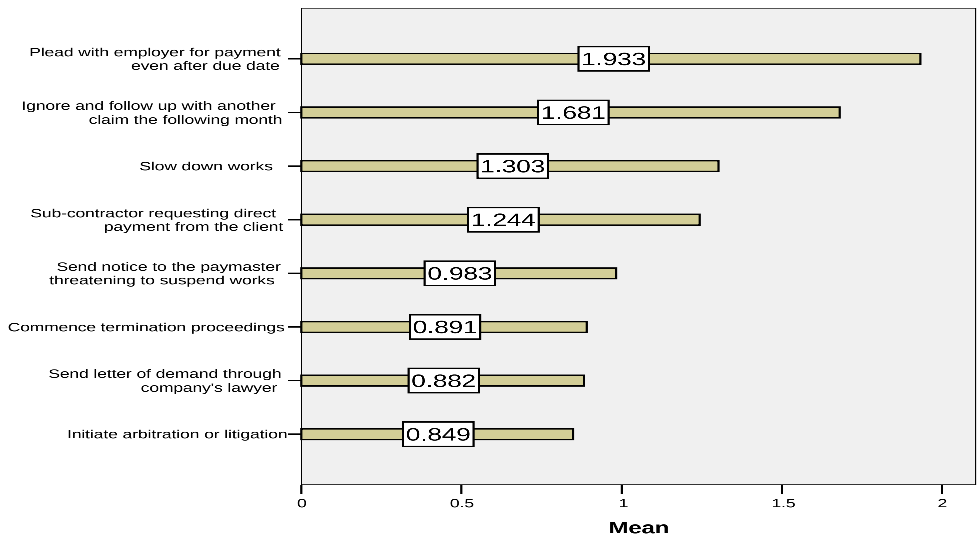

Figure 8: Contractors' Reactions to Non-Payment in Private Funded Projects

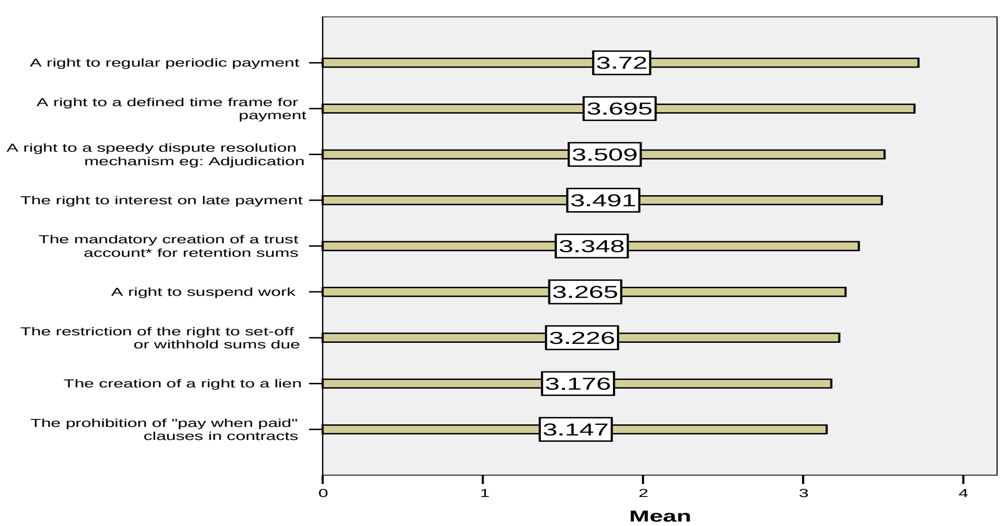

Figure 9: Possible Solutions According to Contractors

INTEGRATING SUSTAINABILITY THROUGH FACILITY MANAGEMENT ACTIVITIES

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ABSTRACT

Sustainability, the talk of the day, becomes a key business imperative. The commercial pressures from increasing environmental imperatives imposed by internals and external constraints put pressures on facility management activities which amount to 75 per cent of the facility total life cycle costs. Therefore, today's companies have to find a way between focusing on profit on one hand and concentrating on issues like environmental or social concerns on the other. This paper aims to examine the current awareness of literature for the conflict between the construction and facility management practices in achieving sustainable building, answer the question of why we need sustainability in our facility management practices based on the current practices; all are demonstrated by examples which shows the financial benefits of applying sustainability, and the limitations that hinder the improvement of facility management practices. The paper concluded with addressing some recommendations for improving facility sustainability through internal business procedures.

Keywords Construction; Environment; Facilities management; Sustainability

1. INTRODUCTION

By 2050 the world population may grow up to 9 Billion, about 1.5 times of the current population accordingly; sustainability development becomes serious moral responsibility towards future generations. Although the urgency of a sustainable development is recognized by many people in business, science, and government, both national and international, it is not yet a common shared orientation for society and many strong forces resist the necessary changes (Fokkema, Jansen & Mulder 2005) especially with treating economic management and environmental quality as non-interacting entities which has resulted in much on the current environmental crisis (Langston 2005).

Buildings, of all types, consume nearly half of the world's resources and energy among all other sectors (Best, Langston & Valence 2003; Paumgartten 2003; Zimmermann, Althaus & Haas 2005). For example, in Australia, buildings are responsible for 30 per cent of all raw materials used by society, and consume more than 40 per cent of all energy produced causing more than 40 per cent of all atmospheric and air emissions (Robinson & Lawther 2005). Commercial buildings in Australia account 35 million tones of carbon dioxide per year (Best, Langston & Valence 2003). Thereupon, the building sector is increasingly facing criticism from its clients and a threat from environmental legislation, in particular in the way it has tended to respond to its processes in design, construction and facility management delivery and quality (Wyatt, Sobotka & Rogalska 2000).

However, sustainable building face some problems such as the lack of brainpower applied to the facility management field, it is difficult to anticipate how the sustainable building may perform overtime because it is based on the forecasting future conditions, and lowly skilled personnel usually find difficulty to understand the building and what is happening to it (Wood 2003) especially that the practical aspects of sustainability are less well understood than the conceptual aspects (Brown & Pitt 2001). Nevertheless, the research in this area remains largely undeveloped, with many research gaps in an extensions possible from the literature (Wilkinson & Hill 2001) particularly the analysis of the companies' environmental management from the facilities or facility management's point of view (Nousiainen & Junnila 2005).

Presently, relatively little research effort is directed towards the assessment of the environmental impact of complete building systems as opposed to individual products and components (Brown & Pitt 2001). Therefore, this paper is an attempt to highlight the achievement of the published literature up-to-date and the gaps in this literature in order for researchers to carry up from that point further researches.

2. SUSTAINABILITY CONFLICT BETWEEN CONSTRUCTION AND FACILITY MANAGEMENT

Building sustainability focuses on the user rather than the building; it depends on location, construction materials and workmanship, maintenance, energy use, and meeting user needs (Wood 2003). For example, conventional design and construction too often keeps experts separated during the building process without taking into consideration the long-term operational costs (Paumgartten 2003). Although facilities represent less than 10 per cent of company's expenses, it cause almost one half of the environmental impact of the organization (Nousiainen & Junnila 2005). Moreover, building assets have not only immediate local effect, but also they may have a global effect on the environment (Boussabaine & Kirkham 2004).

Construction industry and its clients tend to concentrate on short-term gains rather than long-term savings or investment opportunities especially at the study and design period which focuses merely on the first owner interest (Langston 2005; Robinson & Lawther 2005). Therefore, solutions that aim to avoid repetitive maintenance, reduce waste, save non-renewable energy resources, or protect the environment through selection of better quality materials and systems, are often rejected on the basis of the economic analysis process because of its higher capital costs (Langston 2005) which are major obstacles, as they reduce profitability of the project; but exactly how much extra will depend upon the level of sustainability introduced (Langston 2005; Robinson & Lawther 2005).

If we consider the fact that over a building's first 40 years, construction costs amount to only 11 percent compared with operation and alteration costs, which amount to 75-80 per cent (Paumgartten 2003) we can realize that environmentally and socially responsible businesses have the ability to differentiate themselves in a crowded marketplace specially with the advent of globalization, companies have more competitors and being socially accountable is a clear way to differentiate your business (Roberts 2003). Therefore, facility management should have the key role of environmental management since the conceptual design stage especially that facilities can be designed to be more durable and sustainable through the use of smart systems and monitoring tools. Doing so may sound socially reasonable but not attractive financially (Best, Langston & Valence 2003) because these operating costs are generally financed from equity reserves which are combination of commencing funds and progressively accumulated revenue (Langston 2005).

3. WHY SUSTAINABILITY IN FACILITY MANAGEMENT?

Operating, maintenance, and rehabilitation costs of any new or existing facility amount more than 75-80 per cent of its whole life-cycle cost (Boussabaine & Kirkham 2004). Thereupon, generally companies are increasingly realizing the importance of facilities and facility management from the environmental point of view (Nousiainen & Junnila 2005) but it is the question of whether the majority of corporations actually have any such motivation to use this power to help bringing about the transition to sustainable development (Starkey & Welford 2001). Some leading companies, like Shell and Unilever recognized that it is in the interest of business to work towards sustainable development (Fokkema, Jansen & Mulder 2005) and have realized substantial financial benefits for themselves and subsequently for their shareholders (Paumgartten 2003).

Environmental pressure tended to be an external constraints imposed by regulations, legislations, media, accidents, local communities, competitors, green customers and investment groups, activities, scarcity of raw materials, and the rising costs of waste disposal (Wilkinson & Hill 2001). However, in recent years these external pressures have been reinforced by internal pressures from within the firm itself, the growing need to do more with less, increasing budget constraints, and reducing resource availability puts an increasing need on facility management systems to improve their cost effectiveness, efficiency and efficacy (Roberts 2003). In addition, because of the increasing consumer consciousness and societal expectations' of the corporations, society is now forcing corporations to be accountable for the environmental and social impact of their operations. Consequently, it is now virtually impossible for corporations to behave irresponsibly anywhere or to assume that such behaviour will go unnoticed (Roberts 2003).

Facility management has importance role and contribution to life practices not only in maintaining a life-time cost-effective operational environment but also in helping the improvement of life design, life care management, and encouraging the promotion of the life care auditing; in effect by doing so also encouraging sustainable lifetime practices (Wyatt, Sobotka & Rogalska 2000). A key point is to consider both the life cycle assessment and the life care needs so that the service life planning is not compromised by using a shorter service life in a higher order system which could lead to expensive remedial works (Wyatt, Sobotka & Rogalska 2000).

4. SUSTAINABILITY PRACTICES IN FACILITY MANAGEMENT

With regard to the technology systems, the use of appropriate technologies to be consistent with future as well as present needs is one of the sustainability features in any building (Wood 2003). However, current technology is the root cause of the lack of sustainability in modern society (Fokkema, Jansen & Mulder 2005). The prediction of a further increase in world population and the fast economic development in world regions like China and India accentuates the problems of global resource scarcity and the need for technical progress (Bretschger 2005). Although, there still a little doubt that technical change has the potential to substantially contribute to new solutions, inefficient energy systems are one of the main drivers of building renovation (Best, Langston & Valence 2003).

With regard to the maintenance, maintenance costs contribute with almost 12 per cent to the total cost of a building over its lifetime (Boussabaine & Kirkham 2004). When maintenance is required, preferable sustainable materials are the ones which are easy to repair, do not require the use of products that have negative environment impact, do not need to transport long distance for repair, do not cost much to repair as buying new one, and do not require constant maintenance work (Best, Langston & Valence 2003). For a building to be sustainable it has to receive as low corrective maintenance as possible, however, preventive maintenance does not encourage sustainability, it implies that components are replaced while they still have useful residual life (Wood 2003). Moreover, the replacement of useful components creates variety of waste issues such as unwanted furniture, fittings, fixtures and finishes In addition to the waste resulting from ongoing maintenance and repair which is also unsustainable (Best, Langston & Valence 2003). According to Wood (2003), reusability of the building is one of the features of sustainable building, however it’s difficult to find potential users for old building, but sites are often very attractive for the development of new projects. Nevertheless, the building may have architecture merit or over time it may accumulate cultural or heritage value.

With regard to the workforce, commercial green buildings are no longer expensive workplaces for the ultra-environmentalist. Environmental sustainable buildings are no longer just about reduced emissions or increased productivity, but the people who live and work within them are identified and acknowledged as a fundamental and worthy resource in their own right (Paumgartten 2003).

More than 80 per cent of business expenses go toward workforce salaries and benefits; accordingly a building becomes an organizational benefit, and the people within them are considered to matter, rather than simply a way of housing an organization (Robinson & Lawther 2005). It can play a role in reducing staff absenteeism due to symptoms such as irritation of the eyes, nose, throat and skin, mental fatigue, reduced memory, lethargy, headache, dizziness, nausea and unspecific hypersensitivity reactions (Langston 2005). Unpublished research conducted by Advanced Environmental Concepts found that the cost of sick leave remuneration in Australia in 2000 (excluding cost of replacement staff, disruption of production etc) was estimated to be $1550 per employee, whilst the cost of replacing employees, or staff churn, is estimated to be anywhere from 29 to 130 per cent on an employee’s annual salary (Robinson & Lawther 2005).

5. CURRENT LIMITATIONS IN FACILITY MANAGEMENT SUSTAINABILITY STUDIES

Some of the major limitations that are hindering sustainable facility management practices as addressed in the related published literature are as follows:

- Life-Cycle Assessment (LCA) decisions should be based on facility management guidelines including maintenance. These guidelines are also required at the final life stage to manage the process of reuse, recycling, and disposal of the building components in the most efficient way (Boussabaine & Kirkham 2004). However, LCA techniques results suffer large variations based on differences in evaluation methods. Accordingly, LCA results require to be properly interpreted to ensure that meaningful and reliable comparisons between various alternative systems can be obtained (Brown & Pitt 2001).

- LCAs are limited in terms of understanding environmental interactions between a number of interrelated systems or sub-assemblies (Brown & Pitt 2001). There is lack of mathematical models for addressing the eco-costs of the environmental burdens caused by the procurement and operation of assets in their entire life cycle (Boussabaine & Kirkham 2004).

- Life-Cycle Costs (LCC) experience an absence for a any internationally definition or recognized standard (Boussabaine & Kirkham 2004).

- When the design is poorly engineered, little regard has been given to LCC studies or supply chain management issue, which allows a loss of serviceability and sustainability because the society's clients or buildings' owners are handicapped (Wyatt, Sobotka & Rogalska 2000).

- The lack of multi-criteria approach that can offer considerable advantage to deal with the complexities of sustainability assessment, in which options can be ranked according to the perceived level of achievements of sustainable development objectives after taking the key criteria of investment return and financial performance into consideration first (Langston 2005).

- With respect to the social dimension, there is little agreement on which criteria should be considered for social performances evaluations and methodologies which are currently not practical for industry applications and business practices; in contrast, the methodologies for most of the sub-criteria of the economic dimensions are reasonably well defined (Labuschagne & Brent 2005). Therefore, it is difficult, if not impossible, to place an economic value on all environmental and social impacts.

- Measuring and evaluating the sustainability depends on the kind of information that is available at the point of assessing the sustainability performance of a specific operational activity. Additionally, information gathering activities might have to be executed during individual phases in order to obtain the necessary sustainability data that is required for evaluation (Labuschagne & Brent 2005) so only when the data is accurate and interpreted right, these measures can be useful.

6. RECOMMENDATIONS FOR ENHANCING SUSTAINABILITY IN FACILITY MANAGEMENT PRACTICES

- It's important to place a system to deal with the correct disposal of replaced items; this type of system assist in achieving targets but do not set levels of performance. The benefits of that system include assisting facility managers in making decision at every stage of the facility life cycle based on the organization resources, assets and functions; the ability to identify and correct problems internally, it is a consistent framework for monitoring environmental performance and sound basis for performance reporting; assisting in the continuous improvement of environmental performance, achieving reduction in resource use and thereupon greater cost control, achieving reduction in corporate environmental liability and risk which leads to capital access improvement and lower insurance costs, giving positive market image, meeting with vendor certification criteria and accordingly increasing potential market share, and finally it could be linked with other internal organizational systems (Best, Langston & Valence 2003).

- There must be a recognition of the natural downward or degradation pathway of the materials and components used and an understanding that there will be a waste dispersal need because sustainability waste disposal may prove a problem of recovery management if an unacceptable safety or health risk arises (Wyatt, Sobotka & Rogalska 2000). Accordingly facilities will be obliged in the future to treat their own waste (Langston 2005) which means waste disposal will be another function occupancy cost.

- Environmental management systems (EMS) such as ISO 14001, can assist facility managers in their decision-making at all life cycle stages and achieving targets however it does not set levels of performance (Best, Langston & Valence 2003).

- Buildings shall be classed as ecologically sustainable where the environmental loads resulting from their construction, operation, demolition/dismantling, and their energy demand do not exceed their allotted share of the permissible environmental loads. The low savings potential held by refurbishment needs to be offset by disproportionately high cuts in operating energy consumption for heating and water consumption (Zimmermann, Althaus & Haas 2005).

- Achieving environmental efficiency may require a number of strategies ranging from reducing CO2, NOX, SO2 emissions, lowering annual energy costs, reducing resource depletion, increasing recycling, and preventing any loss of biodiversity and damaging effects on flora and fauna. If the facility management is to be successful in reducing the overall environmental impact, comparative quantify analysis tools are of much importance to compare building design options (Brown & Pitt 2001).

- Most building materials are complex in their chemical and physical natures; for example, volatile organic compounds are emitted by some material affecting indoor air quality. Therefore, the use of natural materials, which are less damaging to the environment and require less processing, is recommended especially that they are generally lower in embodied energy and toxicity than man-made materials. When low-embodied energy natural materials are incorporated into building products, the products become sustainable (Gilleard 2005).

- Although direct environmental and social effects underlie direct corporate control, whereas indirect effects cannot be controlled completely by companies; both effects should be considered from a corporate point of view; for example, related effects to upstream processes which are controlled by suppliers can be influenced by the company through its purchasing policy or through business to business cooperation in an indirect way (Pflieger et al. 2005).

- Environmental improvements of building assets are only occur when stakeholders are persuaded to consider boarder environmental life-cycle thinking and are prepared to integrate it into decision making process (Boussabaine & Kirkham 2004). Therefore, profitability must be part of the sustainability equation in order to maximize wealth in addition to consider maximizing utility which is related to community goals (Langston 2005).

7. REAL EVIDENCES FOR BENEFITS FROM APPLYING SUSTAINABILITY PRACTICES

- The corporate social responsible based domini 400 social index over the last 10 years produces an average return of 13.77 per cent versus a 12.95 per cent return for the S&P 500 (Roberts 2003).

- A report to California's Sustainable Building Task Force, touted as "the most definitive cost benefit analysis of green building ever conducted" concluded that minimal increase of capital investment of approximately 2 per cent to support green technologies in buildings would, on average over a 20 year period, resulted in life cycle savings of 20 per cent of total construction costs; approximately 30 per cent of these savings (6 per cent of total saving) emanated from reduced energy and resource usage, and 70 per cent from increased production productivity and health values (Robinson & Lawther 2005).

- The Pennsylvania Power and Light Company incorporated task lighting for their drafting staff. The results were 73 per cent reduction in energy bills by which in itself produced a return on investment of 24 per cent (Robinson & Lawther 2005).

- For projects begun between 1990 and 2000 in the USA, energy savings reached 166 million megawatt-hours (MWh) with a reduced electricity load demand of 2’511 MW, which is enough to power every house in California for two years. These electricity reductions, combined with total reductions in natural gas usage, translate into $16.7 billion in total energy cost savings for the company’s customers, six brand new 400-MW power plants that do not need to be built on the other, and into the removal of 217 million tons of carbon dioxide, which has the same environmental benefit as planting 650 million trees or removing the pollution from 42 million mid-sized cars (Paumgartten 2003).

8. SUMMARY

Construction industry and its clients generally tend to concentrate on short-term gains rather than long-term savings especially at the study and design period which focuses mainly on the first owner interest. In addition, solutions that aim to avoid repetitive maintenance, reduce waste, save non-renewable energy resources or protect the environment through selection of better quality materials and systems, are often rejected on the basis of the economic analysis of the higher capital costs which still unable to consider environmental and social advantages in terms of profit.

The growing need to do more with less, with increasing budget constraints and reducing resource availability increase the need for facility management to improve its systems, cost effectiveness, efficiency and efficacy. However, most current sustainability practices in facility management are does not encourage sustainability such as preventive maintenance which implies that components are replaced while they are still useful residual life in them.

Currently, there are many limitations for facility management to achieve sustainability in buildings at acceptable levels. Some of these limitations, as addressed in related published literature, are Life-Cycle Assessment techniques results can suffer large variations based on differences in evaluation methods and these results require to be properly interpreted to ensure that meaningful and reliable comparisons between various alternative systems can be obtained, the lack of mathematical models for addressing the eco-costs of the environmental burdens, the absence of any internationally recognized standard for Life-Cycle Costs, the need for multi-criteria approach that can deal with the complexities of sustainability assessment, little agreement on which criteria should be considered for social performances evaluations and methodologies in industry applications and business practices, and only when the data is accurate and interpreted right, sustainability performance measurement can be useful, and it is difficult to place an economic value on all environmental and social impacts.

Nevertheless, there are many ways to enhance the sustainability of current practices in facility management and improve it, some of which are to place a system to deal with the correct disposal of replaced items, recycling as a solution for the natural resources scarcity and materials disposal, applying environmental management systems as a useful tool to assist facility manager in life cycle decision-making process, classification of buildings according to their ecological sustainable, incorporating natural materials into building products, influencing environmental and social uncontrolled external effect which is undesirable in an indirect way, etc.

To sum all, further work has to be done in the field of social impact analysis in order to increase our understanding of what nature does and being aware of advantages as well as limitations towards delivering sustainable buildings. In addition to encouraging both innovation and research to meet new and changing environmental and whole life standards and to develop service life planning and modelling techniques to provide quantified environmental life engineering discipline.

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METHODOLOGY FOR DEVELOPING A MODEL FOR THE ANALYSIS OF E-PROCUREMENT CAPABILITY MATURITY OF CONSTRUCTION ORGANISATIONS

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ABSTRACT

Uptake of e-procurement by construction organisations worldwide has been inadequately researched. E-business successes achieved in other industries indicate the potential for the construction industry to achieve the same or better. There have been many government backed programmes and initiatives to encourage e-procurement within the UK. Since inception in April 1995, the Construction Industry Trading Electronically (CITE) standard has been proclaimed as the way forward for construction e-procurement in the UK. However, the poor usage (less than 2.9%) is indicative of the poor state of e-procurement in the UK construction industry (Martin 2003).

There are many drivers and barriers to e-procurement. Previous studies in the US (Davila et.al. 2003, Minahan & Degan 2001) and Australia (Hawking et.al. 2004) have ranked these for the general procurement of goods and services industry. There is no such analysis provided for the construction industry.

This paper presents details of a wider research project aimed at developing a model to analyse the e-procurement capability of construction organisations. This termed as e-readiness of organisations will indicate the current state of a construction organisation in terms of its readiness to carry out e-procurement. The paper describes in detail the research methodology being employed for the development of this model. It also provides details of preliminary findings (based on a pilot study of the Northern Ireland construction industry) of a research project which ranks drivers and barriers to construction e-procurement. It also evaluates the use of CITE prescribed data exchange format for the construction industry.

The results of the pilot study indicate that 71% of construction organisations receive less than 10% of contact documentation in an electronic form. 80% of organisations have never used CITE approved software for bills of quantities preparation or pricing while 84% of organisations use and prefer spreadsheets over CITE approved format for data exchange. It also identifies ‘improving communication’ and ‘reduced administration costs’ as the two most important drivers with ‘security of transactions’ and ‘being unsure as to the legal position of e-procurement’ as the two most important barriers to construction e-procurement.

Keywords Capability maturity model, CITE, Construction, e-procurement, e-readiness

1. INTRODUCTION

E-Procurement enhances all aspects of the procurement process. (National Institute of Governmental Purchasing 2001, Minahan and Degan 2001, McIntosh and Sloan 2001, Ribeiro 2001). The procurement process is not solely the buying of goods and services but incorporates the strategy behind this as well (Egbu et.al.,2003). The principle of electronic procurement is to provide a faultless system of transmitting the input from the contractor's tender through to contract management, removing the inefficiencies, delays and cost involved in manually processing a tender and retranscribing for contract management activity. E-Procurement can then be defined as "*the use of electronic technologies to streamline and enable procurement activities*" (Hawking et al 2004).

In April 1995 'Construction Industry Trading Electronically' (CITE) was instigated to produce a standard system of data interchange for UK construction industry tenders. Original membership included some of the major players in the UK Construction Industry such as the Mansell Plc, Taylor Woodrow and others. CITE describes itself as "a collaborative electronic information exchange initiative for the UK construction industry". The idea was to enable the industry to move forward as a unit using the same formats and systems. In practice, this research shows the situation to be different. The Royal Institution of Chartered Surveyors (RICS) reported that there is as little as 10% of documentation in CITE format (Martin, 2003). This is further ratified by this research.

This highlighted that there were still barriers to be overcome in construction e-procurement. The literature review further revealed that most of the studies relating to drivers and barriers to e-procurement dealt with the general goods and services supply industry (Hawking et.al. 2004, Davila et.al. 2003, Minahan & Degan 2001). The only study that reports on the status of the construction industry was recently reported from Canada (Rankin et.al, 2006). This research in Northern Ireland identified and ranked the drivers and barriers for e-procurement in the construction industry and will form part of a broader study to analyse the e-readiness of construction organisations. The research aims to develop an e-procurement capability maturity model to establish the state of readiness of construction organisations to adopt e-procurement (e-readiness). This paper describes the research methodology used to develop the capability maturity model for e-procurement and presents the initial findings of the research related to drivers and barriers to e-procurement in construction. It also reviews the use of CITE as a protocol for e-procurement in construction.

2. METHODOLOGY FOR DEVELOPING AN E-PROCUREMENT CAPABILITY MATURITY MODEL

The development of the e-procurement capability maturity model can be broken down into three main phases, namely; theoretical, empirical and the modelling and development phase. These are shown by the different types of shading in Figure 1.

2.1 The Theoretical Phase

This phase of the study involves carrying out a detailed literature search into procurement. This is divided into three stages: procurement, electronic procurement and electronic tendering. Each of these stages involves a critical review of traditional methods, the use of electronic technologies in procurement and electronic tendering in construction procurement.

There are studies in the general goods and services sectors, analysing drivers and barriers to e-procurement in the USA and Australia (Davila et. al.,2003, Hawking et. al., 2004), the Northern Ireland study applied these identified drivers and barriers to construction e-procurement. In another recent study reported from Canada, Rankin et.al.(2006) attempts to identify the drivers and barriers to construction e-procurement. The Northern Ireland research reviews both sets of data and applies the drivers and barriers to e-procurement identified by these studies to the construction industry in Northern Ireland.

2.2 The Empirical Phase

This phase involves carrying out a pilot study primarily aimed at identifying the drivers and barriers to construction e-procurement. It also attempts to explore the existing e-procurement initiative CITE as a standard system or data exchange in construction. The survey was limited to the Northern Ireland construction industry. The pilot study is now completed and the main findings are presented in this paper.

There are two further UK wide detailed surveys planned to be executed as a part of this research. Both these surveys aim to capture drivers and barriers to construction e-procurement in the UK. One survey will examine the status at organisation level while the other will explore drivers and barriers at project level. A representative group of 'Industry' specialists who can supply the necessary information will be selected. This group will include representatives from all sections of the construction industry such as; architects, engineers, quantity surveyors and contractors from across the UK. These parties will be required to rank the drivers and barriers to construction e-procurement at both organisational and project levels. The survey will also focus on the particular difficulties which an electronic system of tendering encounters at project level and will investigate why there is a lack of uptake on the Construction Industry Trading Electronically (CITE) approved programmes.

The detailed surveys will be carried out using both traditional and electronic means. The information collected by surveys will mainly be quantitative although a number of qualitative questions will also be included. Empirical data gained from the surveys will be used to create a theoretical structure for ranking drivers and barriers. The web-based surveys will be carried out using PHPSurveyor™ a web-based survey tool mounted on a website. This will allow collection of data in a SQL database that facilitates the export to programmes such as SPSS™, Sphinx™ and Nvivo™ for quantitative and qualitative data analysis. A series of semi-structured interviews with industry experts with e-procurement experience will be used to interpret data analysed from the surveys.

2.3 The Modelling and Development Phase

The key deliverables of this stage are the object oriented classification hierarchy of drivers and barriers to construction e-procurement and the generic e-readiness capability maturity model. Each of these outputs are developed using object oriented modelling techniques, tested using industry case studies and evaluated using the Focus Group of experts as indicated in Figure 1.

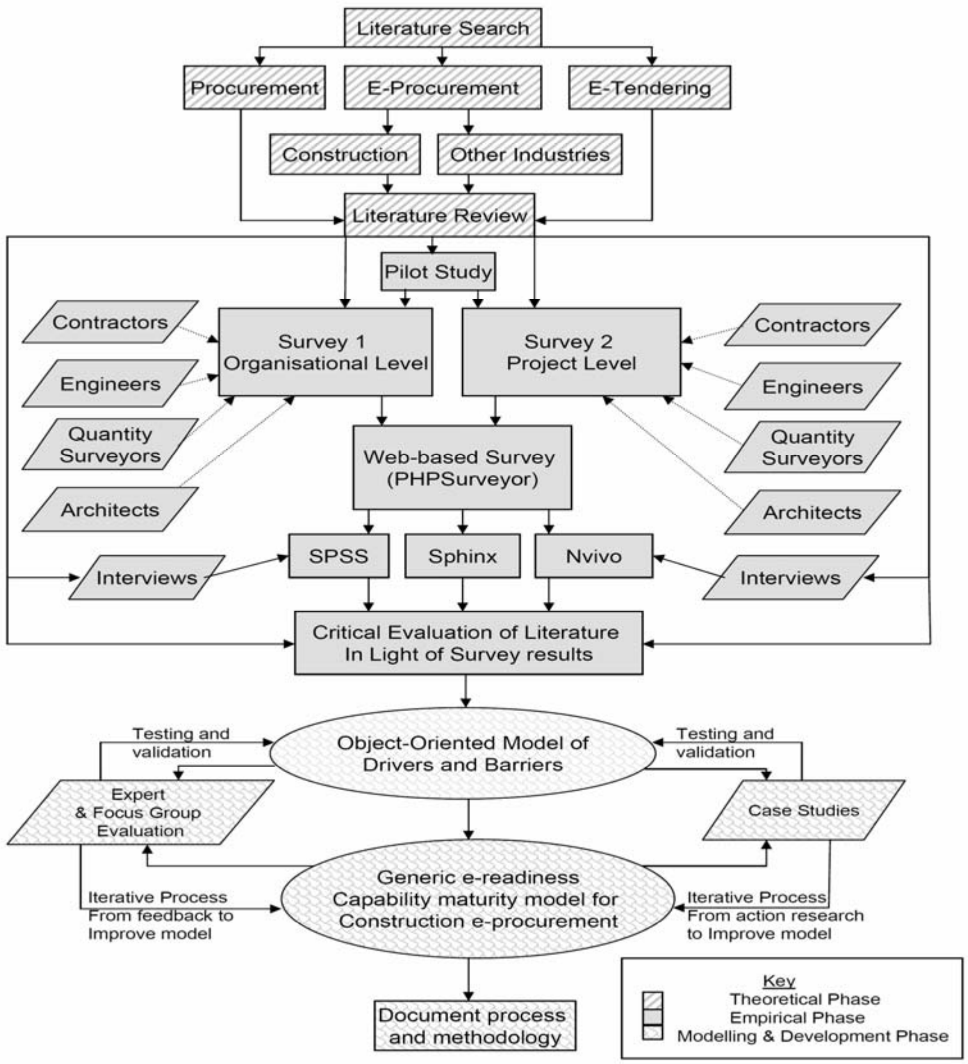

Figure 1 Methodology for the development of an e-procurement capability maturity model

The information gathered from the detailed surveys will be used to develop a driver and barrier hierarchical classification model using Object-Oriented modelling techniques. Many of the drivers and barriers identified in the literature are polymorphic (having many forms) and therefore may be inherited by more than one class (multiple inheritance). It is intended to categorize each object (driver or barrier) into its class and show its inheritance to identify the status of e-readiness of construction organisations to carry out e-procurement. This classification hierarchy will be further developed into a model to analyse the e-procurement capability maturity of construction organizations (e-readiness).

Expert evaluation of the results from the above two models will be carried out by a series of interviews with those involved with e-procurement. A focus group will be formed from the members of the E-Procurement working group established in the Northern Ireland Civil Service. Qualitative data analysis tools such as NVIVO™ will be used to analyse the data gathered.

A series of industry case studies will be used to test and validate the e-readiness model developed. An iterative process of testing and modification of the model is intended with a final validation.

3. THE PILOT STUDY

This section of the paper presents the details and results of the pilot study. The main aim of the pilot study was to test the methodology of carrying out a survey to identify and rank drivers and barriers to construction e-procurement. It also investigated the use of electronic contracts and the existing e-procurement initiative CITE.

Road Service Northern Ireland (RSNI) was selected as the case study organisation for the pilot study. As one of the largest public sector organisations involved in construction with an existing e-procurement system approved by the Office of Government Commerce, RSNI was well qualified as the organisation that is most suitable for the research. Utilising the RSNI's register of contractors, a list of 70 Contractors who had registered an interest in road works over the past four years was compiled. 50 contractors responded to the survey. This sample by its nature included an even distribution of all sizes of companies as indicated in Figure 2.

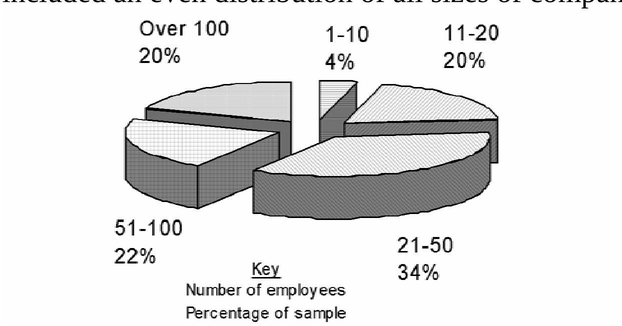

Figure 2 Breakdown of Responding Organisations by Company Size

A short telephone briefing was used by the author's to act as an initial contact pre-notification for the web-based survey to follow. The web-based survey achieved a 73% response rate surpassing the representativeness and bias levels indicated in Eysenbach (2004). This study used PHPsurveyor™, a web-based survey tool similar to that described in Solomon (2001) for the conduct of the survey.

3.1 Construction e-Procurement in Northern Ireland

Understanding the factors that influence e-procurement and the degree of influence each factor generates is fundamental to any study on e-procurement. Most of the previous studies on e-procurement are reported from the US goods and service industry (Minahan & Degan, 2001 and Davila et.al, 2003). These studies were then followed by the work of Hawking et. al.(2004) who attempted to rank drivers and barriers to e-procurement. However, with a static product and a moving production line, greater economic significance and a complex product, the construction industry is fundamentally different to most other industries. The consequence is that the drivers and barriers to construction e-procurement could be performing differently to the general goods and service industry. Until recently (Rankin et.al, 2006) there was no study that reported the state of drivers and barriers to construction e-procurement. Therefore this research filled the gap in knowledge with respect to construction e-procurement, by applying the drivers and barriers for e-procurement identified for the goods and services industries to the construction industry. It allowed respondents to rank the drivers and barriers identified by the research and propose any additional ones. Although respondents successfully ranked drivers and barriers no new ones were identified. The Rankin et.al. (2006) study which evaluated drivers and barriers to construction e-procurement in the Canadian construction industry, verifies and validates most of the findings of this study. However, drawing direct comparisons between these two studies is difficult due to the nature and the difference of methodology used. Rankin et.al. (2006) merely verifies the previously identified drivers and barriers from the goods and services industries could be applied to construction, however, ranking and application may be different.

The pilot study investigated drivers and barriers to construction e-procurement in Northern Ireland. The key findings of the survey indicate the following ranked drivers to construction e-procurement (Table 1) and barriers (Table 2):

Driver	Rank Order for Construction e-Procurement
Improving Communication	1
Reduced Administration Costs	2
Price reduction in Tendering	3
Gaining Competitive Advantage	4
Reduction in time to Source Materials	5
Reduced Operating and Inventory Costs	5
Reduced Staffing Levels in Procurement	6
Enhanced Decision Making and Market Intelligence	7

Table 1 Ranked list of Drivers in construction e-procurement

Barrier	Rank Order for Construction e-Procurement
Security of Transactions	1
Unsure as to the legal position of e-procurement	1
Lack of a business relationship with suppliers providing e-tendering	3
Lack of e-procurement knowledge/Skilled Personnel	4
Interoperability Concerns	5
Lack of Technical Expertise	5
No business benefit realised	7
Company Culture	8
Upper Management Support	9
IT systems too costly	10
Do not have the IT infrastructure	11

Table 2 Ranked list of Barriers to construction e-procurement

In comparison to the drivers and barriers identified in the previous general goods and services industry studies, it can be concluded that the same type of drivers and barriers generally apply to the construction industry. However, the importance of each of the drivers and barriers for the construction industry differ from the goods and services industry. There are some factors peculiar to the construction industry as explained earlier.

3.2 Use of Electronic Contract's and CITE

The RICS carried out a major survey of the UK Construction industry on the use of electronic contracts (Martin, 2003). The results showed that only 10% of the electronic documentation was sent out in CITE format. Only 29% of the Bills of Quantities (BOQ) / Schedules of Rates and Prices (SORP) produced were sent to the contractor in electronic form. This equates to only 2.9% of the UK Construction Industry utilising the CITE format to convey contract documents.

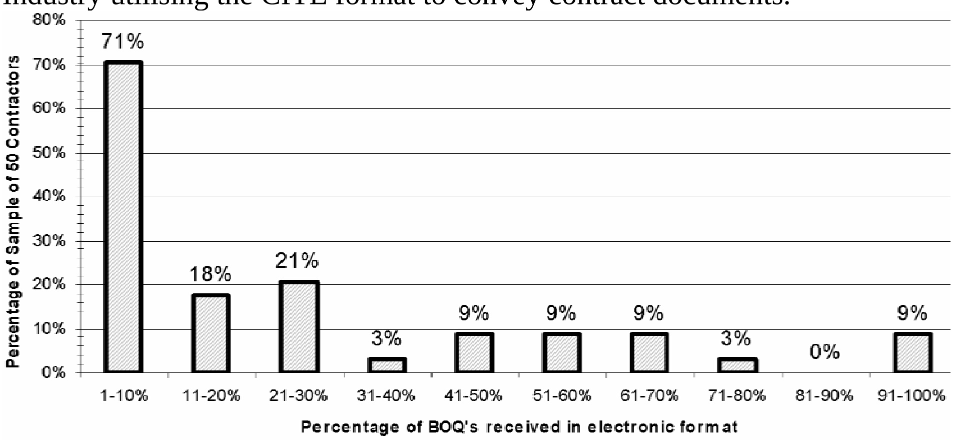

Figure 3 Percentage of BOQ received in Electronic Form by Contractors in Northern Ireland

This research investigated the use of CITE format to convey contract documents within the Northern Ireland construction industry. It first established the quantum of documents conveyed electronically and then the use of CITE format as a percentage of documents electronically conveyed. Figure 3 shows that within the sample of contractors surveyed 71% of contractors receive 1-10% of their BOQ / SORP in electronic form i.e. the overwhelming majority do not use electronic BOQ/SORP. The three smaller Contractors which work solely for RSNI recorded 91-100% of their documentation in electronic format as RSNI convey all their contract documentation electronically.

The study also investigated how many times Contractors used CITE approved programmes during the past 10 years. There are four CITE approved software packages noted on the CITE website **www.cite.org.uk** (Jan 2005) which can be used to produce BOQ's in electronic format. These are Icepac / Ripac, Qumic, Cato Pro and Causeway Estimating. BRIDGE is a freeware package provided by CITE to transmit data into any CITE approved programme without the necessity to purchase the complete package.

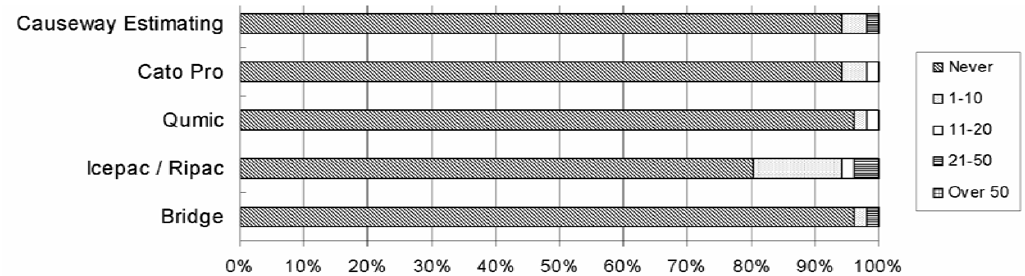

Figure 4 Usage of CITE approved programs

It can be seen from the responses in Figure 4 that Icepac / Ripac software has been more widely used than the other three and yet over 80% have never used it. 96% have never used BRIDGE. The conclusion that can be drawn from this is that CITE's strategy of providing the programme free of charge in order to promote the common format of data exchange introduced by CITE has not achieved its aim within the Northern Ireland construction industry as few companies have used it.

On detailed investigation it was evident that the widespread usage of spreadsheet programmes such as Microsoft Excel™ was creating a major impact on low usage of CITE approved formats. The CITE website states "Alternatively, a text editor, word processor or spreadsheet could be used to add prices to the unpriced BOQ, provided the file is then saved in the CITE format to be returned electronically". This is to provide an industry standard common format for data exchange. However, the fact that client and consultant organisations are issuing contract documents using spreadsheet programmes, and the widespread usage and availability of spreadsheet programmes, has eliminated the need of conversion to a standard format such as the one prescribed by CITE. For example the RSNI procurement system on CD uses a Microsoft Excel™ spreadsheet as the medium on which to price documents. This could be brought into CITE format with the use of a macro.

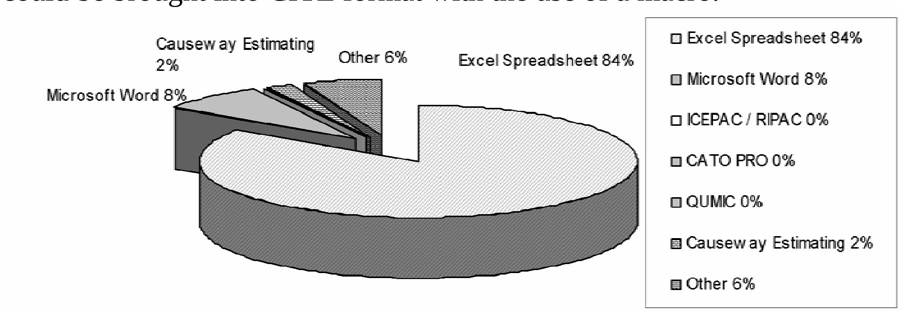

Figure 5 Contractors preferred format for Schedules of Rates / Bills of Quantities

Figure 5 represents the overwhelming popularity of Microsoft Excel™. 84% of the sample preferred it over all other formats. It is ideally suited to the task due to ease of data entry and the ability to let the author lock those cells that need protection. It dynamically calculates results, and is widely available to the industry as part of the Microsoft Office™ suite of software.

This research requested the contractors to rank Compact Disk write–once (CDR) based system used by RSNI. The results in figures 6 and 7 show the complete sample and the sample excluding those who had no experience of using the system respectively.

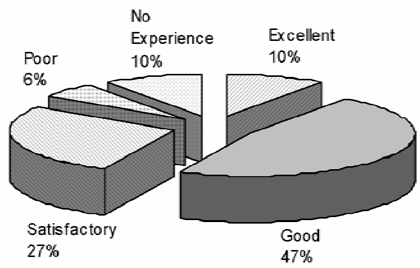

Figure 6 CDR system ratings - All

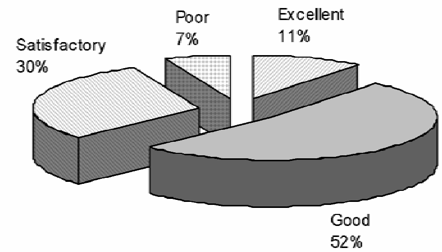

Figure 7 CDR system ratings - Users

Figure 6 shows 84% of those surveyed rated the system as satisfactory or better. This included 10% of the overall sample who had no experience of using the CDR-based system. When this 10% of the overall sample with no experience are removed (Figure 7) the results show high satisfaction levels with 93% of respondents stating that the system was satisfactory or better. 52% of the sample rated the system as good with the mean value falling into this category. This indicates that the majority of Contractors are satisfied with the system.

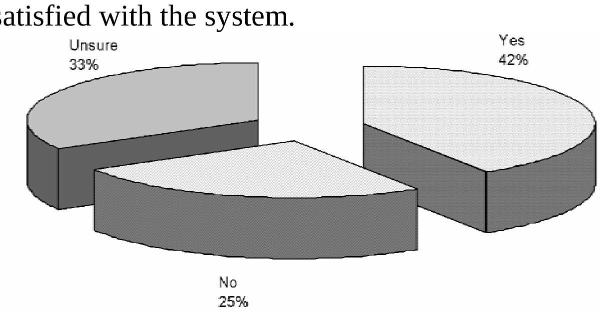

Figure 5 Contractors preferred format for Schedules of Rates / Bills of Quantities

The study revealed that contractors were less sure about moving to a fully web-based solution as indicated in Figure 8.

Figure 8 indicates that only 42% preferred to move to a web-based system. This re-emphasises the concerns which will have to be addressed prior to the construction industry moving to a fully web-based system, and validates this research's identification of the need for ranking drivers and barriers as a pre-strategy to providing e-procurement solutions to the construction industry.

4. CONCLUSIONS

In Northern Ireland the majority of contractors receive less than 10% of their contract documentation in electronic form. The use of the four CITE approved programmes namely Icepac/ Ripac, Qumic, Cato Pro, and Causeway Estimating is low amongst contractors surveyed with less than 20% having used these programmes. The preferred format for BOQ / SORP was Microsoft Excel™ spreadsheet with 84% choosing this option. This shows that there are more e-procurement barriers to be overcome than the mere provision of a standard format for data exchange.

The pilot study assessing the drivers and barriers to construction e-procurement in Northern Ireland showed that 'improving communication' and 'reduced administration costs' are the two most important drivers and 'security of transactions' and 'being unsure as to the legal position of e-procurement' are the two most important barriers. These are mostly in line with the findings of a similar investigation within the Canadian construction industry (Rankin et. al 2006) although differing in performance and effect from goods and services procurement. These differences are significant and therefore further research should exploit these differences in providing solutions to barriers in e-procurement.

This paper illustrated a detailed research methodology for the development of a model for establishing the e-procurement capability maturity (e-readiness) of construction organisations. It is intended to develop an object oriented classification hierarchy of drivers and barriers to construction e-procurement based on results of a detailed UK wide survey of the construction industry. Many of the drivers and barriers identified in the literature are polymorphic and therefore may be inherited by more than one class. Thus, an object oriented model will provide the facility to analysis the level of maturity of construction organisations to procure construction contracts electronically.

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IDENTIFICATION OF SUCCESS IN CONSTRUCTION PROJECTS IN UNITED ARAB EMIRATES

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ABSTRACT

Perception of success in projects is strongly interrelated with its context and industry. The research objective of this paper is to study the project success in the construction industry in United Arab Emirates. The research starts with the definition of the success criteria, followed by the statement of project success factors from the client's perspective in the construction projects in UAE. An introductory questionnaire, preceded by literature survey is used. The questionnaire targets a number of experienced project managers, asking them to identify project success and how to attain such success. The questionnaire is implemented and the results are analysed and compared to similar studies in other parts of the world. The survey shows trends of success perception which are on one hand reflecting similarity to the success criteria identified by international research, but also on the other hand revealing few success perceptions which are in a way unique to the construction industry in this country. More or less, a similar conclusion could be reported about the success factors.

The project success is perceived differently among various cultures. This perception is affected by many factors among which are: communication, culture and prevailing procurement methods. The identification of project success criteria for construction projects in United Arab Emirates may help to achieve a paradigm shift in the construction culture towards sustainability, and can form the foundation of research in other areas such as the role of project electronic communication management in attaining project success. The current research is intended to be a step in this direction.

Keywords: Construction Industry, Perception of Success, Project Communication Management, Project Success Criteria, Project Success Factors. United Arab Emirates.

1. INTRODUCTION

The Association for Project Management (2005) has defined Project success as the satisfaction of Stakeholders needs. The subject of project success in general has been researched and investigated by prominent researchers worldwide (Kerzner, 1998, Turner, 2002, and others), and the flow of research about the success factors from the project managers' perspective has been continuing since the 1960s till today (Fortune and White, 2005).

Success definition and measurement are considerably context oriented, i.e. very much related to the overall environment where the project is undertaken, accordingly this raises the importance of the cultural context (Beatham, 2004), in which it is demonstrated that in some cultures like the European environment where a considerable amount of research is invested, quite well developed models such as the criteria of the European Foundation of Quality Management (EFQM) Excellence Model (EFQM, 1999) have been developed. Some subjective indicators of success which are difficult to quantify have been researched (Hughes, et al 2004). Many research efforts have been concentrated on determining the success factors that have the greatest potential of change, considering the different contexts and in relation to the different phases of the project life cycle (Besner and Hobbs, 2006). The considerable amount of construction projects work in United Arab Emirates needs to be considered from the perspective of success criteria and success factors. A questionnaire directed towards well experienced professionals in this industry, and developed into structured interviews with some of them, aimed as a start to identify the perception of the success criteria from their own perspective and from the perspective of their organisations, and also to select what they regard as the most value adding success factors that can contribute to the success during the different phases of the project lifecycle. To raise the awareness of success criteria for construction projects in UAE is one of the objectives of this effort, an example of this move is when some of the responses reflect that professionals in this field are now listening more carefully to their customers, and care about their expectations and document lessons learned, similarly to what has been reported elsewhere (Forbes, 2001).

The paper starts by discussing the ontology of success in order to introduce the concept of success, success criteria and success factors to the UAE society, it then proceeds to present the methodology and the method, followed firstly by the by results of success criteria and secondly by results of success factors, A preliminary model is proposed and finally some conclusions and the way forward from this research are presented.

2. DISCUSSION ABOUT THE ONTOLOGY OF SUCCESS QUESTION

In order to present the question under consideration, introduce the concept of success, and whether it could be measured or not, who should measure and when, and also to differentiate clearly between success criteria and success factors, and prior to introducing the methodology;

Definition and Quantification of Success:

When someone is described to be successful, and in order to be more specific when it is mentioned that "he is successful in something" it is meant to say that –pragmatically speaking- success in achieving an objective. Accordingly, there are two factors that need to be considered in the definition of success:

1) An objective.
2) Means of measurement to tell how much of that objective has been achieved.

In literature the former is referred to as the "Project Success Criteria: The qualitative and quantitative measures by which the success of the project is judged” (Turner, 2002) and the latter as the Project Key Performance Indicators.

How Can Success Be Achieved?
What are those "knobs" that if turned "clockwise" or probably sometimes “anti clockwise” the possibility of achieving a higher success rate could be increased? For a school student, for example, it is simply said that if he spends more hours in studying, this will enhance the probability of him achieving success. Similarly the question for construction projects in United Arab Emirates or the Project Success Factors which are defined as the elements of the work of the project or the management process that can be controlled by the project manager or the project team so as to increase the chance of achieving success (Turner, 2002).

Time of Judgment and Measurement:
The way the success is considered and the results of this 'consideration' will differ depending on the time that measurement is made (Turner, 1999). For example, speaking about a prestigious construction project like the construction of a major shopping mall, if this measurement is done a year after the opening, it is the profitability which will supersede, while if measured probably 10 years later it might be the effect of that mall on the social system of values which must be considered and if measured 50 years later it is the sustainability and environmental consideration which may supersede. The matter is different if that measurement of success was done 'during' the construction of the mall. This variation is one of the reasons which pushes towards replacing the word "measurement" by the word "perception". Some researchers even suggest that success by itself should be considered as a "moving target", the attribution of success can vary considerably depending upon the time at which the evaluation is done, (Larsen and Myers, 2000).

Who Is Making the Judgment?
Is the owner of the mall, the operator, the 'constructor' team or is it the shopper, or even the whole society affected by the project that the question of success should be addressed to? Now surely it is not the intention to cover or - even try- in this paper the whole 'pool’ or rather 'pools' of stakeholders, but rather try to put the question in the whole context as much as possible as we are trying to consider the largest possible 'system' and for different times. At the same time it is reiterated that the method of measurement and things to measure are evolving over time and are to an extent different depending on the 'observer' (Checkland, 2002). All of these considerations have been considered when elicitation of the information and knowledge needed for this research, and consequently led to the selection of methods.

3. METHOD AND METHODOLOGY SELECTED

We tried to be as systemic (Checkland, 2002) as possible in 'designing' this survey, implementing it, interpreting the results and modifying the research path as we go along. Starting with an open qualitative questionnaire addressed to professionals involved in the conceptualization, design, construction and implementation of construction projects in the Emirates of Abu Dhabi, this group was taken as a pilot group. After reviewing the outcome, it has been decided not to change the questions but to change the tool to a more 'structural interview' type of survey with carefully selected highly professional project managers starting with an introduction about success and the way it is questioned.

A hundred people were contacted, out of which 32 responses were received; this represents a 32% response rate which is appropriate for this type of research. The investigation is still to continue both in interviewing more professionals and interpreting the results using the soft system approach. In the next paragraphs the results of success criteria and success factors are presented and discussed respectively.

4. INTERPRETING THE RESULTS- SUCCESS CRITERIA

Conducting this survey in this environment for the first time, it has been the authors' objective not to restrict the respondents to any previously stipulated list of success criteria done elsewhere. It is one of the objectives of this survey to let as much as possible the respondents to open up and enrich the list of success criteria with new thoughts from their own experience.

Using an open qualitative survey has two difficulties associated with it:

- Respondents need more time to answer the questions, which reduces the tendency to respond.
- Difficulty in analyzing the results.

Turning it to an interview after piloting it, has helped in overcoming the former, while repeating the analysis has been efficient in overcoming the latter by going through the outcome many times, trying to understand the perceptions rather than to quantify them. It will definitely be worth it to make a new research in the future trying to conduct more interviews and build relations between what the interviewee consider as success criteria and his own position in the firm, and establish a dynamic system model.

Baker, et al 1988, concluded that "If the project meets the technical performance specifications and/or mission to be performed, and if there is a high level of satisfaction concerning the project outcome among key people in the parent organization, key people in the client organisation, key people in the project team, and key users or clientele of the project effort, the project is considered an overall success". This conclusion did not consider the time factor about when to make that judgment. They also state that "Perceptions play a strong role in this definition" i.e. definition of success is highly subjective.

Presenting the Results

Figure 1–a summarises the results obtained regarding the perception of success criteria. The graph in figure 1-b is not intended to show the "weight" but it is only an indication of the respondents perceptions, some of the criteria even perceived by few only, but still is as important as the others, as the purpose is to capture the perception.

Comparison with Published Research:

Comparing with some of the published literature (Wateridge, 1995, and Turner, 2002) we notice similarity in many of the criteria, but it is believed that the current survey captured some new criteria or some times new ways of specifying them. As an example of the former is the claim avoidance criterion and an example of the latter is the capability to use the project as a marketing tool for the project team (could be the contractor). A similar kind of perception was expressed by Forbes, 2001 which points out an area of interest that has been traditionally underestimated in the construction industry.

- Time
- Quality
- Cost
- No Claim
- Well Defined Objectives
- Goal Attainment
- Minimum Variations during Construction
- Value to Client
- Maintaining Relationships
- Integration
- Response to Changing Circumstances
- HSE Maintained
- Client Support during Implementation
- End User Direct Input during Concept and Design Stages
- End User Satisfaction
- Client Needs Satisfaction
- Cohesive Team of Stakeholders
- Transparency
- Project Manager's Risk Awareness
- Low Maintenance Cost
- Few Snags at Handing Over
- Revenue
- Project could be used for Marketing of Project Organisation
- Profitable for Project Organisation
- Tender Prices were Close to Estimates
- Orderliness of Construction Site
- Organised Communication during Design
- Organised Communication during Construction
- Consideration of All Bids in the Tender
- Material Approval Submittals on Schedule
- Clarity of Project Specifications

Figure 1-a: List of Perceived Success Criteria

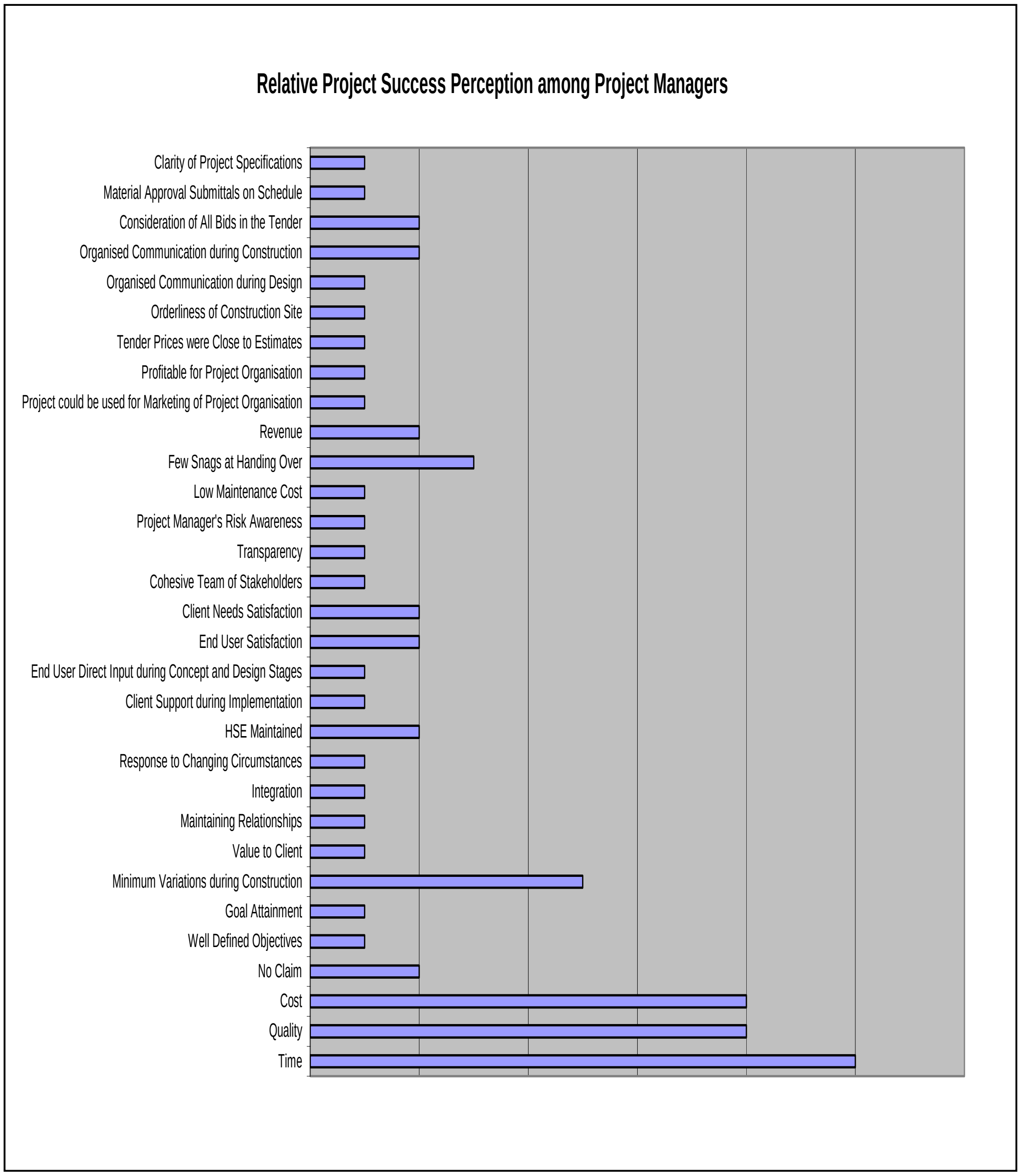

Figure 1-b an indication of success criteria responses.

5. INTERPRETING THE RESULTS - SUCCESS FACTORS

Issue of success factors has been researched worldwide (Fortune and White, 2005). Most of these factors can be more objectively monitored and controlled, but their importance and significance show varying levels of priority during different stages of the project lifecycle, which opens the door again for some degree of subjectivity.

In the questionnaire about success factors, the construction projects surveyed were divided into 3 phases; planning and design phase, procurement phase (tendering) and construction phase, (as this is the dominant division in the construction industry practice and culture in United Arab Emirates. Therefore in order to elicit the thoughts, it has been decided to follow the trend rather than to be followed) success factors (SF's) captured at the three stages are listed as follows:

SF's During Design:

- Well Defined Scope.
- Continuous Workshops and Work sessions with Client.
- Good Design Team.
- Milestone Reviews with End-User on board.
- Good Guidelines for the Design Product.
- Well Defined Space.
- Team Building.
- Time Frame.
- Market Research.
- Configuration Management of Design Deliverables.
- Establishing Project Strategy.
- Sufficient Relevant Data.
- Agree Responsibility Matrix for all Stakeholders.
- Timely Approvals.
- Coordination.

SF's During Construction

- Top Management Support (Project Team Organisation).
- Change Management.
- Communication Management and Document Control.
- Strong and Sufficient Project Management and Technical Teams.
- Configuration Management.
- Lessons Learned.
- Reduce Obstacles.
- Reasonable Schedule Approved.
- Competent & Sufficient Team of Project Management & Technical.
- Ensure adequacy and Continuity of Contractors Resource.
- Timely Issue Attendance.
- Risk Management.
- Management of Existing Services.

SF During Tendering

- Well Defined Procurement Strategy
- Communication Management
- Configuration Management.
- Well Selected Bidders.
- Sufficient Time to Tender.
- Transparency.
- Pre Tender Conference.
- Selection Criteria.
- Completeness and Correctness of Tender Documents.
- Consider Prevailing Laws.

Comments on the Success Factors Elicited

A considerable degree of similarity & matching with most of the literature surveyed has been noticed (Baker, et al 1988, Pinto and Slevin, 1988, and Ling and Liu, 2005). Some interesting success factors were captured in particular to construction industry in transportation (highways and alike), in which the removal of obstacles and management of existing services was considered by many professionals as one of the main success factors. Noted down also was the obtaining of timely approvals which is of paramount importance in the field of construction industry.

Importance and awareness of communication management among project stakeholders during all phases is increasingly manifesting in many aspects as the most dominant success factor (Diallo and Thuillier, 2005), and it could also be implicitly detected as underpinning most of the other success factors.

In general, the survey can be described as being successful in capturing extremely useful success factors very much relevant to the construction industry in Abu Dhabi, which could be described as a treasure of lessons learned.

The listing of some of the success factors elicited is speaking for itself, but it will definitely be worth much deeper analysis and further explanation through more in depth interviews in which the authors most willingly and eagerly are planning to conduct in the future.

6. FURTHER DISCUSSION AND MODELLING:

Thinking in terms of 'action research' the survey (in addition to introducing the subject to decision makers in the construction industry, distributing the questionnaire and conducting the interviews) has been successful to an extent in creating the awareness about project success, and the importance of considering it at the initiation stage, in order for all stakeholders to agree on the success criteria early in the project.

Good communication could be considered as an early key performance indicator which raises the potential of project success (Pinto and Slevin, 1988, and Diallo.and Thuillier, 2005).

Some of the points were raised by only few of the respondents, but considered very highly such as maintaining client satisfaction during project design and construction stage.

Procurement method used in the project environment together with the organization of project stakeholders, and the communication channels between those stakeholders, during and after the procurement process, all of these factors have a major effect on the way project success is perceived, see figure 2.

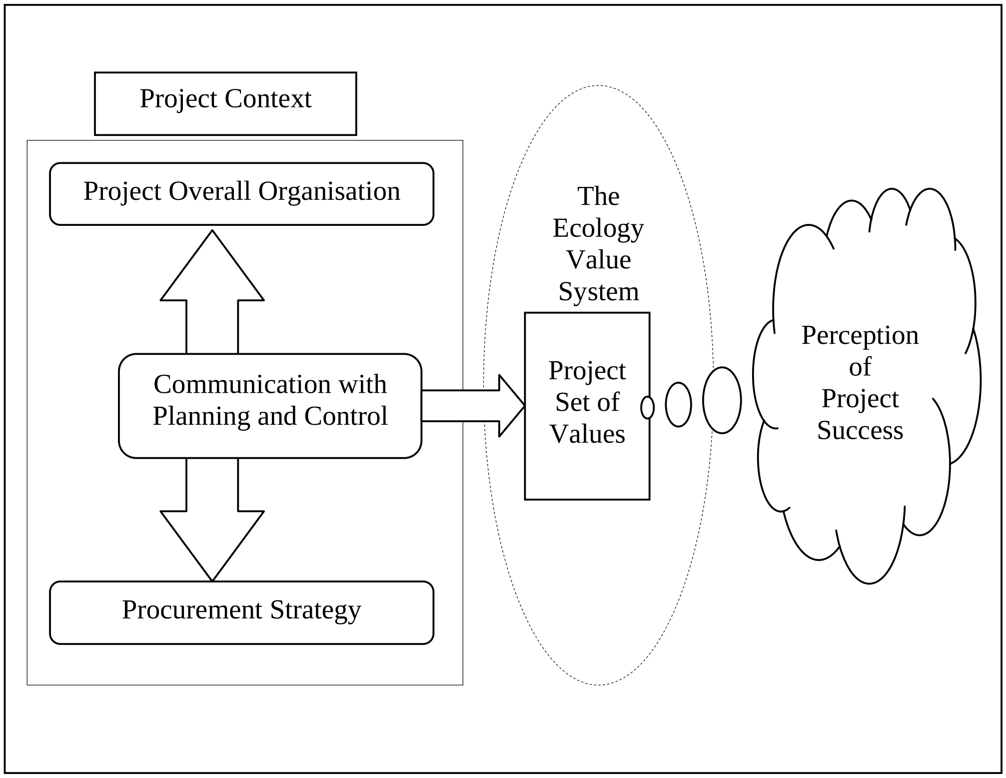

Figure -2- Interrelationship between Procurement, Communication and Success

7. SUMMARY AND CONCLUSION

It is believed that the survey conducted in the course of this research has been successful in confirming the results of worldwide research in the field of project success criteria, and in capturing relatively 'new' success criteria related to project context in the construction industry in United Arab Emirates, an example is the consideration of "No claim" at the end of the project and the potential of marketing the performance of a particular project as success criteria. Furthermore, some conclusions reached in the analysis of the survey are similar to those conclusions arrived to by APM and other researchers indicating that "success criteria must be agreed with stakeholders during the concept phase" and that it "requires quantitative measures against which to judge their success". The results of the survey in the field of success factors showed a similar trend when compared with the published research, but the respondents expressed different patterns of prioritizing the success factors during various phases of the project lifecycle.

The current research will be extended with a survey that applies a dynamic model which shows the interaction between the electronic communication management among the project stakeholders and the perception of success in the project context.

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IDENTIFICATION OF CONSTRAINTS IN CONSTRUCTION PROJECTS TO IMPROVE PERFORMANCE

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ABSTRACT

Needs and constraints in a multi-party working situation bring complications in project management. Needs are diversified when the client is a large organization such as a public client or a corporate client. However, constraints in construction projects limit their achievement of high performance. The aim and scope of this paper is to identify the constraints in construction project working environment and apply the theory of constraints (TOC), which provides practical steps for making organizational decisions in situations in which constraints exist. If constraints are better understood at the outset, it is believed that better performance can be assured. Presently clients' needs in construction are well discussed, but constraints have yet to be understood in context. We identified the constraints in five categories, they are: (1) economic constraints, (2) legal constraints, (3) environmental constraints, (4) technical constraints, and (5) social constraints. The impacts of these constraints to the construction project were studied. We suggest developing awareness to managing and controlling the constraints in construction working environment for achieving high performance in the construction working environment.

Keywords: constraints, construction, theory of constraints (TOC).

1. INTRODUCTION

There are constraints in every working environment. However, there can be situations that we are unaware of the existence of the constraints, or, we tend to put more emphasis on the project goals. Although constraints have been discussed in much of the management literature, there is little detailed study on constraints in construction working environment. The construction working environment involves multi-party participation. Needs and constraints in a multi-party working situation bring complications in project management. These can further develop into conflicts and disputes, which bring cost consequences, direct and indirect, to clients and contractors (Yates, 2002). The project team members have to meet client's needs on one hand and to overcome constraints on the other hand. With the limited literature for the constraints in the construction working environment, it is important to identify the potential constraints in the construction project, which will help to decrease the unnecessary wastage and loss of both money and time because of inadequate planning. Controlling the constraints is thus a pre-condition for high performance of the project.

Constraint is defined as a constraining condition, agency, or force that limits the systems' performance in a given context/environment (Mayer, Painter and Lingineni 1995, Whelton, Penneanen and Ballard 2004). Every production system will have at least one constraint (Chua, Shen and Bok, 2003). Constraint describes the relationships between objects and processes (Whelton, Penneanen and Ballard 2004; Tam, 2006). It is whatever impedes progress toward an objective or a goal (Mcmullen 1998). Constraints may cause undesirable consequences or are not supportive of the organizational goals. It is the environment and the limitations of the system which dictates the solutions (Stein 1997). These constraints should be reduced or eliminated in order to minimize waste and make the flow more efficient.

Constraints have to be managed. Practically, in all cases the constraints' limiting impact can be reduced or eliminated. Constraints management contributes to two major project functions, planning and control (Chua et al. 2005). Planning functions emphasize developing optimal schedules using simple or complicated algorithms with the objective of fulfilling project goals such as duration, cost, and quality. Control functions are focused on both plan and implementation such as work assignment and resource allocation, and supply chain management such as material delivery and inventory control. Identifying and removing constraints (Chua et al. 2003) from bottleneck activities help to reduce uncertainties in construction processes and increases the transparency of project management. Yates (2002) suggests that avoidance measures can be taken if they understand the cause of conflicts and disputes. They proposed a framework to identify the caustic factors of the conflict and disputes in the construction industry.

Mcmullen (1998) categorized the constraints into two groups: the constraints with lesser impact and the ones with greater impact. He suggested that every situation contains many relative lower impact constraints but only a single or a few higher impact constraints. The higher impact constraints are called core problems or root causes. He suggested that as time is everyone's prime constraint, maintaining the focus of an indivi dual or management on identifying and acting on the higher impact constraints will help using the scarce time effectively. There are two basic types of constraints according to Goldratt (1990): physical constraints and non-physical constraints. A physical constraint is something like the physical capacity of a machine, in other words, it is something that is rigid and in its current state has a limit on its ability or throughput (e.g. materials, machines, people, demand level). A non-physical constraint might be something like demand for a product, a corporate procedure, or an individual's paradigm for looking at the world.

Constraints are a function of two variables: capacity and demand. A comparison of the two at the system level provides a reliable indicator of progress towards its goal (Dettmer, 1998). The constraints can be categorized into two types: (1) internal constraint and (2) external constraints.

Internal constraints are inside the system and are usually more under control. This means that when the system cannot keep up with the demand, action needs to be taken to eliminate the constraint. But continuing such an action will in turn bring to a point where capacity exceeds demand and constraint exists in another form. Middle managers frequently encounter situations when a task is assigned by the top management with constraints. The middle managers then have to go over these constraints in order to complete the task. The consequence is that they may have to take more time or resources than what has been planned. If they face constraints that cannot be overcome, there is a possibility that they may have to do things outweighing their capability in order to accomplish the task. Some managers will have to take irregular actions such as illegal action, deceiving action, or force the others to comply without any redress. External constraints are outside the system and are less under control. This means that the system has slack capacity to handle external constraints and action taken can merely minimize the effect of undesirable consequence rather than breaking the constraints. However, constraints can never be permanently broken. They merely migrate from one place to another and TOC has to re-apply.

The theory of constraints (TOC) developed by Goldratt (1990) is a process aimed at identifying and removing constraints in organizational processes that are standing in the way of organizational goals. A constraint is defined as *anything that limits an organization or entity from moving toward or achieving its goal.* TOC logic forms major portions of the organization's philosophy of continuous improvement. It is applied to identify what factors limit an organization from achieving its goals, developing a solution to the problem, and getting the individuals in the process to invent the requisite changes for themselves. The five steps in applying TOC (Goldratt, 1990) are shown in Figure 1.

Removing constraints (Goldratt 1990, Chua et al., 2003) from bottleneck(s) are the most effective means of improving overall system performance. Once the existing constraints are removed, however, new ones emerge. Identifying and removing constraints represents an iterative procedure that pushes system capacity closer and closer to its limit. Therefore, the process should be reapplied (Goldratt 1990as illustrated in Figure 1. It emphasizes balancing throughput across the entire production line and making the best use of available resources via continuous improvement.

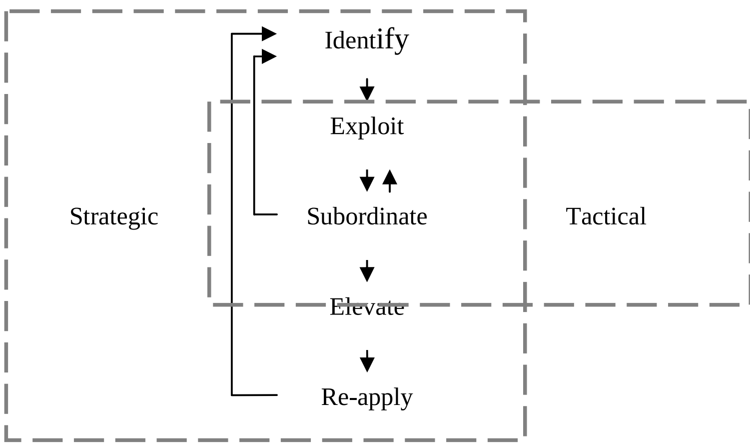

Figure 1 Five Steps of Theory of Constraints (TOC) (Goldratt 1990)

It has been suggested that TOC can be applied to project management (NewBold, 1998; Stein, 1997; Patrick, 1998; Masterman, 2002). Constrction projects (Clough, Sears and Sears, 2000) are intricate, time-consuming undertakings. The construction project needs a good management to achieve the satisfied result including (Walker 1989) functional satisfaction, aesthetic satisfaction, completion on time, completion within budget, value for money, and health and safety. Walker (1989) defines the construction management as: “The planning, control and co-ordination of a project from conception to completion (including commissioning) on behalf of a client. It is concerned with the identification of the clients’ objectives in term of utility, function, quality, time and cost, and the establishment of relationships between resources. The integration, monitoring and control of the contributors to the project and their output, and the evaluation and selection of alternatives in pursuit of the clients' satisfaction are the fundamental aspects of construction project management. Whelton, Penneanen and Ballard (2004) stressed that the project definition process is significant if it offers opportunity for the clients and the team to identify constraints, and project constraints have to be considered when formulating the project strategy (Masterman, 2002). Masterman (2002) suggested quantifying the assessment of the actual constraining effect on project objectives and the procurement process. Chua, Shen and Bok (2003) suggested that the theory of constraints could be adopted in the construction context because project development in this respect resembles a production process in which productivity is affected by various constraints.

2. RESEARCH METHOD

Unpleasant problems or "undesirable effects" are the result of relatively few core problems (Newbold 1998), or, in other word, the constraints. Once these core problems are identified and dealt with, the majority of the undesirable effects will go away. We recognize that the identification of the constraints is the first step to apply TOC in project management to help project managers to make better decision and achieve higher performance in construction project management. In our study, we firstly classified the constraints into five categories based on literature review (Manning 1995, Peter and Rod 2003, Lambropoulos 2006; Schultmann and Rentz 2002). They are: (1) economic constraints, (2) legal constraints, (3) environmental constraints, (4) technical constraints, and (5) social constraints.

Among the 120 questionnaires sent out to the government and contractor companies in Hong Kong. 30 questionnaires were returned. The respondents were asked to fill in an open-ended questionnaire to indicate any of the constraints that they encountered in the project in construction working environment. We conducted follow-up telephone interviews to elaborate the content of the data collected. The respondents were asked to explain the cause, effect and level of impact, using a rating scale of 1-10, of the constraints on project performance and procedure.

3. RESULTS AND DISCUSSIONS

The interviews are recorded and the content of the communications were analyzed. The nature of the constraints is elaborated and their impact to the project is analyzed.

1. Economic constraints

The economic constraints mainly happened with budget limit and allocation of the money. Due to the budget limit, the adopted construction system may not be the best option for achieving the project goal and quality. It will affect the proceeding of the project. As for the allocation of money to be used in the project, if the money is not effectively allocated, it will affect the progress of the project. The effect on the project is the product quality and performance of the project. In summary, if economic constraints for the project could not be managed well, the product/performance/function/quality of the project will be affected.

2. Legal constraints

The legal constraints exist because there are many regulations that are ruling the construction project. The legal constraints are mainly related to work law, safety regulations, and supervision plan. For example, as prohibited by law, certain types of construction work could not be carried out during Sunday and public holidays. From the other perspective, when there are new regulations published in Hong Kong, which is not infrequent due to the recent construction industry reform bill, the project have to update the project schedule now and again to comply with the new regulations. As for the impact of the legal constraints, from one side, it may affect the schedule and lead to project delay. For example, when traffic diversion demands immediate decision, the team has to wait to get procedure approval before proceeding on site. From the other side, it may affect the planning and progress of the project, such as traffic ordinance and excavation permit, where approval is required before the work starts.

3. Environmental constraints

The public concern and regulations require the environment to be protected such as air protection, tree preservation, traffic limit, noise control and so on. In the planning and design stage of the project, the responsible people need to go to the "Environmental Department" to apply for the approval/justification for the project. This takes time and will affect the project progress. If the approval is not obtained on time, the whole project will be delayed, or could not be carried out. There are also other technical constraints arising from air protection, tree preservation, traffic limit, limit due to excavation permit for works, etc.

4. Technical constraints

There are quite a few technical constraints arising from restrictive site area and congested surroundings which are particularly applied to the site environment in Hong Kong. On one hand, building projects in Hong Kong are usually constrained with restrictive site area where storage space, transportation and temporary works require input of careful planning by design engineers, while the design and construction of the building works itself can be fairly certain at the outset. On the other hand, coordination of services works also poses technical constraints in construction. While having electrical wiring, ventilation ductwork, fire services and plumber works with further complication of broadband alignment, telephoning system and security system give rise to technical constraints that demand coordination and collaboration of multi-parties in terms of design and construction. Technical constraints are more readily recognized at the outset and at the stage of design, but this does not mean that all constraints can be overcome.

5. Social constraints

No construction work could proceed in rural area without people's involvement. The social factors constitute constraints in the construction working environment. It is not surprised to learn that undesirable effects come from a relative small number of key persons and the constraints are human constraints. These social constraints may appear minor and insignificant, but is very complicated to deal with. Sometimes it may arouse big problems for the project and will at the same time affect the progress of the project. Chinese "Feng shui" is a good example of social constraints. in New Territory of Hong Kong, the original residence believe the "Feng shui", some of the construction companies need to spend a lot of money to avoid the bad "Feng shui" and also hold some ceremony for the belief of Chinese "Feng shui". Furthermore, public concern and media pressure also constitute constraints to the construction project. Public concern and internal audit on “proper” use of public money, in fact impose restraint on new initiatives and engagement of better contractor on expense of higher contract sum. Sometimes, when a new technology or design is proposed to carry out in a project, the public, such as the media and the audit department, will restrict the endorsement of the usage of the money. The checking system prefers using every dollar effectively. This constraint will affect the adoption of new technology usage in construction project. It also affects the design and contracting of the project.

We observe that the social constraints usually come from the people. Inadequate assumptions or bad judgment arising from human constraints can bring disaster. Frustration, lack of motivation and mistrust will destroy morale and commitments to work (Newbold, 1998). Constraints related to people can appear in three different forms: (1) human resistance, (2) emotional constraints, and (3) ownership of the problem. In implementing changes, there will be human resistance. So constraints have to be thought of during the planning stage before actual implementation so as to minimize the effect of human resistance. As for the emotional constraints, there is a tendency for people to take defensive action rather than ‘toleration’ even the rational minds tell them not to. In this stance, people are emotional disturbed. In situations when constraints are concerning job security, the impact of the emotional constraints can be even greater and can cause devastative effects. As for the ownership of the problem, people may at times facing problems caused by others or by Act of God. It is easy to say that they do not cause the problem and thus are not responsible for it. Someone have to be held responsible for whatever causes there are. Moreover, providing an answer to a problem even if you are aware of it sometimes may not bring in the expected results. By the action of supplying a person with the answer you block them from the opportunity of inventing answers for themselves (Goldratt, 1995) as people like to have autonomy within their capacity. Therefore, to induce people to invent solution would charge the person with ownership of the problem and hence commitments in solving it.

The average score of the rating scores on the level of impact on the construction project is shown in Table 1. The legal constraint has the strongest impact on the construction project, economic and environmental constraints both ranked second among the constraints. The social constraint has a modest impact comparing with other constraints. Technical constraint has the lowest impact on the construction project. The results show that the legal, environmental and the economic constraints have the strongest impacts on the project. It is suggested that time and enough resources be allotted to these constraints in the planning stage of the project. The social constraint has special local and traditional features. Although not as important as the other constraints, it could not be ignored. If the social constraints could not be handled well, the project could not be proceeding well, and at project evolving stage, this may even lead to discontinuation of the project.

Table 1 Level impact of the constraints on the construction project

Constraints	**Level of Impact on the construction project**
1. Legal constraint	7.20
2. Economic constraint	7.00
3. Environmental constraint	7.00
4. Technical constraint	4.75
5. Social constraint	5.40

Although the technical constraints have the lowest score, it is also important for good quality of the product. These constraints are intended to be resolved by engineering design and close coordination of design and construction activity. If technical constraints can be resolved at the design stage, these constraints will no longer be constraints at the construction stage, but this kind of technical constraints can take up much of design engineers' time prior to start of construction and yet there may be new technical constraints arising from actual working environment. An example of this can be seen with the Deep Bay Link (Tam, 2006) where the design and construction team faced a range of ground constraints and time constraints. The solution was to have a technical team assigned to offer design and time-saving solutions together with careful logistic planning.

The results confirm that if one constraint could not be overcome, another constraint may be triggered. For example, if the method of disposing wastage threatens the environment, which breaks the regulations, the company may need to spend money to deal with the wastage in a legal way. The project budget may not be enough as a result, thus economic constraint is encountered.

The identification of the constraints helps project managers not only understand the characteristics of the constraints, but also predict the time and stage that the constraints may be encountered. The economic constraints, legal constraints and the environmental constraints are mainly appeared in the planning and definition stage. It affects the proposal and design of the project. The technical constraints and social constraints are expected to be encountered during the project implementation and maintenance period. A good prediction of the constraints helps make good project planning and resources allocation. Project managers can judge whether the constraint is maintained through the whole progress of the project, which we name them as "permanent constraints"; or where the constraint could be removed, which we name them as "temporary constraints".

4. CONCLUSION

To have a good understanding of the identified constraints at the planning stages, we suggest the management to have the constraints documented and to consider these constraints in the relevant project planning agenda and schedule as well as the designing of the organizational structure. At the implementation stage, the management should keep track of the progress and be aware of the constraints they encounter. The management should ensure that enough resources, which include money, facilities, staffing and effort, are allocated to decrease the limitations from the constraints encountered. In view of the nature of the different types of constraints, we suggest that the middle managers are empowered to take up adaptive management in response to the prevailing conditions. Although we are still in the process of collecting data, we regard the results sufficiently indicative of how constraints in construction would be like. We consider further study in other areas of TOC necessary to understand the complex nature of construction.

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Constraints are a function of two variables: capacity and demand. A comparison of the two at the system level provides a reliable indicator of progress towards its goal (Dettmer, 1998). The constraints can be categorized into two types: (1) internal constraint and (2) external constraints.

Internal constraints are inside the system and are usually more under control. This means that when the system cannot keep up with the demand, action needs to be taken to eliminate the constraint. But continuing such an action will in turn bring to a point where capacity exceeds demand and constraint exists in another form. Middle managers frequently encounter situations when a task is assigned by the top management with constraints. The middle managers then have to go over these constraints in order to complete the task. The consequence is that they may have to take more time or resources than what has been planned. If they face constraints that cannot be overcome, there is a possibility that they may have to do things outweighing their capability in order to accomplish the task. Some managers will have to take irregular actions such as illegal action, deceiving action, or force the others to comply without any redress. External constraints are outside the system and are less under control. This means that the system has slack capacity to handle external constraints and action taken can merely minimize the effect of undesirable consequence rather than breaking the constraints. However, constraints can never be permanently broken. They merely migrate from one place to another and TOC has to re-apply.

The theory of constraints (TOC) developed by Goldratt (1990) is a process aimed at identifying and removing constraints in organizational processes that are standing in the way of organizational goals. A constraint is defined as *anything that limits an organization or entity from moving toward or achieving its goal.* TOC logic forms major portions of the organization's philosophy of continuous improvement. It is applied to identify what factors limit an organization from achieving its goals, developing a solution to the problem, and getting the individuals in the process to invent the requisite changes for themselves. The five steps in applying TOC (Goldratt, 1990) are shown in Figure 1.

Removing constraints (Goldratt 1990, Chua et al., 2003) from bottleneck(s) are the most effective means of improving overall system performance. Once the existing constraints are removed, however, new ones emerge. Identifying and removing constraints represents an iterative procedure that pushes system capacity closer and closer to its limit. Therefore, the process should be reapplied (Goldratt 1990as illustrated in Figure 1. It emphasizes balancing throughput across the entire production line and making the best use of available resources via continuous improvement.

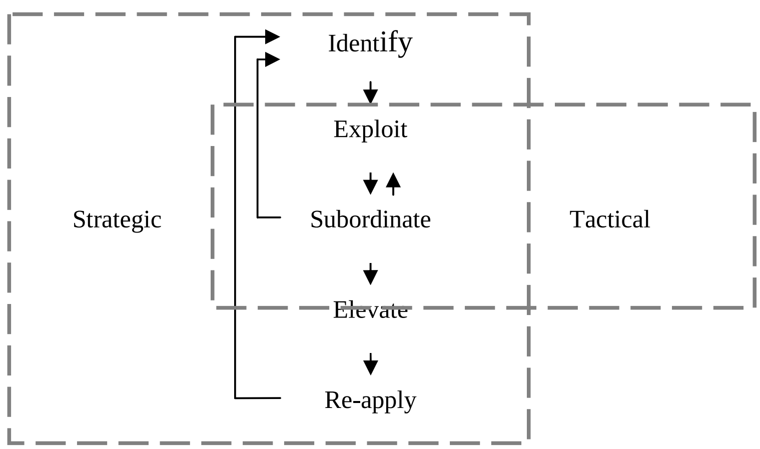

Figure 1 Five Steps of Theory of Constraints (TOC) (Goldratt 1990)

It has been suggested that TOC can be applied to project management (NewBold, 1998; Stein, 1997; Patrick, 1998; Masterman, 2002). Constrction projects (Clough, Sears and Sears, 2000) are intricate, time-consuming undertakings. The construction project needs a good management to achieve the satisfied result including (Walker 1989) functional satisfaction, aesthetic satisfaction, completion on time, completion within budget, value for money, and health and safety. Walker (1989) defines the construction management as: “The planning, control and co-ordination of a project from conception to completion (including commissioning) on behalf of a client. It is concerned with the identification of the clients’ objectives in term of utility, function, quality, time and cost, and the establishment of relationships between resources. The integration, monitoring and control of the contributors to the project and their output, and the evaluation and selection of alternatives in pursuit of the clients' satisfaction are the fundamental aspects of construction project management. Whelton, Penneanen and Ballard (2004) stressed that the project definition process is significant if it offers opportunity for the clients and the team to identify constraints, and project constraints have to be considered when formulating the project strategy (Masterman, 2002). Masterman (2002) suggested quantifying the assessment of the actual constraining effect on project objectives and the procurement process. Chua, Shen and Bok (2003) suggested that the theory of constraints could be adopted in the construction context because project development in this respect resembles a production process in which productivity is affected by various constraints.

2. RESEARCH METHOD

Unpleasant problems or "undesirable effects" are the result of relatively few core problems (Newbold 1998), or, in other word, the constraints. Once these core problems are identified and dealt with, the majority of the undesirable effects will go away. We recognize that the identification of the constraints is the first step to apply TOC in project management to help project managers to make better decision and achieve higher performance in construction project management. In our study, we firstly classified the constraints into five categories based on literature review (Manning 1995, Peter and Rod 2003, Lambropoulos 2006; Schultmann and Rentz 2002). They are: (1) economic constraints, (2) legal constraints, (3) environmental constraints, (4) technical constraints, and (5) social constraints.

Among the 120 questionnaires sent out to the government and contractor companies in Hong Kong. 30 questionnaires were returned. The respondents were asked to fill in an open-ended questionnaire to indicate any of the constraints that they encountered in the project in construction working environment. We conducted follow-up telephone interviews to elaborate the content of the data collected. The respondents were asked to explain the cause, effect and level of impact, using a rating scale of 1-10, of the constraints on project performance and procedure.

3. RESULTS AND DISCUSSIONS

The interviews are recorded and the content of the communications were analyzed. The nature of the constraints is elaborated and their impact to the project is analyzed.

1. Economic constraints

The economic constraints mainly happened with budget limit and allocation of the money. Due to the budget limit, the adopted construction system may not be the best option for achieving the project goal and quality. It will affect the proceeding of the project. As for the allocation of money to be used in the project, if the money is not effectively allocated, it will affect the progress of the project. The effect on the project is the product quality and performance of the project. In summary, if economic constraints for the project could not be managed well, the product/performance/function/quality of the project will be affected.

2. Legal constraints

The legal constraints exist because there are many regulations that are ruling the construction project. The legal constraints are mainly related to work law, safety regulations, and supervision plan. For example, as prohibited by law, certain types of construction work could not be carried out during Sunday and public holidays. From the other perspective, when there are new regulations published in Hong Kong, which is not infrequent due to the recent construction industry reform bill, the project have to update the project schedule now and again to comply with the new regulations. As for the impact of the legal constraints, from one side, it may affect the schedule and lead to project delay. For example, when traffic diversion demands immediate decision, the team has to wait to get procedure approval before proceeding on site. From the other side, it may affect the planning and progress of the project, such as traffic ordinance and excavation permit, where approval is required before the work starts.

3. Environmental constraints

The public concern and regulations require the environment to be protected such as air protection, tree preservation, traffic limit, noise control and so on. In the planning and design stage of the project, the responsible people need to go to the "Environmental Department" to apply for the approval/justification for the project. This takes time and will affect the project progress. If the approval is not obtained on time, the whole project will be delayed, or could not be carried out. There are also other technical constraints arising from air protection, tree preservation, traffic limit, limit due to excavation permit for works, etc.

4. Technical constraints

There are quite a few technical constraints arising from restrictive site area and congested surroundings which are particularly applied to the site environment in Hong Kong. On one hand, building projects in Hong Kong are usually constrained with restrictive site area where storage space, transportation and temporary works require input of careful planning by design engineers, while the design and construction of the building works itself can be fairly certain at the outset. On the other hand, coordination of services works also poses technical constraints in construction. While having electrical wiring, ventilation ductwork, fire services and plumber works with further complication of broadband alignment, telephoning system and security system give rise to technical constraints that demand coordination and collaboration of multi-parties in terms of design and construction. Technical constraints are more readily recognized at the outset and at the stage of design, but this does not mean that all constraints can be overcome.

5. Social constraints

No construction work could proceed in rural area without people's involvement. The social factors constitute constraints in the construction working environment. It is not surprised to learn that undesirable effects come from a relative small number of key persons and the constraints are human constraints. These social constraints may appear minor and insignificant, but is very complicated to deal with. Sometimes it may arouse big problems for the project and will at the same time affect the progress of the project. Chinese "Feng shui" is a good example of social constraints. in New Territory of Hong Kong, the original residence believe the "Feng shui", some of the construction companies need to spend a lot of money to avoid the bad "Feng shui" and also hold some ceremony for the belief of Chinese "Feng shui". Furthermore, public concern and media pressure also constitute constraints to the construction project. Public concern and internal audit on "proper" use of public money, in fact impose restraint on new initiatives and engagement of better contractor on expense of higher contract sum. Sometimes, when a new technology or design is proposed to carry out in a project, the public, such as the media and the audit department, will restrict the endorsement of the usage of the money. The checking system prefers using every dollar effectively. This constraint will affect the adoption of new technology usage in construction project. It also affects the design and contracting of the project.

We observe that the social constraints usually come from the people. Inadequate assumptions or bad judgment arising from human constraints can bring disaster. Frustration, lack of motivation and mistrust will destroy morale and commitments to work (Newbold, 1998). Constraints related to people can appear in three different forms: (1) human resistance, (2) emotional constraints, and (3) ownership of the problem. In implementing changes, there will be human resistance. So constraints have to be thought of during the planning stage before actual implementation so as to minimize the effect of human resistance. As for the emotional constraints, there is a tendency for people to take defensive action rather than 'toleration' even the rational minds tell them not to. In this stance, people are emotional disturbed. In situations when constraints are concerning job security, the impact of the emotional constraints can be even greater and can cause devastative effects. As for the ownership of the problem, people may at times facing problems caused by others or by Act of God. It is easy to say that they do not cause the problem and thus are not responsible for it. Someone have to be held responsible for whatever causes there are. Moreover, providing an answer to a problem even if you are aware of it sometimes may not bring in the expected results. By the action of supplying a person with the answer you block them from the opportunity of inventing answers for themselves (Goldratt, 1995) as people like to have autonomy within their capacity. Therefore, to induce people to invent solution would charge the person with ownership of the problem and hence commitments in solving it.

The average score of the rating scores on the level of impact on the construction project is shown in Table 1. The legal constraint has the strongest impact on the construction project, economic and environmental constraints both ranked second among the constraints. The social constraint has a modest impact comparing with other constraints. Technical constraint has the lowest impact on the construction project. The results show that the legal, environmental and the economic constraints have the strongest impacts on the project. It is suggested that time and enough resources be allotted to these constraints in the planning stage of the project. The social constraint has special local and traditional features. Although not as important as the other constraints, it could not be ignored. If the social constraints could not be handled well, the project could not be proceeding well, and at project evolving stage, this may even lead to discontinuation of the project.

Table 1 Level impact of the constraints on the construction project

Constraints	**Level of Impact on the construction project**
1. Legal constraint	7.20
2. Economic constraint	7.00
3. Environmental constraint	7.00
4. Technical constraint	4.75
5. Social constraint	5.40

Although the technical constraints have the lowest score, it is also important for good quality of the product. These constraints are intended to be resolved by engineering design and close coordination of design and construction activity. If technical constraints can be resolved at the design stage, these constraints will no longer be constraints at the construction stage, but this kind of technical constraints can take up much of design engineers' time prior to start of construction and yet there may be new technical constraints arising from actual working environment. An example of this can be seen with the Deep Bay Link (Tam, 2006) where the design and construction team faced a range of ground constraints and time constraints. The solution was to have a technical team assigned to offer design and time-saving solutions together with careful logistic planning.

The results confirm that if one constraint could not be overcome, another constraint may be triggered. For example, if the method of disposing wastage threatens the environment, which breaks the regulations, the company may need to spend money to deal with the wastage in a legal way. The project budget may not be enough as a result, thus economic constraint is encountered.

The identification of the constraints helps project managers not only understand the characteristics of the constraints, but also predict the time and stage that the constraints may be encountered. The economic constraints, legal constraints and the environmental constraints are mainly appeared in the planning and definition stage. It affects the proposal and design of the project. The technical constraints and social constraints are expected to be encountered during the project implementation and maintenance period. A good prediction of the constraints helps make good project planning and resources allocation. Project managers can judge whether the constraint is maintained through the whole progress of the project, which we name them as "permanent constraints"; or where the constraint could be removed, which we name them as "temporary constraints".

4. CONCLUSION

To have a good understanding of the identified constraints at the planning stages, we suggest the management to have the constraints documented and to consider these constraints in the relevant project planning agenda and schedule as well as the designing of the organizational structure. At the implementation stage, the management should keep track of the progress and be aware of the constraints they encounter. The management should ensure that enough resources, which include money, facilities, staffing and effort, are allocated to decrease the limitations from the constraints encountered. In view of the nature of the different types of constraints, we suggest that the middle managers are empowered to take up adaptive management in response to the prevailing conditions. Although we are still in the process of collecting data, we regard the results sufficiently indicative of how constraints in construction would be like. We consider further study in other areas of TOC necessary to understand the complex nature of construction.

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EVALUATION ON PERFORMANCE LEVEL OF DESIGN-BUILD AND DESIGN-BID-BUILD (FOCUSED ON MULTI-FAMILY HOUSING PROJECTS)

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ABSTRACT

The performance indicator of delivery method could be generally evaluated by a project cost and a project cycle time as a quantitative analysis, and also by construction quality as a qualitative analysis. In most researches, the evaluation of performance level as a part of construction quality has been evaluated by the degree of their satisfaction through the interview with owners. This paper evaluated the difference of performance level by measuring the design documents of Multi-Family Housing projects in South Korea delivered by Design-Build (DB) and Design-Bid-Build (DBB) since 2000 with evaluation items such as design quality, usability, maintainability, etc. In the evaluation process, AHP and Delphi method were applied to improve the reliability of analysis results with regard to the performance level.

Keywords: AHP, Delivery method, Delphi, Multi-Family Housing, Performance Level

1. INTRODUCTION

Recently, construction industries are getting complicated, diversified, and bigger. Also, construction work tasks become more technology-intensive rather than labor-intensive. For these reasons, each nation has attempted with numerous methods to improve the productivity of large-scale public projects. As part of an effort, various delivery methods have been developed and applied to various projects (i.e., Design-Build (DB) delivery method). The pilot projects conducted by the delivery methods such as DB, CM at Risk, and etc., have been compared with the traditional Design-Bid-Build (DBB) for evaluating performance indicator of each delivery methods in many previous researches (Sanvido and Konchar 1998). According to the results of previous researches related to the performance indicator of delivery methods, DB can lead the reduction of project cycle time and also is superior to the traditional DBB in terms of construction quality and constructability because DB has an advantage of a lot of construction information during design phase (Sanvido and Konchar 1998; Bennett et al. 1996)

However, for the previous researches related to the performance indicator of delivery methods, the performance level as a part of quality has been qualitatively evaluated by the degree of owner's satisfaction but evaluated by relatively quantitative data such as a project cost and a project cycle time. It only can measure the satisfaction of the each project's owner. It is difficult to figure out how much the difference of performance level is.

Therefore, this paper analyzed the design documents of construction projects delivered by traditional DBB and DB in multi-family housing projects in South Korea in order to measure design quality, construction quality, usability, maintainability, etc.

2. RESEARCH FRAMEWORK

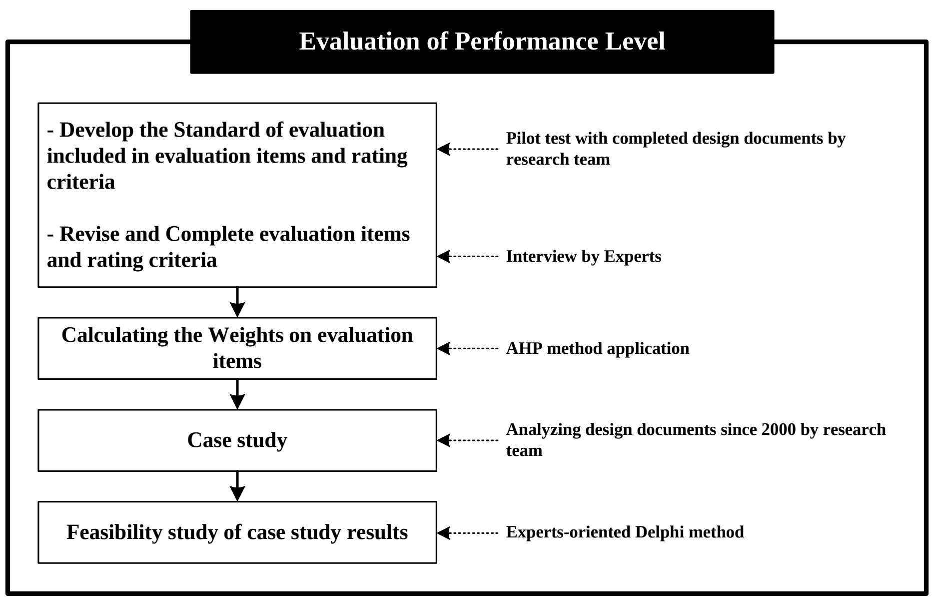

Figure 1. Research Framework

The evaluation on performance level of DB and DBB had been conducted by analyzing the construction documents for the multi-family housing projects in South Korea since 2000. As shown in Figure 1, the research was composes of four steps.

In the first step, the pilot test had been applied to the completed multi-family housing projects in order to develop the standard of evaluation included in "main category," "subcategory," "sub-subcategory," and "evaluation contents" as evaluation items, and the rating criteria of the performance level. The research team had interviewed with ten experts in order to revise and conform the result of the pilot test.

In the second step, for calculating the weights of main and sub-category items developed in the previous step, the Analytic Hierarchy Process (AHP) was used. In the third step, based on the standard of evaluation to measure the performance level which was developed in the first and second step, the design documents and design specification of candidate projects were analyzed and calculated. In the final step, the results of case study which are analyzed subjectively and quantitatively by research team are confirmed with Delphi method.

3. PROCESS ON EVALUATION OF PERFORMANCE LEVEL

Develop evaluation items and rating criteria

The research team conducted the pilot test with the design documents of completed multi-family housing projects in order to develop the standard of evaluation which was composed of evaluation items and rating criteria. Then the developed standard of evaluation was revised through interview with ten experts who have a lot of practical experience in multi-family housing projects over 10 years. As one of components of evaluation items, the main category was divided into six categories: (i) design quality/comfortableness, (ii) usability, (iii) level of facility, (iv) maintainability, (v) safety/constructability, and (vi) environment. As shown in Table 1, each main category was composed of each sub-category. For example, the main category "design quality/comfortableness" has four sub-categories: (i) building characteristics, (ii) aesthetic, (iii) parking planning; and (iv) plan for the path of flow. In Table 2, the sub-subcategory and evaluation contents stand for the description for identifying and quantifying the sub category.

Weights for evaluation item

Thomas Saaty (1982) first introduced AHP as a new approach for solving the complex problems, which often involve a great deal of uncertainties. AHP was developed to assist in making the uncertain decisions that are characterized by a great number of interrelated factors. The AHP developed by Professor Thomas L. Saaty in the 1970's was used to evaluate the hierarchy of criteria with each level and to determine each criterion's relative importance by establishing weight (or priority) among the criteria and sub-criteria (Saaty 1982, Shapira and Goldenberg 2005). The main feature of AHP is its inherent capability of systematically dealing with a number of intangible and qualitative attributes, as well as with tangible and quantitative factors.

Therefore, AHP method was used to calculate the weight of each main and sub category representing performance level. The questionnaire survey was sent to ten experts who were in-charge of architectural design and engineering part (i.e., three owners, four designer, and four general contractors). All of them have practical experience more than five times in the similar kinds of Multi-family housing projects and also over 10 years. The weights are calculated by using Expert Choice 2000 with the date provided by the ten experts. Figure 2 shows the weight for each category.

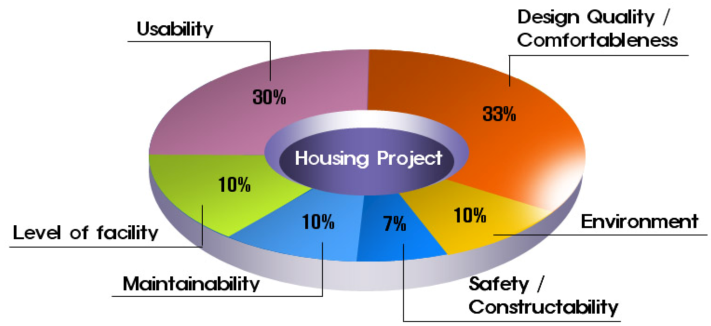

Figure 2. Weights of main category

The results showed that the “design quality/comfortableness” and “usability” should be considered as important factors for evaluating the performance level in multy-family housing projects. In addition, the relative importance of the sub-category for evaluating performance level was calculated (refer to Table1).

Table 1. Evaluation items and Weights

Evaluation Items		Weights	
Main Category	**Sub-Category**	**Main Category**	**Sub-Category**
Design Quality / Comfortableness	Building Characteristics	33	11
	Parking Plan		8
	Aesthetic		10
	Plan for the path of flow		4
Usability	Space Flexibility	30	8
	Specialization in House Unit		6
	Sunshine and Ventilation		8
	Utility Facility		8
Level of facility	Facility Level	10	3
	Finishing Level		7
Maintainability	Repair and Replacement	10	4
	Energy Saving		6
Safety / Constructability	Safety Guide in Construction	7	2
	Safety Plan		5
Environment	Environment Guide in Construction	10	2
	Landscaping area		8
Total			100

Delphi method

The Delphi method was used to achieve a consensus through the discussion with experts. It is a kind of brainstorming method which leads to conclusion by means of group discussion (Hartman and Baldwin 1995). Another reason for using Delphi method was to provide the objectivity with the results of case study which are analyzed subjectively and quantitatively. Seven experts who have more than 15-year practical experiences in housing construction projects were selected for Delphi method.

The Delphi process was proceeding as following steps. In the first Delphi Round, the experts reviewed the results of case study which were obtained from the research team. In the second Round, the score, given by research team, with regard to each evaluation item were supplemented by exchanging experts' opinions based on their experience.

4. STANDARD OF EVALUATION FOR PERFORMANCE LEVEL

In this section, the evaluation items and rating criteria which are applied to various methods such as Pilot test, AHP and Delphi method are explained with representative categories (i.e., design quality/comfortableness and usability). In addition to those categories, the sub-subcategories which were composed of the sub-categories were measured with evaluation contents and rating criteria shown in Table 2.

Design quality / Comfortableness

As shown in Table 2, the "building characteristics" has been categorized as following sub-subcategories: (i) main building's plot angle, (ii) the top floor specialization, (iii) the first floor specialization, (iv) the side pitch of building, (v) the front and back design variation, and (vi) the side design variation. For the "aesthetic", it is analyzed that the exterior design of low story parts, the originality of exterior subsidiary facility, consideration of topography circumstances, and skyline variation are considered for evaluating performance level in terms of aesthetic. For the "parking plan", it is analyzed with parking ratio, underground parking lot ratio, integration of underground parking lot and main building. Lastly, "the first floor piloti ratio, view and walking axis" were considered for the "plan for the path of flow" (Refer to Table 2).

Usability

For the "usability," it was categorized as following sub categories: (i) sunshine and ventilation, (ii) space flexibility, (iii) house unit specialization, and (iv) utility facility. For the "sunshine and ventilation," it is analyzed with the number of air face and building height of the front side. "Temporary wall, balcony conversionability, and open window" were considered for the "space flexibility." For the "house unit specialization," it is analyzed with work arrangement installation, antechamber installation, and support kitchen installation. Lastly, for the "utility facility," it is analyzed that the number of bathroom, the number of bathroom faced with the air, balcony space ratio, and compatibility of drier space are considered for evaluating performance level in terms of utility facility (Refer to Table 3).

Table 2. Detail evaluation standard for design quality / comfortableness

Evaluation Item				Rating Criteria
Main Category	**Sub-Category**	**Sub-sub category**	**Evaluation contents**	
Design Quality / Comfortableness (30)	Building Characteristics (8)	Main Building's Plot Angle (Sunshine) (2)	Nature Lighting and Heating Effect	3 Grades of Relative Evaluation by the angle among housing
		Top Floor Specialization (2)	Variation on Roof Design	Garret : 1 Point Roof Garden : 1 Point
		First Floor Specialization (1)	Variation on the First Floor Design	Private Garden : 1 Point
		Side Pitch of Building (1)	Effective on Draft and View	2 Grades of Relative Evaluation by Mean Pitch of Building
		Front and Back Design Variation (1)	Diversity Elevation	Front View Variation : 0.5 Point Back View Variation : 0.5 Point
		Side Design Variation (1)	Diversity Elevation	2 Grades of Relative Evaluation by the Side Design Variation Rate
	Aesthetic (Harmony with Circumstances) (10)	Exterior Design of Low Story Parts (2)	Variation in Complex and Friendly Feeling	Material Variation : 2 Points Color Variation : 1 Point
		Originality of Exterior Subsidiary Facility (3)	Complex Outdoor Facility Plan	Connection with Open space : 1 Point Main Entrance Specialization: 1 Point Walk : 1 Point
		Consideration of Topography Circumstances (3)	Green Space	Deck Parking Lot : 1 Point Building Plot as Topography : 1 Point Facility Plot as Topography : 1 Point (Flat : 1 Point)
		Skyline Variation (2)	Diversity	2 Changes : 1 Point Over 3 Changes : 2 Points
	Parking Plan (8)	Parking Ratio (%) (4)	Sufficient Parking Area	4 Grades of Relative Evaluation by Parking Ratio
		Underground Parking Lot Ratio (%) (3)	Green Space on ground level	3 Grades of Relative Evaluation by Underground Parking Lot Ratio
		Integration of Underground Parking Lot and Main Building (1)	Convenience of Using Parking Lot	Integration of Underground Parking Lot and Main Building : 1 Point
	Plan for the path of flow (4)	First Floor Piloti Ratio (2)	Opening the First Floor Space	4 Grades of Relative Evaluation by Piloti Ratio
		View and Walking Axis (2)	Consideration on Movement	View Axis : 1 Points Walking Axis : 1 Point

Table 3. Detail evaluation standard for Usability

Evaluation Item				Rating Criteria
Main Category	Sub-Category	Sub-sub category	Evaluation contents	
Usability (30)	Sunshine and Ventilation (10)	The Number of Air Face (5) (The number of Bay)	Sunshine and Ventilation Advantage	5 Grades of Relative Evaluation by the Mean Number of Air Face
		Building Height of the Front Side (5)	Sunshine and Ventilation Advantage	5 Grades of Relative Evaluation by the Mean Building Height of the Front Side
	Space Flexibility (6)	Temporary Wall (3)	Floor Plan Variation	Masonry Wall : 1 Point 1 Temporary Wall : 2 Points 2 Temporary Walls : 3 Points
		Balcony Conversionability (2)	Balcony Conversion Availability	Masonry Wall for Conversion (Only Furniture Part is Framed) The Number of Expansion Available Room 1 Room : 0.5 Point 2 Rooms : 1 Point 3 Rooms : 2 Points
		Open Window (1)	Balcony Conversion Availability	Open Window is the Entire Window from Top to Bottom. 1 Open Window : 0.5 Point 2 Open Windows : 1 Point
	House Unit Specialization (7)	Work Arrangement Installation (3)	Work Arrangement Installation in the Limited Space Work Arrangement : Furniture Installed Space Reserved : Furniture Uninstalled	The Number of Room > Work Arrangement + Space Reserved : 0 Point The Number of Room = Work Arrangement + Space Reserved : 1 Point The Number of Room = Work Arrangement : 2 Points The Number of Room < Work Arrangement : 3 Points
		Antechamber Installation (2)	Space in front of the Entrance	Antechamber Installed : 2 Points Antechamber Uninstalled : 0 Point
		Support Kitchen Installation (2)	Expansion Space of Kitchen	Support Kitchen Installed : 2 Points Support Kitchen Installation Space Considered : 1 Point
	Utility Facility (7)	The Number of Bathroom (2)	Usability of Bathroom	2 Bathrooms : 2 Points (2 Points, if over 1.5 on average) 1 Bathroom : 1 Point (1 Point, if under 1.5 on average)
		Bathroom Faced with the Air (1)	Nature Ventilation and Airing Consideration	The Number of the Air Window = The Number of Bathroom : 1 Point The Number of the Air Window < The Number of Bathroom : 0.5 Point No Air Window : 0 Point
		Balcony Space Ratio (%) (3)	Free Extra Space Plan	3 Grades of Relative Evaluation by the Balcony Space Ratio
		Compatibility of Drier Space (1)	Flow Plan for Housewife	Compatible (Same Place with Washing Machine and Drier): 1 Point Average : 0.5 Point Incompatible : 0 Point

5. THE RESULTS OF EVALUATING PERFORMANCE LEVEL IN MULTY-FAMILY HOUSING PROJECTS

Candidate Projects for evaluating performance level in housing projects

In evaluating performance of housing delivered with DB and DBB method, it is ideal to evaluate under the same topography and conditions in order to improve the credibility of analysis. However, it is not easy to identify the candidate projects which are similar with the project characteristics, size, and time. Firstly, two companies for selecting candidate projects were selected which was similar with the project types and organizations because the performance level to housing projects generally depends on the ability of the owner's organization. The number of the cases and the selection standard of the final selected cases for analyzing are presented in Table 4.

Table 4. Number and selection standard of candidate projects

Type	A Company	B Company	Total	Selection Standard
DB	7	3	10	- Projects similar to the time of execution - The same project type (Public Sale, Public Lease) - Projects similar to the size of the house unit - Adjacent area of projects
DBB	11	3	14	

In order to improve the effectiveness of the analysis, the sale types of multi housing projects were divided into three types: (i) the public sale, (ii) public lease, and (iii) public sale + public lease. In addition to those types, for comparable analysis on the performance level between DB and DBB, the completed project date and the project area were considered to categorize the 24 candidate projects by nine groups (i.e., 1 or 2 DBB projects to 1 DB project)

The Result of Analysis

Irrespective of three project types such as public sale, public lease, and public sale + public lease, the similar results are shown in Table 5. The performance level of DB is higher to DBB (i.e., approximately 121.0% in public sale, 156.0% in public lease, and 126.7% in public sale + public lease).

Generally, the performance of DB is superior to DBB method at the all main categories except for "facility." In case of the "facility," it is shown that the rating score of DBB are slightly higher to those of DB, but it is not significant. Specifically, the performance levels of DB delivery method are superior to those of DBB in terms of "Design Quality / Comfortableness, Usability, Quality, and Maintainability."

Table 5. Result of evaluating performance level between DB and DBB in multi family housing projects

Rating Items		Type : Public Sale						Type : Public Lease						Type : Public Sale + Public Lease					
		Rating scores				Comparative Rating		Rating scores				Comparative Rating		Rating scores				Comparative Rating	
		DB		DBB				DB		DBB				DB		DBB			
Main Category	Sub-Category	Main Category	Sub-Category	Main Category	Sub-Category	DB	DBB	Main Category	Sub-Category	Main Category	Sub-Category	DB	DBB	Main Category	Sub-Category	Main Category	Sub-Category	DB	DBB
Design Quality / Comfortableness	Building Characteristics	24.8	6.8	20.0	5.4	✓		23.8	6.2	13.3	3.4	✓		26.2	6.7	20.7	6.0	✓	
	Parking Plan		9.0		6.5	✓			8.7		4.4	✓			9.7		6.7	✓	
	Aesthetic		5.5		5.5	•	•		5.3		3.2	✓			6.2		5.0	✓	
	House Flow Plan		3.5		2.6	✓			3.7		2.3	✓			3.7		3.0	✓	
Usability	Space Flexibility	24.6	8.8	18.4	6.3	✓		22.2	5.7	12.6	3.0	✓		21.3	8.0	16.0	5.3	✓	
	Specialization in House Unit		4.3		3.6	✓			4.3		3.2	✓			4.7		2.3	✓	
	Sunshine and Ventilation		6.5		4.3	✓			6.0		1.9	✓			4.0		3.3	✓	
	Utility Facility		5.1		4.2	✓			6.2		4.5	✓			4.7		5.0		✓
Level of facility	Facility Level	7.0	3.0	6.7	3.2		✓	7.3	3.3	5.0	3.0	✓		7.2	3.2	7.5	3.5		✓
	Finishing Level		4.0		3.5	✓			4.0		2.0	✓			4.0		4.0	•	•
Maintainability	Repair and Replacement	7.5	2.0	6.2	2.0	•	•	9.0	4.0	5.6	2.0	✓		7.0	2.0	5.0	1.0	✓	
	Energy Saving		5.5		4.2	✓			5.0		3.6	✓			5.0		4.0	✓	
Safety / Constructability	Safety Guide in Construction	9.5	2.0	8.3	2.0	•	•	9.5	2.0	8.4	2.0	•	•	7.0	2.0	6.0	2.0	•	•
	Safety Plan		5.0		4.0	✓			5.0		4.1	✓			5.0		4.0	✓	
	Field Evaluation		2.5		2.3	✓			2.5		2.3	✓			-		-	-	-

Environment	**Environment Guide in Construction**	7.8	2.0	7.5	2.0	•	•	7.7	2.0	5.8	2.0	•	•	9.7	2.0	6.7	2.0	•	•
	Ecology Ratio		5.8		5.5	✓			5.7		3.8	✓			7.7		4.7	✓	
Total		**81.1**		**67.0**		✓		**79.5**		**50.7**		✓		**78.3**		**61.8**		✓	
Note		**DB is superior to DBB 121% in public sale.**						**DB is superior to DBB 156.8% in public lease.**						**DB is superior to DBB 126.7% in public sale + public lease**					

6. CONCLUSION

Generally, DB delivery method leads the reduction of project cycle time as one of critical advantages. This research was implemented to quantitatively measure the performance level while the previous researches were only evaluated through the interviews with the owners of the facilities.

This research took into consideration the objectivity of evaluation items and rating criteria for the performance levels because their properties could be a subjective outcome in analyzing the performance level of DB and DBB delivery method. AHP and Delphi method were used to improve the reliability of analyzing the performance level.

The design documents of multi-family housing projects delivered DB and DBB since 2000 were analyzed by using the standard of evaluation for performance level which was composed of main categories, sub-categories, sub- subcategories, evaluation contents, and rating criteria. The analyzing results of candidate projects showed that the performance level of DB delivery method was generally higher to those of DBB about 120% (MOCT 2006, Seoul Metropolis 2000).
However, it should be noted that the “cost” did not considered in this research. Therefore, it can not say that DB is superior to DBB by all respects, based on the result of this research. Therefore it is required to conduct researches considering the cost effectiveness and performance level simultaneously.

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SELECTION MATTERS - IN ASSEMBLING TEAMS FOR SUCCESSFUL PPPS

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ABSTRACT

This paper integrates two research streams in addressing an increasingly important, but still complex question confronting both developing and developed countries: on how best to mobilise suitable and sustainable teams for long term PPPs (Public Private Partnerships) in delivering valuable infrastructure. Research outcomes from an investigation into constructing 'relationally integrated teams' for better construction project performance, are fed into a framework that is conceptualised for generating and sustaining win-win relationships in a necessarily longer-term PPP scenario. While initiated from Hong Kong, the investigations yielded (1) positive outcomes from a multi-country survey on the potential for developing relational contracting regimes and integrated teamworking scenarios, and (2) encouraging feedback on the conceptual framework, from internationally experienced PPP experts. The foregoing outcomes are synergised, in formulating pointers towards improved team selection for more successful PPPs. The proposed framework targets envisaged synergies that should feed-forward into more sustainable infrastructure, and thereby into more sustainable development.

Keywords: Public Private Partnerships, Sustainability, Team selection, Teamworking.

1. INTRODUCTION

Historically, many countries have experimented with the extremes of entrusting socio-economic development, either entirely to the government/ public sector, or totally to market forces/ private sector. Some such excursions have led to disasters, and even complete reversals following violent upheavals. A 'middle road' of Public Private Partnerships (PPPs) has been available for centuries e.g. going back to the ten year concession of commercial exploration of the Guinea Gulf awarded to a sailor Fernao Gomes by the King of Portugal in 1469 in exchange for the 'discovery of new lands' (Branco et al., 2006). However, the popularity of PPPs has ebbed and flowed with the varying needs of the times and levels of success achieved e.g. as governments play a bigger role during crises, such as wars and in times of economic depression.

The recent resurgence of interest in PPPs in the last two decades has moved from an initial phase of essentially seeking private funds to finance urgent infrastructure development in developing countries; to a search for flexible efficiencies in both developed and developing economies. The efficiencies are expected to result in superior performance levels in creating and managing (not just 'maintaining') assets that include not only physical infrastructure such as roads, bridges and power stations, but also schools, hospitals and prisons. This 'second generation' of PPPs thus calls for a wider conceptualisation of these partnerships, with an emphasis on ‘value for money’ (Anvuur and Kumaraswamy, 2006). However, the ‘middle road’ is not a clear path. Also, those pursuing PPPs must cross dangerous mine fields in any case (Ogunlana, 2005), given the many more variables, uncertainties and lack of experience in dealing with such complex scenarios. Furthermore, the long time frames of most concessions impose an extra dimension, demanding that PPPs should not just be ‘successful’ but sustainably so.

Meanwhile, it is increasingly evident that high performance levels in infrastructure development and management depend not just on streamlined structures and systems, but also on integrated teamworking (Construction 21 1999; CIRC, 2001; Constructing Excellence, 2004). Taken together with the needs for sustainable performance levels in PPPs as above, these highlight the imperative for assembling excellent teams who can work together into the long term future in infrastructure development and management. This paper therefore applies and extrapolates research findings on factors facilitating relationally integrated project teams, to present a conceptual framework aimed at developing and sustaining good relationships and performance levels throughout the PPP time frame. Feedback from a group of international PPP experts is summarised to indicate the suitability of the framework and its proposed further development.

The timeliness of the above applications and developments are further justified by recent research elsewhere. For example, (1) Zhang and AbouRizk (2006) aim ‘to develop a relational concession framework’ for PPPs in infrastructure development; and (2) Chen et al. (2006) proposed a decision support model to evaluate (a) the ‘sustainable performance potential of partner candidates’ in terms of environmental consciousness and sustainable performance, as well as (b) the sustainability of such construction partnerships, for construction projects in general. The latter can thus be usefully applied to PPPs where sustainability is seen to be more significant, given the much longer time frames.

2. TEAM-BUILDING

Teams, Teamworking and Integration

Teams are more than just working groups. Indeed they are groups of people with complementary skills, a common purpose and mutually accountable for its achievements, with members being mutually supportive in working together towards their goal (Constructing Excellence, 2004). Many models have been developed to understand and promote higher performance levels in teams in general (e.g. Rippin, 2002; Belbin, 2004). However, in the construction industry, specialisation over the centuries has led to fragmented project teams. More recently, this has been deplored as unproductive (e.g. Latham 1994), because the advantages of specialisation have been overwhelmed by the difficulties of co-ordinating inputs and integrating outputs.

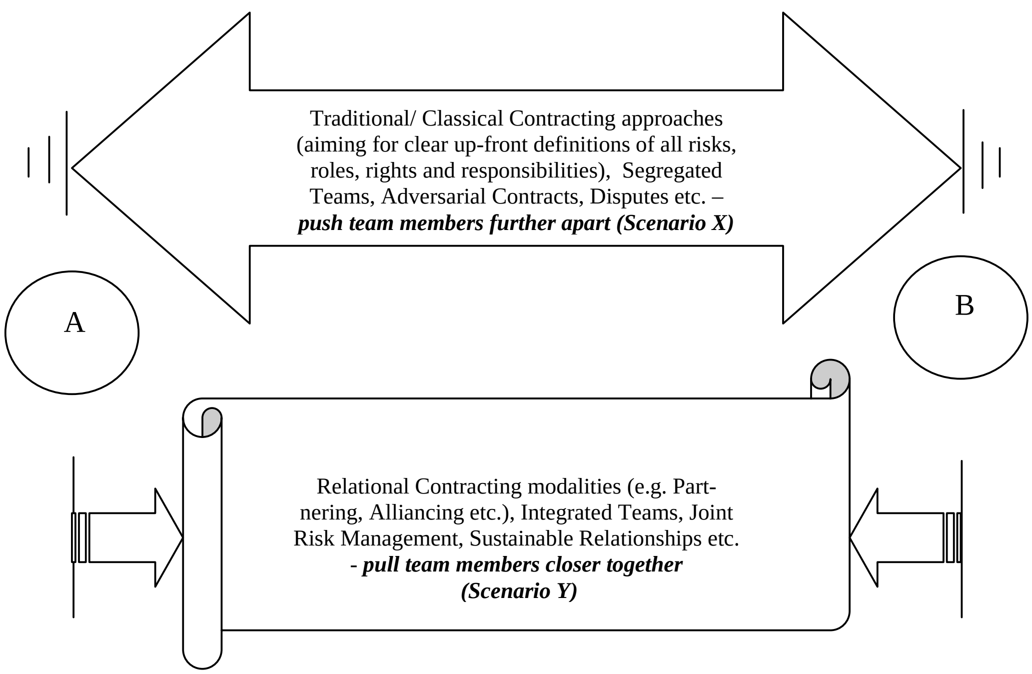
To counteract this problem, clarion calls for integrated teams have echoed across the globe in the last two decades (e.g. Egan, 1998; ISR, 1999; CIRC, 2001; Constructing Excellence, 2004). However, the calls for integrated teams in Singapore, focused more on organisational or ‘structural’ integration, in terms of linking the functions of design and construction in design & build contracts. On the other hand, the UK, Australia and

Hong Kong Reports recognised the need for what has recently been termed 'relationally integrated teams (Kumaraswamy et al., 2005a), that require more than just organisational or functional integration of structures or even systems.

Constructing Relationally Integrated Project Teams (RIPTs)

Appropriate team selection by itself has been recognised as critical to the success of construction projects in general. To achieve this, there has been a significant shift from the previous 'lowest price wins' paradigm to incorporating non-price criteria in selecting contractors (Kumaraswamy and Walker, 1999) and other supply chain partners (Palaneeswaran et al., 2001) and indeed even more so in PPPs e.g. in selecting BOT concessionaires (Zhang et al., 2002). However, given the above noted recent emphasis on 'relational integration' in teams, it was felt useful to explore this particular non-price criterion in greater depth.

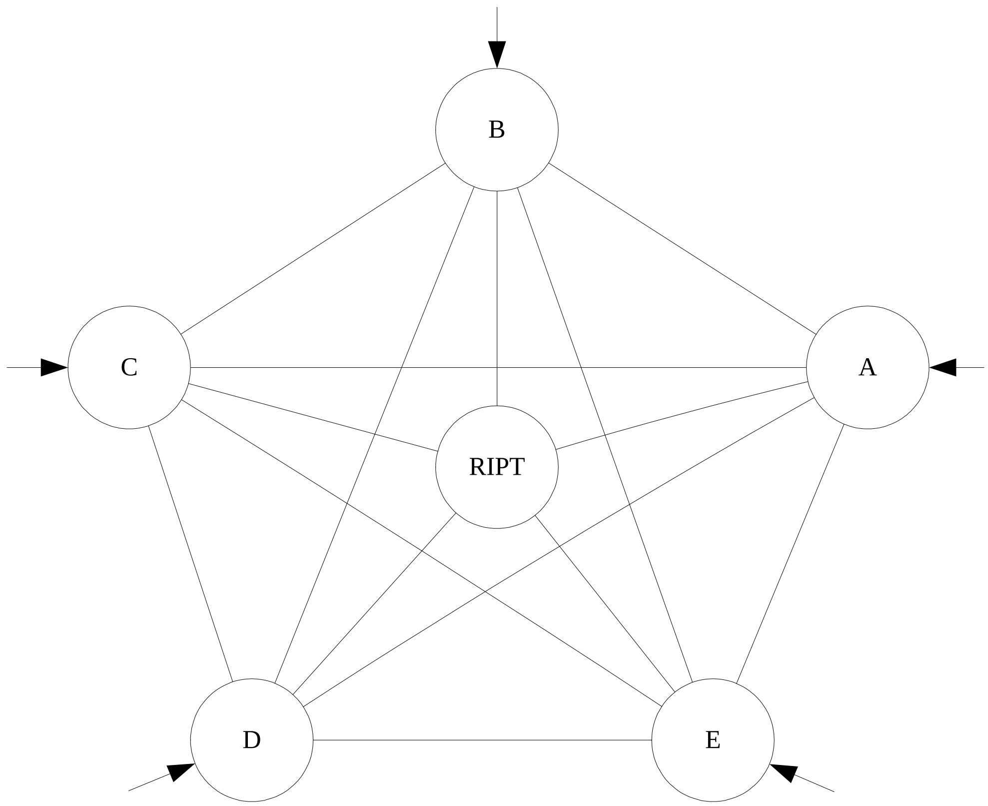
Growing recommendations for 'relational' approaches are justified (a) in practice, by successful partnering and alliancing arrangements (Bennett and Jayes, 1998; Hauck et al., 2004); and (b) in theory, by the benefits of superseding rigid dispute-generating traditional contracts with relational contracting (Macneil, 1974) that can empower joint risk management between partners (Rahman and Kumaraswamy, 2002). Relational contracting reduces reliance on contract documents, hence decreasing the numbers and complexities of formal transactions, as well as friction and disputes. It enables a focus on common objectives, including value for money and could generate the co-operation that is needed for project success (Phua and Rowlinson, 2004). Relational contracting approaches could thus counteract the 'push apart' force fields of the classical contracting approaches by pulling together each pair of team members as in Figure 1. They could work closer together and co-operate better, if the relational forces are stronger than the traditional contracting forces pushing them apart.



NOTE: The above compares two potential scenarios X and Y

Figure 1: Potential Push and Pull forces between any two Team-members A and B

This concept could be extrapolated for pulling together the many organisations now found in most construction projects into a relationally integrated project team as in Figure 2. Multiple participants in PPP projects could particularly benefit from such improved relationships and teamworking, given the long term nature of their 'multiple marriage'. Furthermore, the stakes are much higher in such necessarily multi-objective projects that would involve operation, maintenance and other aspects of asset management, and hence multiple performance criteria.



A, B, C, D, E are stakeholders
RIPT - Relationally Integrated Project Team
NOTE: lines between stakeholders indicate 'relationships', and become shorter as they become 'closer'

Figure 2: Relationally Integrating larger PPP Teams

For example, Kumaraswamy et al. (2005b) described how the time dimension could transform JRM (Joint Risk Management) concerns and efforts into JSRM (Joint Sustainability Risk Management) in order to jointly address the sustainability of the assets. This could feed into more durable designs including specifications for materials, constructability, environmentally friendly construction methods, better maintainability and operatability. Apart from this sustainability of the physical infrastructure assets, the sustainability of the team relationships themselves is the other crucial aspect to be considered in PPPs. This will be explored further in the next section on Sustainable Relationally Integrated Teams (SRITs).

Meanwhile, a multi-country survey of cross-sections of Australian, Hong Kong, Dutch, Singaporean and UK construction practitioners, revealed a readiness to incorporate relational contracting and integrated team working into their projects, with a view to enhance performance levels (Rahman et al., 2005). Interestingly, there was clear evidence of a deep appreciation of the need for constructing relationally integrated project teams (RIPTs) in Singapore as well (Kumaraswamy et al., 2005a), although the C21 (1999) Report had previously focused on structural (functional) integration unlike the Australian, UK and Hong Kong Reports that had stressed integrated relationships already. For example in Singapore, 27 factors facilitating integrated project teams and 26 factors deterring integrated project teams were found to be significant out of 28 and 31 hypothesised factors respectively (Kumaraswamy et al., 2005a). Such knowledge could aid the construction of RIPTs in different countries or regions.

3. SUSTAINABLE RELATIONALLY INTEGRATED PROJECT TEAMS (SRITs)

Developing an overall Framework and a SRIT shortlisting/ prequalification Model

Moving from RIPTs in shorter term projects, to the longer term PPP scenario, would superimpose additional needs, such as for sustainable relationships and JSRM as noted in the penultimate paragraph in the above section, for what may be termed SRITs as above. These further imperatives call for additional selection criteria in the choice of PPP teams e.g. in assessing the potential for sustainable relationships. An example of a possible approach to select SRITs for PPPs was conceptualised and used in a survey of experts in 2005. Summarised extracts from a detailed 10 page description issued along with the questionnaire are presented below:

The conceptualised PPP team selection approach focuses on short-listing/ prequalification, and ties performance on (1) 'hard/technical' (2) 'relational' and (3) 'sustainability' factors into an integrated framework, along with tools for evaluating such performance. It is suggested that such an integrated approach offers great synergies and better assurance of sustainable infrastructure. While many short-listing/ prequalification systems have been developed to evaluate against hard/ technical criteria, only a few provide for useful assessments of relational criteria, and even fewer consider sustainability factors.

What is presented here is for the shortlisting/ prequalification only. It therefore focuses on team capacities and potential, based on track record etc, and not (at this stage) on other criteria needed for evaluating PPP proposals, e.g., the financial and technical packages actually offered for a given project. The proposed shortlisting system would provide for: (a) scoring against important factors under all three categories in the above paragraph, and (b) combining the resulting scores appropriately in a given scenario. The 'relational capability' and 'sustainability potential' scores, in addition to performance against hard/ technical criteria, can be stored in continuously updated databanks of public or large private clients to provide information on a viable supply network. The threshold performance scores defined by the client organisation can determine membership of this network. Tendering consortia with members belonging to these supply networks who respond to an Expression of Interest (EOI), may then be assessed for their eligibility e.g. at prequalification stage (or even post-qualification stage), by comparing their (1) technical competence, (2) relational capacity and (3) 'sustainsivity' (conceptualised here to mean 'sensitivity to key sustainability issues').

The combined score for the past performance of each tenderer is the sum of the weighted scores in the technical, relational and sustainability assessments. Then the Past Performance Score of the i^{th} applicant consortium can be computed as:

Past Performance Score$_i$ = $W_T T_i + W_R R_i + W_S S_i$

where, W_T , W_R and W_S are the chosen weightings applied to the technical, relational and sustainsivity (see above) scores respectively, where $W_T + W_R + W_S = 1$; and T_i, R_i and S_i, are the respective technical, relational and sustainsivity scores for the i^{th} consortium expressing an interest to tender. The weightings would depend on the relative importance of the T, R and S priorities on any given project. Therefore they should be assigned by the project decision-makers. The scores are based on the assessments of each of the applicants. Furthermore, each applicant is assumed to be a consortium of companies including designers, constructors and operators. The T_i, R_i and S_i referred to above are therefore, the averages of the technical, relational and sustainsivity scores respectively of the individual companies constituting the respective applicant consortium. For example, the technical competence score, T_i of the i^{th} consortium can be given by:

$T_i = \frac{1}{n}\sum_{j=1}^{n} t_j$ where, t_j is the technical competence score for the j^{th} member of the i^{th} consortium, which incorporates n companies.

Alternatively, these t_j scores may also be weighted before summation, by the relative importance of their expected contribution. If no performance records exist for a particular member of a consortium, the scores can be assumed to be the average of those of the other companies in that consortium. However, if no performance record exists for any member of a consortium, the past performance score can be the average of the past performance scores attained by the other applicant consortia. While this adds to the client risks, it is a way to incorporate new progressive companies and thereby invigorate existing supply chains. A deliberate policy may be formulated to short-list only one such 'completely new' consortium in any major prequalification.

These Past Performance Scores can then be used as the basis for short-listing (pre-qualifying) companies to respond to a formal Request for Proposals (RFP). Since each short-listed tendering consortium should have the minimal relational capacities, their proposals at this stage should be assessed based on how well they respond to the project specific criteria outlined in the RFP, the price tendered for the range of services required and their value contributions to the development and management of the asset. After the selection of the preferred bidders, structured team building workshops can be organised to promote cooperative interaction between the contracting parties and align their respective project objectives as in Figure 3. During these workshops contractual adjustment mechanisms, issue resolution protocols, incentive mechanisms and team interaction protocols can be negotiated. Agreed project objectives comprising technical (e.g. schedule and quality/ performance levels as well as financial and socio-economic), relational (e.g. teamwork and openness) and sustainability (e.g. reducing environmental impact) targets can then be set out in a Partnering Charter or Alliance Agreement.

The assembled PPP project team will then be able to effectively mobilise their various individual relational qualities to synergistically interact, collaborate and deliver the ‘sustainable’ product/ service. The joint problem solving initiatives can then be extended to cover both risk and sustainability issues. This integrated approach contributes directly to sustainable infrastructure and indirectly through the longer-term and wider contributions via ‘sustainable relationships’ through relationship building and ‘knowledge-building’ for example, of critical success factors that will then be incorporated in the ‘knowledge base’ as in Figure 3. Through this approach, it is expected to focus more attention on increasingly important considerations such as efficient use of resources, supporting desirable natural environments, improving value for money, providing customer satisfaction, facilitating flexibility for user changes and enhancing the quality of life. A focus on these considerations will clearly contribute to more sustainable infrastructure and ultimately, sustainable development as also shown in the overarching broad framework in Figure 3.

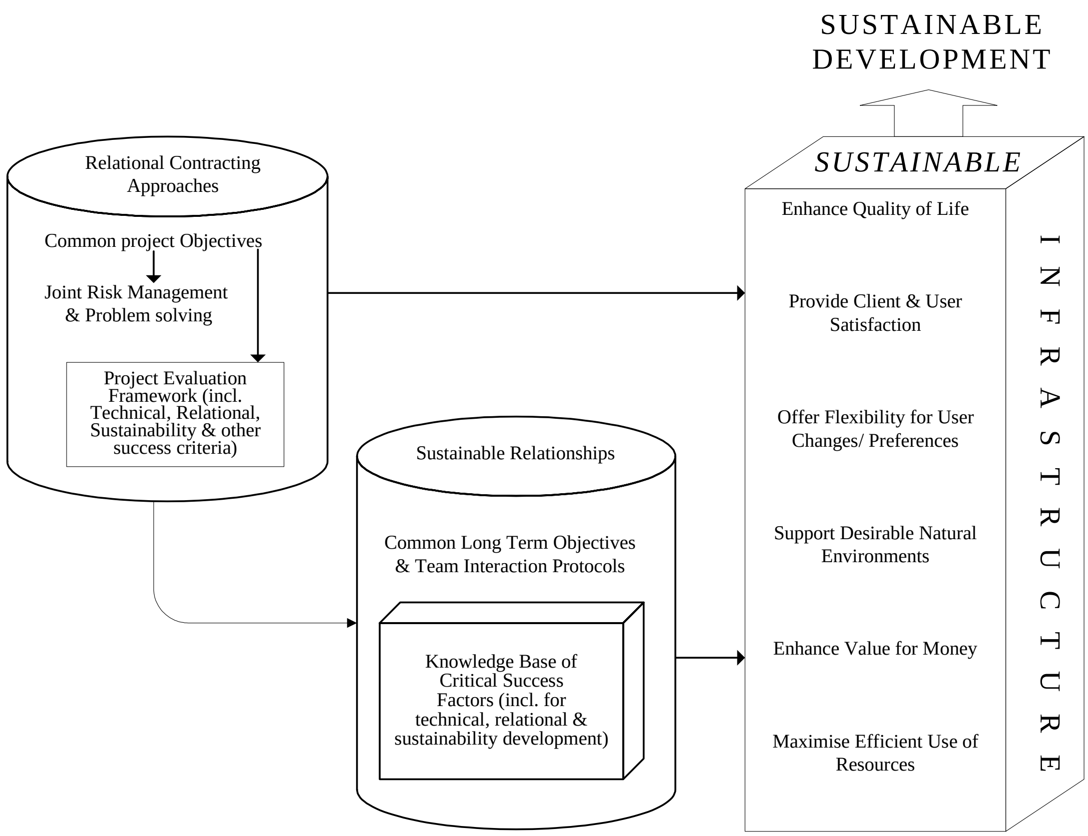


Figure 3: Framework for mobilising Relational Contracting and Sustainable Relationships for Sustainable Infrastructure Development

Assessing the Framework and proposed SRIT shortlisting/ prequalification model

An example of the proposed operationalisation of the above framework was indicated in another Figure (included herein as an Appendix, due to space limitations) with examples of relational factors and sub-factors. These details, with further descriptions, were included in the 10 page document issued for the survey of experts in 2005.

The proposed model uses a set of relational criteria or factors e.g. (1) values, (2) attitudes; each of which links to a number of independent key relational sub-factors e.g. (1) consistency, openness, fairness; and (2) receptivity, commitment, care, readiness for joint decision-making etc. The relational factors may be weighted to reflect different priorities of the project and/or client. Each relational sub-factor is then assigned a score of 0, 1, 2, 3 or 4 representing ‘unacceptable’, ‘below average’, ‘acceptable’, ‘good’ and ‘excellent’ respectively. Guidance notes will provide information for scoring at each point of the Likert scale. The relational score is then the sum of the weighted scores earned for each relational sub-factor. This will allow a less subjective comparison of the relational qualities of various potential team players based on measurements of their ‘relational capability’ on previous projects. A rating system classifies the relational scores into bands/intervals of ‘relational capabilities’ defining ‘excellent’, ‘good’, ‘acceptable’, ‘below average’ or ‘unacceptable’. Decision rules, formulated on the basis of a suitable multi-attribute decision-making model, would be established and define the minimum ‘relational capability’ required for shortlisting. This will then enable for example, a shortlisting of only potential team players with ‘good’ relational qualities.

Table 1 summarises the consolidated scores given by the 11 expert respondents in what is planned to be the first step of a Delphi-type survey, which can be continued in the planned research after further development of the framework. The respondents were internationally well experienced in PPPs; with two based in Australia, three in Hong Kong, one in Singapore, one in Thailand and four in the UK; and include engineering, financial, legal and construction experts. The high average scores and broad consensus of the experts encourage further development of the overall conceptual framework and basic evaluation model.

Criterion		Average	Standard
Number	Description	score*	deviation
Assessment of overall framework that incorporates relational, technical and sustainability factors for sustainable infrastructure			
01	Clarity	3.77	0.88
02	Validity in reflecting real needs	3.64	0.92
03	General coverage of macro-level critical performance factors	3.41	0.66
04	Applicability	3.32	1.19
05	Adaptability to different scenarios	3.59	0.86
06	Potential reliability after expansion	3.06	1.01
07	Suitability for further development	4.20	0.79
Assessment of basic model for evaluating relational performance #			
08	Coverage of relational factors	3.68	0.72
09	Coverage of relational sub-factors	3.77	0.61
10	Potential reliability after expansion	3.06	0.94
11	Suitability for further development	4.00	1.00

Notes:

* Average (Arithmetic Mean) of scores assigned by 11 experts on a scale of 1 to 5, with 1 being 'poor' and 5 being 'excellent'

The Figure and further explanations conveying the basic Model are excluded from this paper due to space constraints.

Table 1: Average assessment scores of experts

4. CONCLUDING OBSERVATIONS

Improved team selection is clearly more critical for sustainable PPPs and the basic model outlined here indicates an initiative for incorporating relational factors into the shortlisting process. Furthermore, the overall framework indicates a need to integrate this relationship dimension with considerations of technical competence and sustainsivity (sensitivity to sustainability issues). While KPIs (Key Performance Indicators) and related assessment tools for evaluating technical competence have been developed over many decades, sustainability KPIs are being focused upon in many regions in the last few years (e.g. Ugwu et al., 2006). 'Relationally integrating' factors for construction project teams have been identified from the literature and the reported multi-country survey. Applying and adapting selected relational factors along a PPP timeline, as attempted in the proposed model, was seen to be useful by the surveyed experts. Further development of this shortlisting model is envisaged in the relational, as well as sustainability dimensions. It can later be integrated with the overall PPP team selection system that will also include the next stage - for the evaluation of proposals from shortlisted consortia.

Meanwhile, the overall framework presented in this paper provides an overview of how relational contracting approaches and sustainable relationships can contribute to more sustainable infrastructure, and in turn to suitably integrated long term development. While PPPs can provide useful vehicles for mobilising and synergising such forces, it is of course noted that PPPs are certainly not appropriate for all scenarios. Parallel research initiatives (e.g. Anvuur and Kumaraswamy, 2006) are directed at developing decision support for differentiating between scenarios that are either more, or less suited for PPPs, and indeed for different types of PPPs. Together these will help answer the complex questions of how best to launch appropriate PPPs where useful, and to select suitable and sustainable PPP teams, in both developed and developing countries.

5. ACKNOWLEDGMENTS

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APPENDIX

As indicated in the main text (just below Figure 3), the following Figure A is indicative of the proposed operationalisation of one part of the proposed framework (as presented in Figure 3). Figure A also conveys examples of relational factors and sub-factors that can be used in the relational assessments, that would contribute to the combined score for past performance of each tenderer as discussed in the text (above Figure 3). Of course 'default' recommended factors and sub-factors may be replaced or modified before applications in different scenarios.

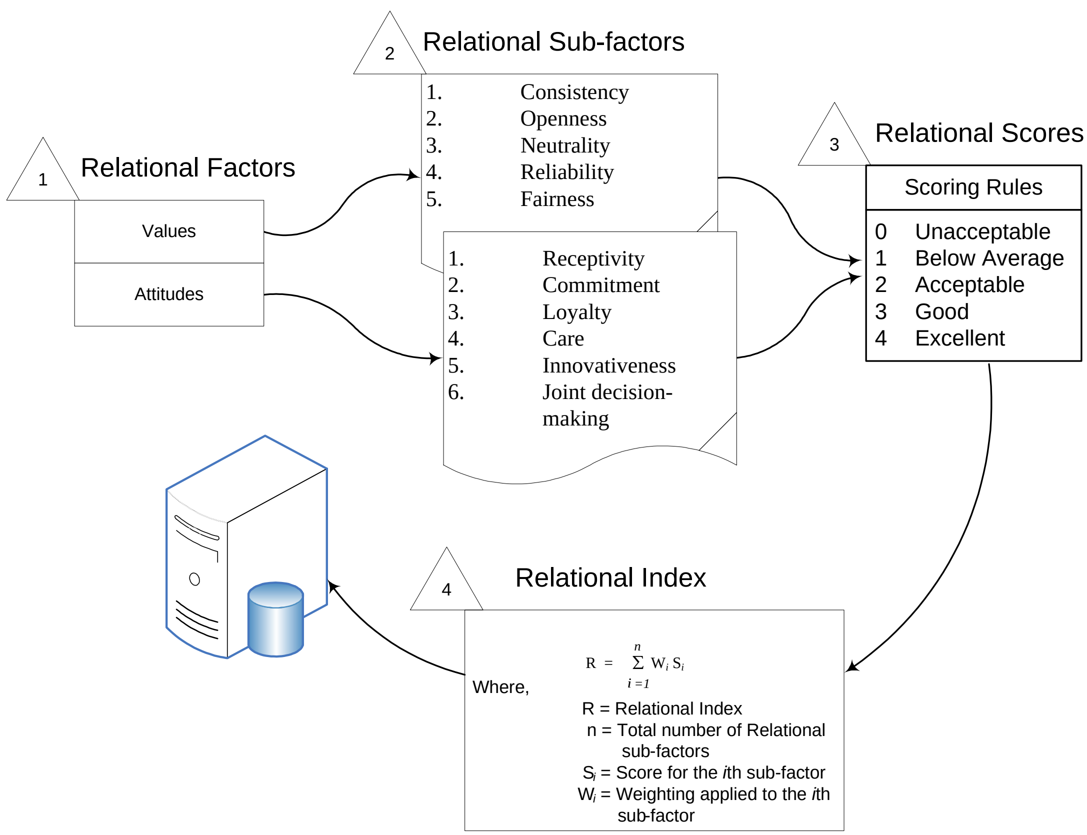

Fig. A: Example of a basic framework for Evaluating Relationships

THE ROLE OF TRUSTWORTHINESS IN THE FORMATION AND GOVERNANCE OF CONSTRUCTION ALLIANCES – A CASE STUDY IN BOTSWANA

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ABSTRACT

The ensuing globalization of the construction industry as well as its highly fragmented and divisive nature are among the forces that are influencing it to seek management approaches such as strategic alliances that could leverage the capabilities of the various participants. This paper reports on a study that investigated the factors considered by firms when selecting alliance partners, and the influence of trustworthiness in deciding the governance structures of the alliances. A study of key partners in existing and potential construction alliances in Botswana that was carried out using a postal questionnaire and structured interviews determined that firms consider complementarity, similar status, indirect prior alliance experience and reputation before they make a selection of alliance partner. The study also determined that partner trustworthiness eliminates the need of contractual clauses in the operation of the alliances. The paper concludes that trustworthiness of a partner is an influencing factor in all stages of the alliance development.

Keywords: Strategic alliances, partnering, joint ventures, trustworthiness, construction industry.

1. INTRODUCTION

Partnering between a client and a contractor is one form of alliance between parties that are not in direct competition with one another. Several studies suggest that such an approach leads to more successful procurement of projects than other traditional management approaches (Larson, 1995; Gransberg *et al*., 1999; Bresnen and Marshall, 2000). As a way of enhancing construction project delivery and improving their construction supply chains, many countries are encouraging their construction industries to embrace partnering (Construction Industry Institute of Australia, 1996; Black et al., 2000; Construction Industry Review Committee of Hongkong, 2001).

However, alliance between firms that are engaged in similar activities has both cooperative and competitive aspects. While the former enables the firms to leverage their complementary capabilities for common benefits, the latter tend to push the allied firms to engage in competitive racing in learning the capability of the partner(s) for private benefits (Khanna *et al*. 1998). Often when the learning is complete the incentive to continue the alliance ceases and this may lead to its break up (Hamel, *et al*., 1989)

This paper is to reports on a study that was carried out in Botswana to determine the factors that firms use to select alliance partners, and establish the role of trustworthiness in deciding the governance structure of the alliances. The paper begins by describing alliances in the construction industry. It then defines trust and related concepts of trustworthiness and opportunism. Next it describes the role of trust in alliances, after which a study in Botswana is reported and discussed.

2. ALLIANCES IN THE CONSTRUCTION INDUSTRY

The globalization of the construction industry is rendering the familiar model of a single company doing all things in-house outdated, and alliances are becoming a common feature. Alliances are defined as voluntary arrangements between firms involving exchange, sharing or co-development of products, technologies or services (Gulati, 1998). They can occur as a result of a wide range of motives and goals, take a variety of forms and occur across vertical and horizontal boundaries and range from joint ventures to partnerships.

In the construction industry joint ventures are employed when parties that are involved in similar activities, such as contractors join forces to leverage their complimentary capabilities to carry out work. However, joint ventures are simultaneously cooperative and competitive enterprises. The cooperative aspect arises from the fact that each firm needs access to the other firm’s know-how and that the firms can collectively use their knowledge to produce something that is beneficial to them all (common benefits). The competitive aspect is a consequence of each firm’s attempt to also use its partner’s know-how for private gains, and of the possibility that significantly greater benefits might accrue to the firm that finishes learning from its partner before the latter can do the same (Khanna, *et al*., 1998). As the result of this, the choice of a partner is carried out carefully and as stated by various scholars (e.g., Richardson, 1972; Coleman, 1990; Gulati, 1995) partners will consider the following factors in determining how to establish the alliances: complementarity, status similarity and social capital.

Partnering on the other hand, is essentially the establishment of an informal group among construction partners such as a client and a contractor to create a non-legitimate but “permanent” relationship. The literature distinguishes two types of partnering: project partnering (relationship established for a single project) and strategic partnering (a long-term commitment beyond a discrete project).

During the life of alliances, the internal and external circumstances may change, often in unexpected ways (in the construction industry circumstances continuously change). How partners adapt to these changing circumstances determines whether an alliance prospers or flounders (Kraar, 1989). Successful adaptation of these changes calls for a delicate balance between the twin virtues of reliability and flexibility. Flexibility is necessary for partners to have a viable relationship in the face of changing circumstances, yet unlimited flexibility affords companies the opportunity and incentive to cheat, reducing the reliance partners can place on each other (Heide and Milner, 1992). There are thus two types of uncertainties in alliances: uncertainty regarding unknown future events, and uncertainty regarding partner’s response to those future events. It is in this environment of double uncertainty that trust emerges as a central organizing principle in alliances (Powell, 1990)

Trust Defined

Coleman (1990) defines trust as "committing to an exchange before you know how the other person will reciprocate". Sabel (1993) puts it more succinctly "trust is the mutual confidence that no party to an exchange will exploit another's vulnerabilities". Parties to an exchange can be vulnerable when they find it very costly to evaluate accurately the quality of the resources or assets others assert they will bring to an exchange (Akerlof, 1970), or to evaluate accurately the quality of resources or assets others are actually offering in exchange (Holmstrom, 1979). Also when parties to an exchange make large asymmetric transaction, they are subject to hold-up vulnerabilities (Klein *et al*., 1978).

The literature on trust contains various insight regarding cooperative relationships and the role of trust (e.g. Zucker, 1986; Smith *et al*., 1995; Lewicki and Bunker, 1996; Lane, 1998). Some researchers (e.g. Williamson, 1975; Granovetter, 1985; Hill, 1990; Sako, 1992; Barney and Hansen, 1994) have observed that, while trust is the mutual confidence that one's vulnerabilities will not be exploited in an exchange, different types of trust can exist in different economic exchanges.

Sako (1992) categorized reasons for predictability in behaviour to distinguish between three types of trust: contractual trust (will the other party carry out its contractual agreements?); competence trust (is the other party capable of doing what it says it will do?); and goodwill trust (will the other party make an open-ended commitment to take initiatives for mutual benefit while refraining from unfair advantage taking?).

Trust in Alliances

As cooperation and competition coexist between alliance partners, cooperative relationship evolves over time as partners learn more about each other's motives, capabilities and attitudes toward control, conflict, cooperation and competition. During this period, and the entire life of the alliance the partners are vulnerable in the various ways mentioned earlier. Thus, in successful alliances, trust is often touted as a prerequisite, a necessity, an absolute must (Byrne, 1993). The converse is also true: a major contributor to failed alliances is lack of trust (Peng and Shenkar, 1997).

Trust is central for strategic alliances for three main reasons: First, no contract or agreement, no matter how complete or detailed, can account for every issue or every contingency that might arise. Formal contracts, for instance, can never anticipate and identify all the events and changes that occur over the lifetime of the strategic alliance. Second, the alliance of two or more creates a strong potential for dysfunctional conflict and mistrust as the partners differ in organizational cultures and management philosophies, among others. Thirdly, learning that is often cited as one of the major benefits and motivations for strategic alliances may suffer if the partners do not trust each other.

3. A STUDY IN BOTSWANA

Background
With a total area of 582 000 km^2 and a population of 1.7 million people (CSO, 2001), Botswana has experienced rapid growth since the time of independence in 1966. The construction industry has constituted 7.5-10 percent of the Gross Domestic Product (GDP) and during the current five-year development plan (NDP9) spanning between 2003-2009 Botswana will invest a total of P 25 billion (US$ 5.5 billion) in infrastructure development.

Construction firms that intend to undertake public works are required to register with the Public Procurement and Asset Disposal Board (PPADB) that was established in 2002 to take over the functions of the former Central Tender Board. The PPADB has six categories of building and civil engineering contractors as shown on Table 1. Categories OC, A and B are reserved for citizen contractors while in categories C, D, and E foreign firms are allowed to register.

Table 1 Categories of construction companies in Botswana

Category	Contractor's ceiling In Pula*	Number of registered firms
OC	300,000	385
A	900,000	139
B	1,800,000	82
C	4,000,000	117
D	8,000,000	29
E	Unlimited	16

*I Pula = 0.21 US$ (September, 2004)

Over the years, the government has encouraged local construction firms that are small compared to their foreign counterparts to form alliances among themselves so that the emerging entities can handle large and sophisticated projects. As a response to this encouragement, a number of strategic alliances have been established beginning from early 1980s (Ngowi, 2001).

Objectives of the study
The objectives of the study were:

- To assess the factors that are used in selecting alliance partners
- To establish the role of trustworthiness in deciding the governance structure of the alliances

A two-part study involving firms that have formed or were contemplating to form construction alliances was carried out in Gaborone, the capital city of Botswana.

Part 1 of the study involved a questionnaire survey. The survey asked respondents to evaluate the factors that influenced them to select their partners. The respondents were identified at an earlier seminar that was organized by the Ministry of Works and Transport to discuss the implementation of Public and Private Partnership (PPP) in Botswana. At this seminar, which was attended by 97 people, the details of the participants who have formed or were in the process of forming construction alliances in response to government encouragement were taken. A total of 21 participants were identified and their particulars were confirmed at the PPADB, where additional 7 firms were found to have registered as being in the process of forming alliances. Out of these firms, 6 have existing alliances and the remaining 22 have initiated the process of forming alliances having identified right partners. Two (2) of the firms are registered in category A, 16 in category B and 10 in category C. Questionnaires were sent to all 28 firms.

The addressees were reminded about the return of the questionnaires by telephone and the researcher offered to collect the ones that had not been returned by the set deadline. This ensured a 100% return rate. The factors that are considered in selecting an alliance partner are shown in Table 2.

The factor of complementarity was operationalized by the statement "We create excess value by pooling our resources relative to their value before pooling". There was strong agreement with this statement: agree strongly (94%) and agree (3%); and this concurs with observation by many researchers (e.g., Harrigan, 1985; Burgers, *et al.*, 1993) that by pooling their resources and capabilities with those of their partners, firms can initiate projects that they could not have successfully done alone. For a firm attempting such a project, the consideration of the resource complementarity becomes an important issue (Harrigan, 1985; Burgers, *et al.*, 1993). Similarly, Doz (1988) observes that the complementarity of strengths and assets between firms is often clear even prior to negotiations on the terms of alliances because it is what brings the partners together in the first place.

The factor of similar status was operationalized by the statement "Our similar status will promote social interaction". There was a strong agreement to the statement: strongly agree (36%) and agree (50%) and this is consistent with observation by researchers (e.g, Camic, 1992; Hannan and Freeman, 1977; Lorange and Roos, 1992). Often, firms considering alliances assess both the complementary capabilities and the status of their potential partners. Firms of similar status are likely to ally with each other.

The factor of direct prior alliance experience was operationalized by the statement "We prefer to deal with a partner with whom we have prior experience". The responses indicate a disagreement: strongly disagree (18%), disagree (57%) and not sure (14%). This is contrary to observations by researchers (e.g.,Gronovetter, 1985) that in forming strategic alliances, a natural solution for a firm is to first consider previous partners with which it has direct prior alliance experiences. Moreover, in establishing a long-time relationship each partner has to invest a substantial amount of time and energy (Burt, 1992) and this investment is a fixed or sunk cost which is impossible to recover when switching transaction partners.

Table 2: Factors that are considered in selecting an alliance partner

	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree	Total
Complementarity (We create excess value by pooling our resources relative to their value before pooling)	0 (0%)	1 (3%)	0 (0%)	1 (3%)	27 (94%)	28
Status similarity (Our similar status will promote social interaction)	0 (0%)	0 (0%)	2 (0%)	14 (50%)	12 (48%)	28
Direct prior alliance experience (We prefer to deal with a partner with whom we have prior experience)	5 (17%)	16 (56%)	4 (14%)	3 (10%)	1 (3%)	28
Indirect prior alliance experience (We can rely on a referee to prevent our partner from taking unfair advantage of our firm)	0 (0%)	3 (11%)	5 (18%)	14 (50%)	6 (21%)	28
Reputation (We prefer to deal with a partner whose reputation is above board)	0 (0%)	0 (0%)	2 (7%)	20 (72%)	6 (21%)	28

The factor of indirect prior alliance experience was operationalized by the statement "We can rely on a referee to prevent our partner from taking unfair advantage of our firm". The responses to this factor are in agreement with the statement: strongly agree (21%) and agree (50%). Indirect ties between two firms through a third party may enhance the chances that the two firms will form a strategic alliance because the indirect ties can function as an information conduit and because a common actor can play the role of a reference and become a mechanism for deterring opportunistic behaviors. According to Uzzi (1996) when a common actor has built a trustworthy relationship with two other actors, it will refer each party favoroubly to the other party in need of alliance partners.

The factor of reputation was operationalized by the statement "We prefer to deal with a partner whose reputation is above board". The responses are in agreement with the statement: agree strongly (21%), agree (71%) and not sure (8%). This should be expected given the number of complaints that have been lodged by various parties in Botswana that most contractors have poor credibility. It, therefore, follows that before any firm decides to deal with another, it has to seek information regarding the reputation of the potential partner.

Part 2 of the study involved structured interviews with the CEOs of the 6 firms that have existing alliances. Face to face interviews based on how much trust they could place on their partners were held with each CEO in their offices for 45 minutes. The questions were based on the three way categorization of trust developed by Sako (1992). The characteristics of these alliances are shown in Table 3. Note that the firms are coded for reasons of anonymity, which was their precondition for participating in the study.

Table 3: Construction alliances operating in Botswana between 1980 and 2005

Alliance	Origins of the Firms	Year of Registration in Botswana	Projects Executed	Approximate Value (Mil. Pula*)	Status of the Alliance
A	a_1 - Kuwait a_2 - South Africa	1978 1971	5	598	Sustained
B	b_1 - Botswana b_2 - South Africa	1970 1980	8	477	Sustained
C	X-Botswana Y-Botswana	1984 1994	2	31.2	Recently formed

*I Pula = 0.21 US$ (September, 2004)

The following are the interview questions, summary of responses and discussions

What type of governance structures are employed in your alliance?

The responses to this question determined that the two sustained alliances, i.e., A and B have employed different types of governance structures at different times. At the inception of the alliances it was felt necessary that all the contractual clauses should be clarified and written down. However, after successfully carrying out more than two projects, the partners got to know each other better and hence the need for strict contractual procedures was found unnecessary. The use of contractual clauses indicates that the partners were maintaining contractual trust at the inception of the alliances and as soon as they found out that the other party would carry out its contractual agreements, the trust level started to shift. The partners in alliance C had known and worked with each other prior to the formation of the alliance and they responded by saying that they did not need any contractual clauses to work together. However, during the formation of alliance C a contract of operational procedures was signed by the two partners.

Do you always follow the advice given by your partner?

This question intended to establish whether the partners in the alliance trusted that the counterpart was capable of doing what it says it will do. Although there was a unanimous response that the advice was always followed, the respondents indicated that at the formation of the alliances each partner was cautious about such advice. It was only after working together on a number of projects and observing that the other party was conducting itself professionally, and was conversant with the relevant technical and managerial standards that the partners were convinced that the other party was capable of delivering what it promised. Once this stage was reached, each party in the alliance allowed the other to make decisions without prior consultations. The responses are consistent with observations by Sako (1992) that competence trust requires a shared understanding of professional conduct and relevant standards

Have you ever made investments into the alliance that are not stipulated in the agreement?

This question intended to establish whether the partners in the alliances trust each other enough to make unilateral investments without fear of loss due to opportunistic action of the conterpart. All respondents indicated that they have made unilateral investments in favour of the alliances, which were not stipulated in the agreements. For instance, the CEO of firm b_2 indicated that he let his land on the outskirts of Gaborone to be used as plant and material storage yard instead of hiring the same from the market. He also paid to join a consortium that developed a quarry pit with associated crusher plant so that the alliance could get easy access to fine and course aggregates.

Given the chance, do you think you partner may take an unfair advantage on your business?

This question intended to determine whether the partners had any suspicions that the other party might act opportunistically. The notion of trust implies that the partner has freedom of choice to take alternative courses of action. Thus, predictability in behaviour arises not because of constraints which force the other side to stick to a single possible course of action. All respondents indicated that they do not think that the other party would act opportunistically given the opportunity. The CEOs of firms in alliance A (i.e., $a_1$and a_2), for instance, indicated situations that the other party could have taken advantage, but did not. As it was observed earlier, gaining a reputation as a trustworthy partner occurs, over time, and once it is gained the firm would not like to lose it through opportunistic activities.

Looking at the framework for establishing and maintaining trust in construction alliances, how far does the process apply to your alliance?

The respondents were shown the framework for building and maintaining trust in construction alliances (Figure 1) and taken through the three stages. The respondents indicated that they were in agreement with the three stages and that their alliances went through them. However, they indicated that the trustworthiness of the partner plays a role in all three states.

Stage	Activity/ Action	Important activities	Expected outcome
1	Formation of alliance	Information about the market and the various alternatives for cooperation Specifically: 1. Seek a partner(s) with complimentary capability and where possible same culture 2. Set clear mutual goals and objectives 3. Appoint staff with interpersonal skills 4. Define roles and responsibilities 5. Establish communication procedures	Choice of alliance as the best method for cooperation
2	Operations	Provide adequate manpower, equipment, and finance Specifically: 1. Enlist the support of top management 2. Agree on operation procedures 3. Adopt progress evaluation system 4. Adopt joint problem solving philosophy 5. Adhere to mutual goals and objectives 6. Adhere to roles and responsibilities	Establishment of a separate governance structure for the alliance
3	Growth	1. Provide more comprehensive information	More resources

		about the partners 2. Seek information about market demands jointly 3. Carry out joint strategic planning 4. Identify and analyze feedback on operations 5. Identify specific learning requirements for the alliance team	dedicated to the alliance for growth and efficient operation

Figure 1: A framework for building and maintaining trust in construction alliances (Ngowi, 2005)

In the formation stage (stage 1), for instance, the respondents in alliances A and B indicated that they carefully studied signals of trustworthiness on their potential partners before they decided to form alliances with each other. They indicated that they carefully checked the reputation, compliance with taxation regime and construction related investments of the potential partner. As partners in alliance C had known each other for a long time, they were aware of each other's trustworthiness.

At the operation stage (stage 2) all respondents indicated that they judged trustworthiness of their partners through their openness to outside auditing of their activities. Firm a_1, for instance, indicated that it asked the partner a_2 to provide an auditor for their operations, while it provides an accountant to ensure that their operations were always above board. This may appear contradictory to the spirit of trust, but willingness to be open to outside auditing was said to reinforce trustworthiness.

At the growth stage (stage 3) all respondents indicated that they judged the trustworthiness of their partners through the unilateral transaction-specific investments they made in the partnership beyond what was prescribed in their agreements.

4. CONCLUSIONS

Strategic alliances can be formed by firms that are not in direct competition with one another or by firms that are engaged in similar activities, hence in direct competition. This study intended to determine the factors that firms use in selecting partners when forming alliances, and the influence of trustworthiness of alliance partners in deciding governance structures of the alliances.

Literature review established that various forms of strategic alliances exist in a spectrum ranging from joint ventures to partnering. As there exists uncertainties regarding unknown future events on the one hand and regarding partner's response to those events on the other hand, trust has emerged as a central organizing principle in alliances.

This study established that in Botswana potential alliance partners consider complementarity, similar status, indirect prior alliance experience and reputation when selecting a counterpart. Within the limitations of the available data, the study established that alliance partners start with contractual trust, which develops to goodwill trust based on the number of projects executed by the alliance. The study also determined that partners' trustworthiness influence the conduct of the partners in all stages of alliance development.

The study verified that the three stages of the framework for building and maintaining trust in construction alliances (Ngowi, 2005) are valid for the existing alliances, and they could be a valuable lesson for the firms that are in the process of forming alliances.

As this study was based on only three known alliances and 22 firms that are in the process of forming alliances, it is recommended to monitor the development of the alliances that are currently at the formation stage with the aim of passing on to them the experiences learned by the three existing alliances. It is also recommended to extend the study to a wider market, such as SADC to determine whether there are findings that can improve the alliances based in Botswana and vice-versa.

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COMMUNICATION PRACTICES WITHIN THE UK CONSTRUCTION INDUSTRY

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ABSTRACT

Converged networks, that use voice, video and data all combined have promised cost savings for its users. Much of the construction industry spends over £1 million on communication, mainly from the construction site to the head quarters. With the use of IP telephony and converged networks, the cost can be reduced significantly. Using existing 802.11b/g wireless networks, access to the voice network can be delivered on a construction site allowing mobile users access to personnel as well as data instantly.

The construction industry stores all types of communications in order to review projects; however voice communication, which is often where most decisions take place is not recorded and used. The ability to augment applications such as call logging and recording applications onto the converged network to track all calls opens the possibility of introducing voice communication within the realm of project data.

This paper looks at the application of IP telephony within a construction site, and identifies some areas where converged networks would provide key benefits, taking into account the requirements of the UK industry.

Keywords: Collaboration, Communication, Construction, ICT, VoIP

1. INTRODUCTION

Convergence or the unified network is the combination of voice, data and video networks into one uniform infrastructure, namely the data network. All traffic can then flow over this one network using the common IP protocol.

The introduction of convergence has bought significant advantages to different industries, the most highlighted of which is cost savings. The reduction on communication costs come about due to the voice traffic travelling over private networks and using the internet to connect remote locations. The voice traffic bypasses the traditional PSTN (Public Switched Telephone Network) therefore incurring no call charge. This and other advantages can be transported to the construction sector which has a need for constant communication between construction sites and company headquarters. Other advantages include the utilisation of voice data along with other types of data, the ability to have voice operated applications and the ability to deliver a rich interactive collaborative experience with the use of all three (data, voice and video) in one interface.

This paper will present research carried out with the UK construction industry to evaluate the communications preferences, the use of new technologies, in particular the wireless network and project resource storage. The three areas are interlinked with opportunities presented by converged networks.

The paper will then examine various scenarios where converged networks and applications could provide potential benefits to the industry, with a brief look at the view the UK construction industry has of the new technology.

2. CONVERGED NETWORKS

Converged networks are the combination of voice, data and video networks into one uniform infrastructure. The benefit of convergence is the ability to interweave the different communication mediums to give rich interactive, enhanced user experiences.

The key driver behind the move to convergence is the digitalisation of the various communication methods, and the utilisation of IP as a transport protocol for all. This therefore means there is no longer a need for three separate networks to pass data, voice and video, they can all be run on the same infrastructure and be carried across the world using the internet.

The key advantage convergence brings is the reduction in cost associated with creating and managing three separate networks, as the number of networks has physically reduced to one. Advantages of converged solutions identified by Siemens include (Siemens, 2005):

- Presence-based communication improves reach ability
- Easy organisation of virtual team meetings
- Seamless integration of mobile workers
- Unified communications across all channels
- One number service for easy call forwarding
- Comprehensive consulting services for process optimisation

Voice communication was the first communication medium to move over to the data network in the form of Voice over Internet Protocol (VoIP). Figure 1 is a typical VoIP deployment model where three sites are connected. The basic setup for the one site includes an IP-PBX, a network and client devices. The client devices can be either hardware phones or software based 'soft-phones'. When connecting different sites together over the internet or a private WAN, the need for routers capable of delivering quality of service (QoS) is important to deliver a reliable call service. QoS ensures that data such as voice and video is given higher priority over standard data where delays can be tolerated.

The deployment of VoIP (convergence) technology into the construction industry would be very similar to the typical deployment shown in figure 1. The remote sites in this case would be the construction sites themselves, with the deployment on the sites remaining for the duration of the project. The requirement would therefore be a setup which can easily be torn down and then rebuilt on different locations.

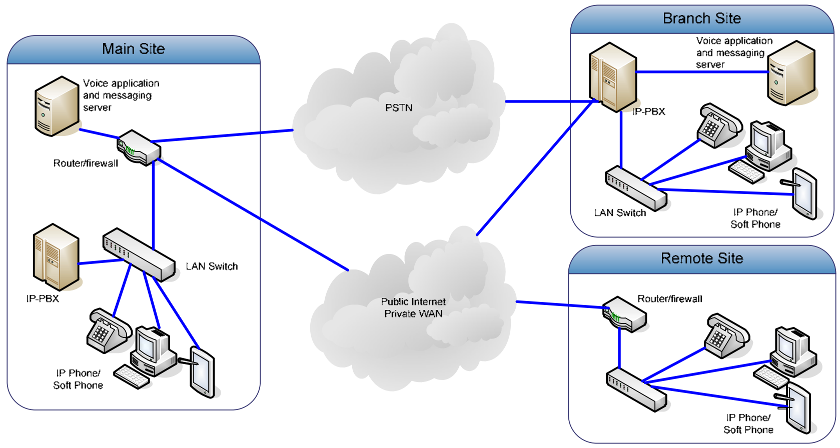

Figure 1 VoIP in the Enterprise (Thus, 2006)

In a typical installation, the site office would contain the bulk of network equipment running the converged network. Wireless access points would be the method to extend the range of the network over to the rest of the site. There exists several methods of deploying a wireless network, among the research undertaken with construction site, the majority have deployed networks using a cellular approach (De La Garza et al., 1998). This approach may have problems with establishing a voice network, as the time taken to authenticate users form one access point to another may result in loss of connection. Manufacturers have identified this problem with several different methods being introduced including wireless mesh networking and pre-authentication on access points.

The construction site has particular requirements, namely the ability for the technology (infrastructure through to client devices) to withstand the rough environment. Ruggedised equipment has become available to cater for outdoor deployment. Researchers investigating the use of wireless equipment on site managed to use standard equipment in ruggedised containers to protect them (Ward et al., 2004). Other issues with establishing the technology on the construction site include the delivery of power in remote areas. This has been resolved in one case by connecting the devices to power available on large equipment such as rigs (Ward et al., 2004).

In Australia, the converged network was used to establish telecommunication capabilities to connect remote sites together for Abigroup Limited (Optus, 2005). The setup allowed for communication between two permanent constructions sites whilst building a railway line. The setup also provided portable communications facilities that could be torn down at short notice within camps along the construction route as it progressed. This capability is available due to the flexibility provided by IP networks, with the added advantage that the same communications network is use to provide access to data and information.

3. UK INDUSTRY PERCEPTIONS AND HABITS

The research on construction communication practices was carried out with the UK construction industry with the use of surveys and interviews. The surveys targeted construction companies within the midlands with a 20% response rate. The survey was an online survey, and emails were sent to 90 individuals across the UK. A total of five follow up interviews were undertaken with managers of major UK construction companies including Marriott Construction, SOL Construction and Scott Wilson. The survey was used to understand the current practices, preferences, and technology used on-site. The surveys and interviews also explored the storage of communication from a project that would be used for later analysis.

Table 1 lists the results of communication preferences. The respondents were asked which form of communication they preferred to be contacted on and which they preferred to contact others on from a scale of 1 to 6, with 6 being the least preferred and 1 being the most preferred. The research identified the telephone as the most preferred method of contacting other members using some sort of technology. Earlier surveys (Ahsan, et al., 2004) identified face to face communication as the ideal form of communication as it allowed for communication on more than one level.

Rank	Outgoing Communication	Incoming Communication
1	Telephone (50%)	Mobile Phone –Call (37%)
2	Mobile Phone –Call (42%)	Telephone (44%)
3	Email (59%)	Email (36%)
4	Mobile Phone –SMS (57%)	Mobile Phone –SMS (67%)
5	Instant Messenger (75%)	Instant Messenger (73%)
6	Walkie Talkie/Radio (67%)	Walkie Talkie/Radio (65%)

Table 1 Communication Preference in Construction

It is worth noting that in the interviews carried out after the surveys, it was expressed that the method of communication depended on the situation and where the individual was located. For example, on the construction site if it was a simple case of getting hold of someone known to be onsite, the radio was the device used, whereas the mobile phone would be used.

The mobile phone appearing in second place for outgoing and first place for incoming communication shows the increased importance in mobility, and the reliance on the mobile phone. This corroborates previous research by Howard and Peterson in 2004 which was carried out in Denmark highlighting the similarities between the UK and international construction environments.

Using dual-mode phones, capable of handling both wireless and GSM, the ability to have the best of both worlds is achieved. If a wireless network is present, then the device would switch to the soft-phone enabling the device to route calls over the private network, and if the wireless network connection is not available, then the GSM network is used.

The reliance on voice communication through these technologies falls in line with the amount spent on communication. The research showed that a majority of the industry spent over £500 thousand a year on communication, with most spending millions of pounds. This was however spent on communications for a number of projects.

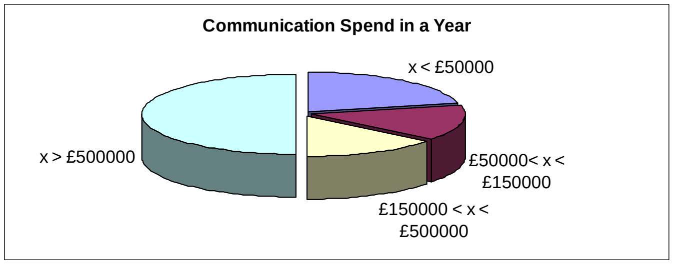

Figure 2 Pie Chart showing the cost of communications in construction companies for 2005

The research investigated the use of technology, in particular the use of wireless networks, and whether these were found to be of use, and where in the construction life cycle the technology was required. It was shown that 56% of respondents had a wireless network setup for employees, whereas 50% of these had the use of wireless networks on the construction site itself. The industry, however, responded with 92% wanting a wireless network on the construction site showing the increased awareness of the technology and the benefits it can bring.

Many different wireless technologies have been tested on construction sites including different infrastructures and communication devices (Bowden, 2002, Meissner et al., 2001, Beyh et al., 2004 and de la Garza et al., 1998). The COSMOS and MICC projects tested various technologies on the construction site including DECT, GSM (Global System for Mobile communications), WLAN (Wireless LAN), and TETRA (Terrestrial Trunked Radio). The MICC project identified the DECT technology to be suitable for the construction sector due to its reliability (Deguine et al., 1999). However the DECT system has problems with standards and cannot match the bandwidth of other technologies such as the wireless LAN, therefore running both data and voice intensive applications would prove difficult.

When identifying the various communication methods available, researchers have identified certain characteristics which should be looked into (Beyh et al., 2004):

- Benefits in terms of the nature of information that need to be transmitted including voice, data, video, web collaboration, etc.
- Access to all members forming the project teams including site workers, gangers, and foremen
- Reliability, availability and quality of service
- Cost of service including network administration, maintenance and upgrade
- Availability of terminals and users' devices such as mobile handsets.

Many of these technologies have been reviewed with an emphasis on data communications (Bowden, 2002, Meissner et al., 2001, de la Garza et al., 1998, Cus-Babic et al., 2003). Data communications that would occur on the construction site usually require less bandwidth than voice communications and are less demanding on network resources. The wireless LAN proves to be of relative simplicity and provides the correct infrastructure for carrying voice and even video. The impact of such a system is highlighted as it could allow access to information and contact with remote experts from a construction site (Miah et al., 1998).

Examining the number of devices that are used by personnel, the results showed that 56% of respondents carried more than one device with them when on the move. When questioned about the usage of these devices, the majority of respondents listed the reason to be for email access. Three different types of devices were identified, the PDA, blackberry and laptop as devices taken on site. The necessity to carry two devices, one to allow voice communication and the other to allow access to emails is removed with the use of a converged network as the single device can be used for both. Access to address books and calendars can also be achieved on-site where the site network has a link to the central HQ.

The research examined the storage of communication produced during a project. It was shown that the current practice was to store all printed documentation and email correspondence. The result of email appearing as the second most collected form of communication in this study lends more credibility to the fact that email has become increasingly important for communication within construction. Email lends itself particularly well to storage as all emails regarding a project can be extracted and saved.

Voice communication featured on a very small scale in the conducted study. However upon further investigation it was clear that the reason for this was due to the complexity of recording such a medium. The desire to record such communication was expressed, but the difficulty lies in the way voice communication is currently carried out – over varying networks such as the PSTN (Public Switched Telephone Network), or GSM. Although the complexity is currently withholding this requirement, the introduction and use of a converged network can allow it to become reality. Call logging and recording applications can easily be augmented onto the network as all voice would pass through a central area. The logging application would be able to log who was involved in a conversation with the recording application storing the conversation itself.

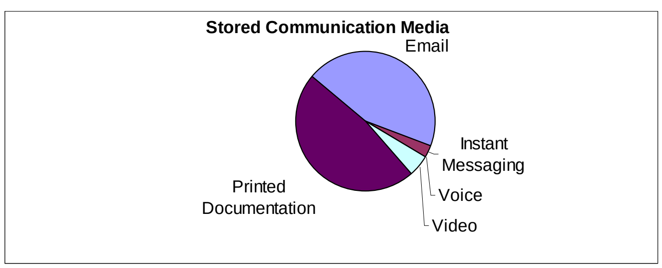

Figure 3 Stored Communication Media within UK Construction firms

The research investigated the industry's perspective on VoIP technology, having discovered that 67% understood the term VoIP. This was mainly through home use with the use of software such as Skype which offers users PC to PC calls for free.

VoIP was understood by many respondents as a means to save on communication costs, with the vast majority of respondents indicating the success of VoIP within construction lied in its support of communications between various offices. It is interesting to note that the ability to keep an audit trail, and the ability to use features such as click to call were identified by some respondents indicating an understanding of the capabilities of a converged network, and the benefits it can bring.

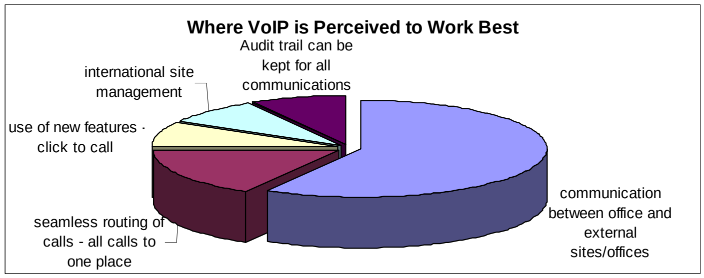

Figure 4 Where VoIP is Perceived to Work Best

The construction industry still remains cautious about the technology as it is still very new within most industry sectors. Surveying the perceived problems, setup costs, reliability and voice quality were identified as the largest issues. Issues of cost are valid, as the implementation of a converged network running voice, data and video would require investment, however it is estimated that the payback would take 2.06 yrs (BT, 2006). An Italian study of the costs of a VoIP setup found the cost significantly cheaper than that of a traditional phone setup in all aspects of cabling, deployment, training, management, maintenance, telephone traffic and interconnection apart from data/voice devices, i.e. the cost of IP phones (Corte et al., 2006). The reliability of the converged network and the quality of voice calls are issues across all sectors where the technology is deployed. Most modern network hardware is capable of handling the increased bandwidth usage brought about with data, voice and video all running on the same network as most implement QoS protocols.

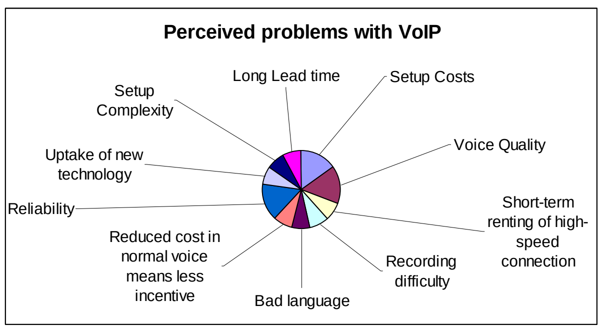

Figure 5 Problems with VoIP as Perceived by the UK Construction Industry

It is interesting to note that problems such as internet connection were raised. Issues of internet connectivity from the construction site are of particular importance, as without a connection the VoIP setup would only be able to provide on-site communications. There are several ways to gain internet connectivity over and above the standard use of a telephone line, which include satellite connections. The advent of WiMAX would also add another method of internet access from the construction site. WiMAX presents some interesting opportunities for construction, namely the ability to deploy a network connected to the corporate network where no communications infrastructure exits. WiMAX 802.16-2004 is a further advancement on the current 802.11 wi-fi standard offering fixed broadband wireless access (IEEE). The technology will be a significant enhancement allowing for broadband speeds of 15Mbps for a 5MHz channel to 35Mbps for a 10MHz channel, and ranges of kilometres (WiMAX Forum, 2005). The 802.16e standard will enhance the current 802.16-2004 standard to allow for roaming instead of fixed devices which will broaden the mobile internet market much further. Advantages of the new WiMAX standard including speed, distance and QoS provide fertile ground for further enhancing the convergence space. Some observers believe WiMAX poses a genuine threat to 3G networks, although the two technologies are as much complementary as they are competitive (Ankeny, 2005).

4. CONVERGENCE SCENARIOS

Several scenarios will be described in this section where the implementation of a converged network can support construction. The majority of improvements lie in benefits gained with immediate access to personnel and information, and the ability to augment different applications together to provide a seamless interface between voice and data.

The issue of keeping immediate contact with information and personnel is not specific to construction only. In a survey of various businesses (Siemens, 2005), it was found that:

- 67% of mobile workers have to leave messages in several different places to actually reach the intended recipient
- 65% often defer important decisions because their co-workers are unable to respond to their inquiries fast enough
- 59% are often not able to reach co-workers when they need to speak with them directly on urgent matters

Different information needs have been identified on the construction site. Research has identified the typical information tasks taking place (De La Garza et al., 1998). Out of the tasks identified, the following were highlighted to have voice as the most important format for information transfer:

- Design and intent clarification
- Contract specification
- Work package information
- Means and methods questions
- Implementation problems

The following will identify different advantages gained by convergence, and it is assumed that the deployed network has been planned and is supported to ensure minimum disruption of any network problems.

Monitoring the design and construction process

The role of a project manager with regards to this process is as follows (CIB, 1996):

"Monitor design and construction process to see that:

- Adequate and timely information is available to contractor(s) and that their reasonable requests are met
- Production information is available in accordance with programme requirements and that approval of contractors' drawings/specifications is given within the time limits
- Costs are contained within the cost plan/budget
- The overall development objective and detailed programmes are achieved (e.g. meeting progress, specification and quality targets)

- Works supervision and inspection are carried out by parties concerned in accordance with the conditions of their contracts/agreements"

The role of a project manager to provide adequate and timely information to the contractor can be effectively supported with the use of a network established on the construction site. The use of a converged network can help further as contact information can be retrieved from a central location ensuring that required personnel are easy to find. Many vendors involved in deploying VoIP products have produced systems that reduce the amount of time it takes to contact people. These systems are called presence servers and are used to identify when a member is contactable and which mode of communication would be best to approach them. This way the chances of contacting the relevant person are increased.

The scenario here would require the project manager to carry a PDA, or tablet PC with a soft-phone. Using the device and the wireless network infrastructure connected to the head office via the internet, access to the central store to retrieve data would be carried out as and when information would be needed. Giving all key members of the project team access to devices which allow for voice and data access would provide enhanced collaboration as voice and data information can be transferred simultaneously.

In monitoring the design and construction process, each aspect of the role can be supported with a well designed and supported converged network. Ensuring adequate and timely information is an aspect which is easily supported as access to the central network and project repositories would be possible. Access to emails from the construction site and the ability to find the relevant people would help reduce the time taken to retrieve the desired information. Access to project extranets from the construction site will also help.

Ensuring availability of production information is of crucial importance. Without access on site, this process is disjointed with information being access from the central office or site office via fax. As identified in previous research, this aspect relies heavily on voice to ensure correct instructions and information is delivered (De La Garza et al., 1998). The push towards electronic documentation and adoption of standards is of significant importance to allow documents to be exchanged freely. With the ability to use the one device to send documents whilst in a voice conversation, the ability to establish a conference call with key individuals on site and in various locations to make sure the correct information is passed and any queries dealt with, all achieved with convergence, can lead to fewer mistakes made in the design stage.

To manage costs, it is important that all costs are duly noted. It is essential that the information be stored in a central location (project database, project extranet), to ensure accessibility to those who require access. Incorrect decisions can be made when information is not up-to-date, therefore access to allow the updating of project information is paramount. Access from the construction site therefore would help speed up decisions.

In the event of work supervision, the ability to log issues onsite is a very big step forward. This will result in issues being logged instantly. The ability to have voice logs is provided with converged networks. Time taken producing a progress log can therefore be reduced as the requirement would no longer need for a document to be produced, but a comment from the supervisor recorded onto a central store. This comment/voice log can be stored and linked to the project as an audio file, or even be transcribed by an automated system for easy retrieval.

Changes in the Client brief

Construction projects require ongoing changes to solve problems that were unforeseen during the design, to accommodate changes from the client. In order for these changes to be executed, they require communication amongst the relevant personnel as well as written confirmation of the change. Figure 6 shows the overall processes involved in the change request issued by a client. The change request process requires a great deal of communication as well as referencing and updating of project data. This process can become lengthy and impact on the project heavily if the changes are excessive. Applying a unified network can help reduce the time to decision by enabling faster access to important data and personnel.

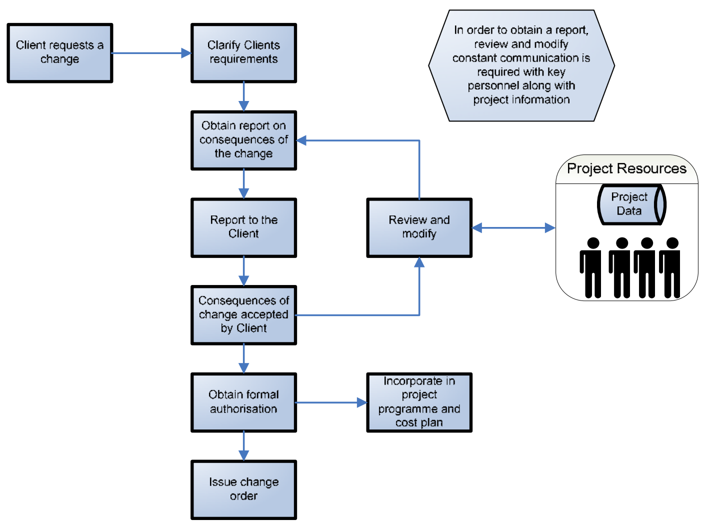

Figure 6 Changes in the client's brief (CIB, 1996)

The process of obtaining a report on the consequences involves access to a number of project members including the project manager, consultant, quantity surveyor and client. Access to project information is essential to make a correct and informed decision, but it is also necessary for the information to be distributed to all necessary individuals in the decision making group. Access to this information onsite can effectively be managed using a network connected to the main head quarters to create what is termed a virtual private network. The virtual private network allows a connection between two separate networks via the internet allowing them to combine as one, with encryption for security. Access to personnel utilising voice over the IP network can allow immediate cost savings for the company. Essentially the process of gathering information can be sped up as there would be less time retrieving relevant information.

Although changes can be requested from the client, there are many changes that are necessary due to other issues that are discovered during construction. When problems occur with the construction varying from initial designs, it is important for the appropriate personnel to be contacted, such as the architect, and decisions made. Since much of this takes place over the phone, when it comes to the project review stage, or there is a dispute regarding the decision, it is important that the change is documented. The process of documenting the change can often be missed due to time constraints, therefore leading to no documentation surrounding the change. The necessity for the conversation to be stored is highlighted by this scenario. The use of converged networks would allow for calls between users to be logged and stored. The saved voice call can either remain as an audio file and be logged along with the rest of the project data, or it can be processed through a speech to text programme which can transcribe the conversation. This transcribed version can therefore be stored along with the rest of the project communication that already exists. The availability of such a file would help in dispute resolution as complete transcripts of conversations and decision taken would be available for inspection.

5. CONCLUSION

The industry as a whole is spending large amounts of money on communication alone. Much of this money is taken up by communication from the construction site to the main office. Wireless networks are being introduced on the construction sites and offices of construction companies. The availability of a network covering a construction site allows for instant access to data around the site. Converging networks running voice over the same network allows and improves access to personnel as well as data from a site with ease.

The research identified which methods of communication were stored for project review, with voice appearing very low. The complexity of being able to store voice calls would be near impossible due to the voice traffic running on separate networks, but the merging of the two networks into one allows for call logging and recording applications to be easily augmented. The converged network can allow for different applications to be augmented allowing for increased functionality, including voice access to commonly used applications.

The ability to run all communications, data, voice and video through a central network has a number of benefits, the most obvious being of costs and cost control. The ability of instant access to data and personnel can bring increased productivity on site allowing for issues to be resolved quickly ensuring time is not wasted and problems addressed sooner rather than later. Access to call logs can provide detailed information on communication occurring during every stage of a project giving valuable data for the industry to use.

Other industries have benefited from the cost savings the converged network can bring, but also the flexibility to expand the voice and data network easily, the ability to connect different sites together and share resources, the ability to interconnect various applications like SAP to enhance decision making. Of implementations already in place within construction, it seems that the cost saving issue is of paramount importance, however greater benefits can be found with the sharing of resources among various sites giving rise to greater information being available at the time of decision making, thus leading to fewer mistakes being made.

The research has uncovered the benefits of this technology and has shown that it is possible to deploy a setup with the hardware and software currently available. The use of this technology can bring about significant cost savings in the long-run, but the ability to augment different application together to make them accessible to personnel from any location, be it the head office or any of their construction sites, will bring about the greatest benefits.

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SUPPLY CHAIN SUSTAINABILITY – THE ROLE OF TRUST AND RELATIONSHIP

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ABSTRACT

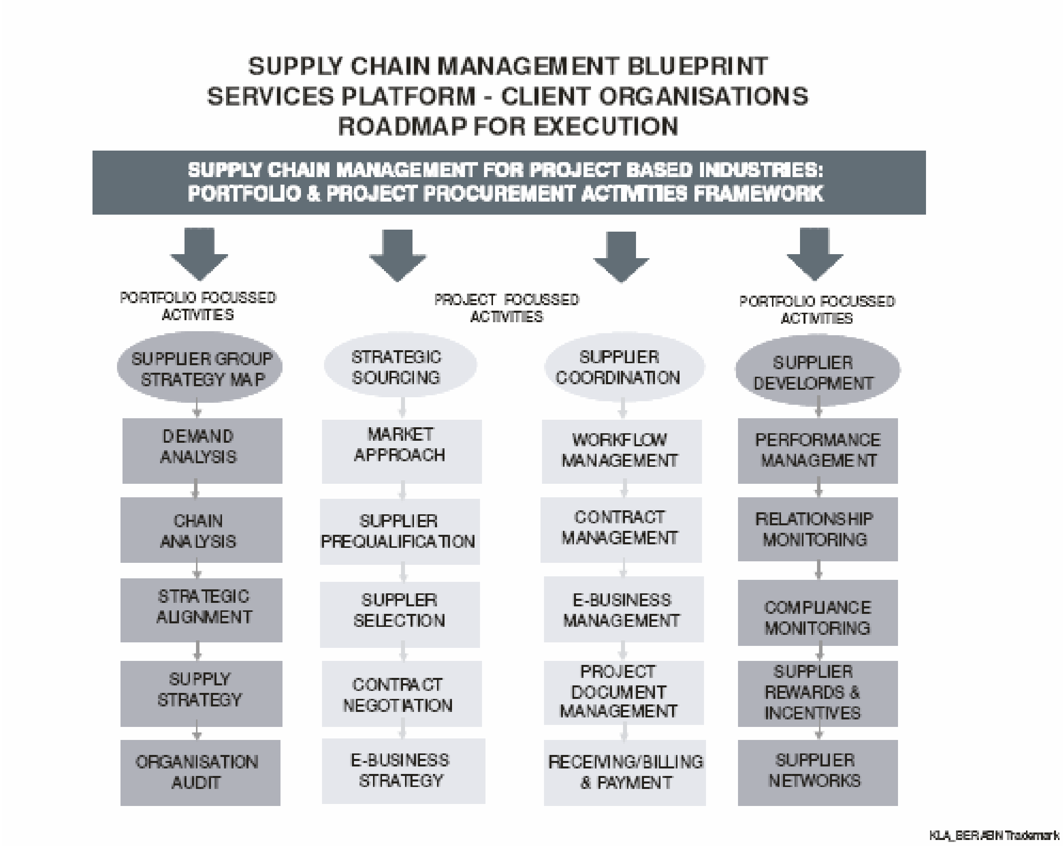
This action research project aims to improve economic, social and environmental sustainability of the pre-cast concrete and construction and demolition waste supply chains through the development, trial and evaluation of an innovative supply chain management strategy. The long-term goals are to improve competitive behaviour and market sector performance and improve business process efficiency and effectiveness of public sector program delivery by influencing policy development, changing organisational behaviour and implementation development to achieve economic, social and environmentally sustainable markets. In order to facilitate this, the culture change brought about by implementing relationship management in the supply chain is investigated and this paper reports on this aspect of the project.

Keywords Australia; Culture; Relationship Management; Supply chain; Sustainability; Trust.

1. INTRODUCTION

Public sector clients have the opportunity to create improvements and develop economic, social and environmental sustainability in various market sectors which support their asset portfolio, organisational and whole of government industry development objectives; through supply chain management. There are numerous activities that asset owners can and do undertake to achieve strategic alignment of their objectives to selected supply chain management strategies as illustrated in Figure 1 below.

Figure 1 Supply Chain Management – Portfolio and Project Procurement Activities Framework (adopted from Project 2004-016-A Project Agreement, pp. 4)



This research project aims to improve economic, social and environmental sustainability of the pre-cast concrete and construction and demolition waste supply chains. This research project seeks to address government's strategic objective of increased recycled materials content of construction projects through the expansion of the construction and demolition waste sector through market diversification. The strategies for economic sustainability of the pre-cast concrete sector have been altered, through a state-wide smoothing of a government agency's market investment strategy with the long-term benefits of stabilisation of employment levels, reduction in high staff turnover and flow on improvements in skill levels and occupational heath and safety. Short-term benefits include improved product quality and reduction in remedial work as well as reducing waste of government resources in monitoring a poor performing sector.

2. RESEARCH BACKGROUND

Supply chain management has long been considered an important strategy for public sector governance, however it has proven difficult for all governments globally to implement (see Burnes and Coram 1999, for example). Research shows that relationship management brings about more harmonious working relationships (Cheung et al. 2006). Other than at the operation level, relationship management at a state level has the potential to deliver government priorities such as regional and industry development, empowerment, work life balance and a sustainable industry (Cheung et al. 2006). Relationship management is a sustainable approach to the industry in terms of people, environment and economics and can provide a positive contribution to sustainability and help to satisfy client and stakeholder interests (Blau 1963; Darwin 1994; Darwin et al. 2000; MacNeil 1978; MacNeil 1985; Rousseau and Parks 1993). It provides the means to achieve sustainable, ongoing relationships in long and complex contracts by an adjustment process of a more thoroughly transaction specific, ongoing, administrative kind (Kumaraswamy and Matthews 2000). Clients and contractors can potentially make savings in their operations under a relationship management regime through sharing and exchanging technical and managerial knowledge of the project.

Rowlinson and Cheung (2002)give a working definition of relationship contracting:

"Relationship contracting is based on a recognition of and striving for mutual benefits and win-win scenarios through more cooperative relationships between the parties. Relationship contracting embraces and underpins various approaches, such as partnering, alliancing, joint venturing, and other collaborative working arrangements and better risk sharing mechanisms. Relationship contracts are usually long-term, develop and change over time, and involve substantial relations between the parties and development of trust."

The implicit link between organisational culture and organisational performance has long been recognised in both mainstream management literature (Handy 1985; Hofstede 1980) as well as in the construction management literature (Liu and Fellows 2001; Rowlinson 2001). Within the construction research domain, the impact of culture and organisation on project performance is becoming an increasingly important topic for the development of sustainable practices in the built environment A number of characteristics have been identified in recent studies e.g. Rowlinson (2001), Winch *et al*. (2000; 1997). These studies addressed innovation and change in the context of the working relations in project organisations. A number of main parameters identified as being significant in shaping how an organisation performed and the spirit within the organisation are:

- Organisational culture and structure – organisational culture and structure must be matched if participants are to retain commitment to the organisation (Rowlinson and Root 1996);
- Commitment – commitment to the goals and objectives of the organisation is crucial in implementing new approaches to contract strategy (Cheung and Rowlinson 2005);
- Individual motivation, work process and organisation structure – autonomy at work, work coordination and work control along with job satisfaction, motivation and feedback instrumental in ensuring effective cooperation and collaboration (Winch et al. 1997); and
- Individual Culture and Value - shared values between members in an organisation play a crucial part in linking people together (Wood et al. 2001).

3. METHODOLOGY

Action research method is adopted in this project. The aim of this research project is to develop, exam and evaluate an innovative supply chain management strategy in two public organisations in Queensland, to bring about changing organisational behaviour, influencing policy development and implementation. In order to facilitate this, the change of culture by implementing relationship management in the supply chain sector was investigated and initial findings are presented in this paper.

Relationship management in the supply chain sector was examined using questionnaires, interviews and assessment of project/organisation documentations. The four variables mentioned in the section above already has well developed measurement instruments that have been adapted to the Queensland supply chain industry to study the collaboration process between the client and supply chain groups. This part of the research is broken down into two distinct phases:

- Investigation of the impact of the various cultural variables on project performance (questionnaire and follow up interviews); and
- Analysis of the variables influencing the success of relationship management in the supply chain (interviews and case studies).

Both qualitative and quantitative approaches have different strengths and logics, and are best used to address different questions and purposes (Maxwell 1996). The qualitative approach derives primarily from its inductive approach and its emphasis on words rather than numbers. It focuses on specific situations or people. By involving inductive, theory-generating, subjective and non-positivist processes (Lee 1999), the qualitative approach seeks to gain insights and to understand people's perceptions of 'the world', as individuals and as groups (Fellows and Liu 1997). Qualitative methods allow selected issues to be studied in depth and detail. Approaching fieldwork without being constrained by predetermined categories of analysis contributes to the depth, openness and detail of qualitative inquiry (Patton 1990). On the other hand, the quantitative approach tends to relate to positivism and to gather factual data, then studying the relationships between facts and how such facts and relationships accord with theories and any previous research findings (Fellows and Liu 1997). Hence, the research methodology adopted for investigating relationship management in the supply chain is a triangulated approach.

By using independently collected data, it is possible to verify the thinking of key individuals in the public sector agencies as to the strengths and weaknesses of the systems currently in place. The basic concepts and variables relating to cooperation, collaboration, organisational issues and performance are investigated through the interview process with the organisations. The existing system is re-engineered to take account of the study findings. Data collection will be conducted through a questionnaire survey and in-depth interviews, with assessments of project/organisation documentation. The questionnaire survey combines four well-developed instruments which measure variables on organisational culture and structure (assessed using Handy's instrument), commitment (assessed using Allen & Meyer's instrument), work process (assessed using Van de Ven and Ferry's instrument) and individual value (assessed using Schwarz's instrument).

By way of example, these are the sorts of issues that can be formulated into hypotheses for the research: organisational culture and organisation structure must be matched if participants are to retain commitment to the organisation (Cheung 2006; Rowlinson 2001). In recent research conducted by Cheung (2006), the degree of match and mismatch between organisation culture and structure is found to have an impact on staff's commitment levels. Findings also point out that mismatches exist between actual and perceived organisational culture and structure in the public sector organisations. The reasons for these mismatches appear to be different cultures between parent organisation and intra-organisation (project).

4. RESULTS TO DATE

Recent research findings suggest relationship management suits the Australian culture very well (Rowlinson and Cheung 2004). So, how does this translate into the supply chain, where relationship management is vitally important for the success of all parties? It has been shown by Cheung (2006) that Australian professionals prefer physical interactions and direct confrontation while dealing with matters. Getting the right mix of people in the team has been identified as one of the most crucial elements for the success or failure of relationships and the supply chain. In order to maintain harmony and an effective working atmosphere, senior management and/or parent organisation must be prepared to identify unsuitable member(s) in the team and take appropriate measures to assist them to fit in.

5. STRUCTURE

Through a structured context, relationship management, when applied to the supply chain, increases both formal and informal communications amongst participants. Higher frequency of communication does not necessarily lead to better relationships or more collaborative problem solving behaviour. Instead, good working relationships and collaborative behaviour are found where respect and acknowledgments are expressed amongst supply chain members. The organisational cross-sectional nature of the participants taking part in meetings in the supply chain appears to have a positive impact on the quality of communication and information flow, and is a stimulus to timely and appropriate action.

6. ORGANISATIONAL CULTURE, STRUCTURE AND COMMITMENT

This research suggests the degree of match and mismatch between organisation culture and structure has an impact on staff's commitment levels. This study corroborates previous work (Cheung 2006) in that the fundamental element for successful implementation of changes is strong buy-in from top management. This research indicates buy-in is crucial from all levels for successful implementation. In this case, the relationship management concept needs to filter down to all levels in the supply chain if team members are to retain commitment and buy-in to the relationship.

7. ORGANISATION AND SUPPLY CHAIN CULTURES

This research also corroborates previous research (Cheung 2006) and points out that mismatches between client organisation and supplier organisation cultures (including the temporary, intra-organisation links down the supply chain) must be recognised and accepted by organisation staff. In the research carried out by Cheung (2006), mismatches existed between the organisation culture as perceived by the professionals and the organisational structure – a developmental group mode is seen to be most suitable for the organisation but a systematised impersonal/discretionary personal mode was more closely followed.

Table 1 Hypothesised Patterns of Systematized, Discretionary and Developmental Modes of Structure in Complex Organisations (extracted from Van de Ven and Ferry, 1980, pp. 368-369)

	Systematized Impersonal Mode	**Discretionary Personal Mode**	**Developmental Group Mode**
Difficulty & Variability of Tasks, Problems, Issues Encountered by subsystem –	**Low**	**Medium**	**High**
Salient Dimensions of Managerial Subsystem			
1. Organizational Referent	Central information systems	Hierarchy & staff	Coordination committees
2. Coordination and Control by:	Rules, plans, schedules	Exceptions to hierarchy	Mutual group adjustments
3. Resource & Information Flows among Organizational Levels, Units, & Positions:			
a. Direction	Diffuse	Vertical	Horizontal
b. Amount	High	Medium	Low
c. Standardization & Codification	High	Medium	Low
4. Perceived Interdependence among Components	Low	Medium	High
5. Frequency of conflict among Components	Low	Medium	High

The client organisation obviously influences supply chain culture; commitment to the goals and objectives of an organisation is crucial in facilitating successful implementation of relationship management or organisational changes. However, these goals must be explicitly stated in the both the client policy and the conditions of contract and must be fully understood by all parties in the supply chain. To this end, facilitation workshops can play an important role in achieving these understandings.

8. FACILITATION

Facilitation workshops in the relationship management process provide an ice-breaking platform for project participants and encourage open and honest communication between the client and supply chain organisations. By facilitating from the outset an atmosphere that promotes open communication and willing cooperation, a brainstorming approach to problem solving and a value engineering approach can be brought to bear on project issues and solutions. To maintain and develop non-adversarial attitudes and a collaborative supply chain culture, continuous facilitation workshops should be used to ensure open and continuous communication between the client organisation and the supply chain.

The role of facilitator is crucial in the relationship management process, across the production process, for better supply chain relationships (Dainty et al. 2001).However, the cost of employing an external facilitator is also very high, which subsequently affects the frequency of the facilitator's involvement in the process. Although it is a general perception that the facilitator should be a neutral party to the project but Cheung (2006) argued that either employing a third party as a facilitator or an in-house facilitator are scenarios which can work successfully.

9. TRUST

Trust plays a crucial role in facilitating the implementation of relationship management and organisational changes. Trust is a major component in building a cooperative relationship between partners. It creates an increase in openness between parties. Trust is perceived as a result of effective collaborative relationships and leading to higher levels of partner/customer satisfaction (Mohamed 2003; Zineldin and Jonsson 2000). Moorman, Deshandè and Zaltman (1993) believe that trust is built up over a series of interpersonal encounters, in which the parties establish reciprocal obligations. Yet, Gambetta et al (1998) see trust as a precondition of cooperation because partners need some assurance that the other parties will not defect. Thus, trust is an essential element of employing relationship management approaches in supply chain management.

Trust is said to have a direct effect on work group process and performance, and in Dirks' findings (1999), it is shown that better coordination and greater efficiency are found in a high-trust group and hence better performance. High trust between parties does not only reduce the transaction costs, make possible the sharing of sensitive information, permit joint projects of various kinds, but also provides a basis for expanded moral relations in business (Brenkert 1998).

Construction project teams are unique entities, created through a complex integration of factors, with inter-disciplinary players, varying roles, responsibilities, goals and objectives (Goodman and Chinowsky 1996). Collaboration and teamwork are therefore crucial since sharing up-to-date information between participants which lead to minimisation of errors, reduction of time delays and breaking the widespread rework cycle. Benefits of collaborative, rather than adversarial, working relationships within construction organisations are well documented (Walker and Hampson 2003).

Successful collaborative relationships rely on relational forms of exchange characterised by high levels of trust. However, the construction industry has a stronger preference for distrust rather than the full benefits of cooperation (Wood and McDermott 1999). There is a need for culture change to bring about increased cooperation between parties on a long-term basis. With relationship contracting, based on long-term relationship and trust, a win-win situation can be created for both the client and the supply chain organisations.

Relationship management can provide a positive contribution to sustainability and help to satisfy client and stakeholder interests. It is a sustainable approach to the industry in terms of people, environment and economics. Clients and contractors/suppliers can potentially make savings in their operations under a relationship management regime through sharing and exchanging technical and knowledge of the project. Cheung et al (2005) point out that the development of trusting relationships also encourages a more proactive working manner – more harmonious working relationships allow both parties to focus on work issues rather than other contractual issues, saving both cost and time. Thus, the true benefits of relationship management can only be achieved if there is a change of culture in the industry – in the client, contractor and supply chain sectors (Cheung 2006).

10. CONCLUSIONS

Relationship management can be easily adopted in the Australian culture. Physical interactions and direct confrontation are preferred while dealing with matters. Getting the right mix of people is a key to maintain a harmony and effective working atmosphere. Trust is crucial in building a cooperative and collaborative relationship between parties. Hence, up-to-date information and knowledge are shared between parties which lead to both cost and time saving.

The degree of match and mismatch between organisational culture and structure has an impact on staff's commitment level. The concept of relationship management needs to filter down to all levels in the supply chain if participants are to retain commitment and buy-in to the relationship.

Higher frequency of communication does not necessarily lead to better relationships or more collaborative problem solving behaviour. Although application of structured relationship management approach in the supply chain increases both formal and informal communication amongst participants, good working relationships and collaborative behaviour are found where respect and acknowledgements are expressed. Facilitation workshops in the relationship management process promote a collaborative supply chain culture, move away from adversarial to cooperative attitudes amongst participants; provoking a change of culture in the client, contractor and supply chain sectors.

Sustainable supply chain requires proactive relationship management and the development of an appropriate organisational culture. These, in turn, are predicated on trust. This research has explored these dimensions and come to the conclusion that organisational structuring has a significant impact on all of these issues and that attention must be paid to this structural aspect of organisation as well as the human and economic aspects.

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RELATIONSHIP BETWEEN ORGANIZATIONAL SIZE AND CONTRACTOR'S BEHAVIOURAL PATTERN IN PRICING WEATHER RISKS

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ABSTRACT

Transferring contract risks to contractors involves financial consideration and the assessment of the cost for risk adjustment has long been a difficult problem in risk management. Depending on the organizational size of a contractor, it may generate different corporate culture that adopts a different perception and behaviour in addressing risk in a project. In the examination of the aforesaid cost, it is critical to identify any potential cost variance should the risks be priced by contractors of various sizes. Therefore, the relationship between contractors' organizational sizes and their risk-pricing behavioural patterns forms the focus of this study.

In view of the significant impacts that weather risk poses on the smooth progress of a construction project and the common practice to remove contractors' entitlement to Extension Of Time (E.O.T.) due to inclement weather, such deletion of E.O.T. provision from contract is selected as the illustrative example for risk transfer in this study.

In examining contractors' risk-pricing behaviours, a questionnaire survey was conducted to investigate how the behavioural patterns of different-sized contractors changed from their risk perceptions and attitudes. The survey preliminarily reveals that smaller contractors are more willing than well-established contractors to absorb their perceived and programmed risks in returned tenders in order to stay competitive. Methodologies for further detailed studies are also proposed in this paper.

Keywords Organizational size, risk-pricing behaviour, weather risk

1. BACKGROUND AND AIM OF STUDY

Risk allocation through contractual provisions involves financial considerations and the transfer of significant risks from employers to contractors would adversely affect the competitiveness of returned tenders. It is not an easy task for employers to assess the cost that they have to pay for a risk adjustment exercise and appointed consultants are also seldom able to give concise and accurate cost advice on this issue. Under the lack of knowledge in this area, it is critical to examine the cost implications brought by contract risk transference.

In the examination of the aforesaid cost, a major consideration should be put on the identification of any potential cost variance if the risks are priced by contractors of various sizes. It is a challenge to tell whether small contractors or large contractors are more risk-taking in programming risk items and it is also a complicated question on which group of contractors is more willing to absorb the cost of risks in tenders. Therefore, the relationship between contractors' organizational sizes and their risk-pricing behavioural patterns forms the focus of this study.

Inclement weather is inevitably a major cause of delays in construction projects (Alkass et al., 1996, Lam and Runeson, 1999 and Smith and Bohn, 1999). In view of its significant impacts on project programmes and completion, employers normally tend to avoid the undesirable consequences thus arisen. Such weather risk can easily be transferred in a construction contract by deleting the extension of time (E.O.T.) provision due to inclement weather in the conditions of contract. Therefore, the removal of contractor's entitlement to E.O.T. due to inclement weather is selected as the illustrative risk item in this study.

One's risk-pricing behaviour for weather risk is somewhat affected by (i) his / her perception of the significance of weather risk, (ii) his / her risk attitude in programming weather related threats in construction stage and (iii) the corporate strategy in making monetary allowance for risk items in tenders. All these three elements may in turn be impacted by the corporate culture driven by the organizational size of the contracting firm. Therefore, the aim of this study is to find out the relationship between organizational size and the contractors' risk perceptions, attitudes and behaviours when encountering weather risk.

The findings obtained from this study can facilitate employers' understanding on the weather-risk pricing behaviour for contractors of various sizes and can give an indication on the cost of this risk adjustment exercise. They eventually assist employers in making sensible and cost effective decisions in drafting time- and weather-related contract conditions and mitigating the adoption of traditional assessment method based on pure guess.

2. PREVIOUS STUDIES

Organizational Size and Culture

Occupational community is a group of people who share with one another a set of values, norms and perspectives. Unique work cultures are then created and sustained by these occupational communities (Van Maanen and Barley, 1984). Culture may be defined as norms, values and informal beliefs held by people in an organization, and the prevailing culture gives rise to specific decisions, policies and activities. Culture is highly informal and perceptual, but usually dictates what activities or behaviours are necessary to become successful in a particular organization (Ghobadian and Gallear, 1997, Chan and Tse, 2003). Besides, the configuration of corporate governance may impact on the financial performance of construction firms (Rebeiz and Salameh, 2006), and Barney (1986) suggested that firms with sustained superior financial performance typically were characterized by a strong set of core managerial values that defined the ways they conducted business. Organizations of different sizes are likely to possess different values, leadership styles and cultures (Chan and Chan, 2005), Ghobadian and

Gallear (1997) carried out a comparison between the characteristics of small, medium and large organizations and concluded that they are different in terms of structures, procedures, behaviours, people and contacts.

In exploring the international market, Gunhan and Arditi (2005) opined that track record, specialist expertise, project management capability are important company strengths; loss of key personnel and shortage of financial resources are important threats; and increased long term profitability and the ability to maintain shareholders' returns are important opportunities. It is believed that these strengths, threats and opportunities can be largely applied in the survival in the local market as well (Chan and Suen, 2005).

Ammar *et. al.* (2003) studied the firm's size-profitability relationship and pointed out that firms might experience a lack of profitability as the firm grew in size, and statistical analysis revealed that small, medium and large firms were significantly different from each other in terms of their profit rate. Flanagan and Norman (1982) also concluded that the bidding performances of small, medium and large contractors in respect of type and size of construction work were different, and the competitiveness of differently sized contractors towards the type and size of construction work differed to varying degrees. Shash and Abdul-Hadi (1993) examined the mark-up size decisions of contractors of different sizes and revealed that the importance and significance of many subjective factors varied as the contractor size changed.

Interpretations can be made from the above that a successful firm should possess its unique work culture and a clear definition on the ways they conduct business, and these are dependent upon the organizational size. Before these culture and definition can be set, the management level should have identified the corporate strengths and weaknesses (such as the past performance, adequacy of specialist expertise, adequacy of human and financial resources, etc.). These factors can also be largely reflected in the organizational size. Furthermore, given the above evidence indicating that contractors of various sizes perform differently in bidding exercises, organizational size should always be taken into consideration when studying contractors' bidding behaviours.

Weather-risk Pricing Behaviour

Previous studies mainly focused on evaluating the impacts of inclement weather on construction activities or studying the methods in planning and scheduling to cater for weather conditions. Huang and Halpin (1995) used computer simulation techniques and graphical method to evaluate the effects of exogenous factors on the transient environment for construction operations by measuring the productivity. Ng *et. al.* (1998) attempted to demonstrate how a project manager could rationally and systematically establish a set of project control baselines to deal with the changing nature of realities such as inclement weather conditions through the building and use of a dynamic simulation model. Moselhi and Hassanein (2003 and 2004) presented a model, designed to optimize and integrate the planning and scheduling phases of linear projects like highway construction, taking into account the effect of inclement weather on crew productivity.

Very little works had been published addressing the associated costs incurred by inclement weather, and this study attempts to fill this literature gap. These costs mainly include the expenses in special planning and scheduling of works, accelerating works with more labour input and risking the possibility of having liquidated damages deduction, etc. As no individual item is normally included in the pricing document for weather risk, contractors' behaviour in allowing the associated costs in tenders have to be studied.

One of the major approaches to measuring attitudes and behaviours is derived from the expected utility (EU) framework (e.g. Neumann and Morgenstern, 1974, Schoemaker, 1982, Fishburn, 1988 and Pennings and Smidts, 2000). However, problems and queries often arise on the accuracy of this framework in estimating one's risk behaviour (Bromiley and Curley, 1992, Erwin, 2001 and Weber *et al.*, 2002). Previous studies (Pennings and Smidts 2000, Krzysztofowicz 1983a, 1983b, Keller 1985, Weber and Milliman 1997) provided support that apart from expected utility (i.e. weather history in this case), contractors' perceptions and attitudes also formed the major determinant factors constituting the commercial deal for the risk allocation. Au and Chan (2005) further explained the relationship among contractors' risk perception, attitude and behaviour by setting out the potential change in pattern from perception to attitude and from attitude to behaviour. Therefore, in order to investigate the root of different behaviourial expressions, contractors' risk perceptions and risk attitudes should also be studied.

3. RESEARCH DESIGN

Adoption of Questionnaire Survey

Postal questionnaire survey was conducted for this study. In order to facilitate quick comparison of the risk perceptions, risk attitudes and risk behaviours of differently sized building contractors (with the same specialty and nature of business), straight-forward questions had been asked on (i) how many days in each month do they consider that inclement weather will affect the progress of work (their perceived significance of weather risk), (ii) how many days in each month will they allow for delay due to inclement weather when they are preparing a work programme (their attitudes in programming weather risk) and (iii) how many days of delaying costs will they allow in returned tenders for each month in order to cover the potential loss due to inclement weather when they are submitting a bid (their behaviour in pricing weather risk). This survey can give preliminary findings on how the contractors' risk perceptions, attitudes and behaviours differ in accordance with their organizational size.

Target Respondents

To investigate the risk-pricing behaviour of contractors, general building contractors currently operated in Hong Kong were invited for participation in the survey. In view of the possible differences in behaviour among different sizes of contractors, the respondents were classified into three groups (Group A plus those not on the List / Group B / Group C) in accordance with the List of Approved Building Contractors maintained by the Environment, Transport and Works Bureau of the Hong Kong Government. Group A contractors are eligible to tender for works with an estimated value less than HK$20M, Group B contractors can tender for works with a value ranging from HK$20M to HK$50M, Group C contractors, being the most well-established group, can bid for works exceeding HK$50M in value. In the private construction market, these contractors are usually allowed to tender for contracts with higher estimated sums than those allowed in the public market. So, the above only sets out the indicative project value that small, medium and large contractors normally hold.

Comparison with Expected Utility

The inclusion of expected utility (i.e. the average actual number of days of inclement weather) in this study can help ascertain the reasonableness of the respondents' perceived significance of weather risk and can form a good comparison basis if a model is to be developed in future studies on this topic. The expected utility was worked out based on the ten years' weather record (Year 1995 to Year 2004) obtained from the Hong Kong Observatory website (for Year 1997 to Year 2004) and the journal "Meteorological Results" published by Royal Observatory (Hong Kong) (for Year 1995 and Year 1996). As there is normally no construction activity in Sundays and public holidays, the numbers of days of inclement weather collected from weather history are multiplied by $^{6}/_{7}$. However, the expected utility worked out from weather history is only considered as the "most likely number of days of inclement weather" and it excludes the possible subsequent chain-effects brought by inclement weather. As it is difficult to estimate and assess the subsequent effects and these effects are not the focus of this study, the discrepancies that may arise are neglected in this study.

4. PRELIMINARY RESEARCH FINDINGS

Sample Size

Sixty completed questionnaires were received comprising fourteen from Group A contractors, twenty from Group B contractors, twenty-four from Group C contractors and two from contractors not on the List. Respondents to the survey include company directors / associates, project managers, quantity surveyors, contracts managers and estimators involved in the bid preparation exercise.

The findings are summarized in Table 1 and are better illustrated in Figure 1.

Table 1. Summary of the Risk Perception, Attitude and Behavioural Patterns of Small, Medium and Large Contractors

Contractor Group	Risk Perception	Risk Attitude	Risk Behaviour
A (Small Contractors)	Perceive inclement weather as a comparatively significant risk, but it is generally in line with the expected utility	Appears to be more risk averse in programming weather risk. This may due to the fact that small contractors usually handle small projects with short contract period which allows little time buffer for delays caused by inclement weather.	Willing to offer significant reduction from their perceived / programmed risk; the resultant cost allowance is similar to that offered by Group B Contractors. Reasons: (i) enhancing competitiveness and expanding customer base and (ii) adoption of flexible decision making approach with high personal authority
B (Medium Contractors)	Perceive inclement weather as a comparatively insignificant risk, but it is generally in line with the expected utility	Appears to be more risk loving in programming weather risk	Maintain the constant declining trend from perception to attitude and from attitude to behaviour
C (Large Contractors)	Similar to Group A Contractors	Appears to be more risk averse in programming weather risk. This may due to the fact that large contractors usually handle large-scaled development for which the long wet-trade period is likely to coincide with the wet season.	Only willing to offer slight reduction from their perceived / programmed risk; the resultant cost allowance is the highest among the three groups. Reasons: (i) possession of competencies other than cost and (ii) adoption of fact-based decision making approach with formal evaluation and control procedures

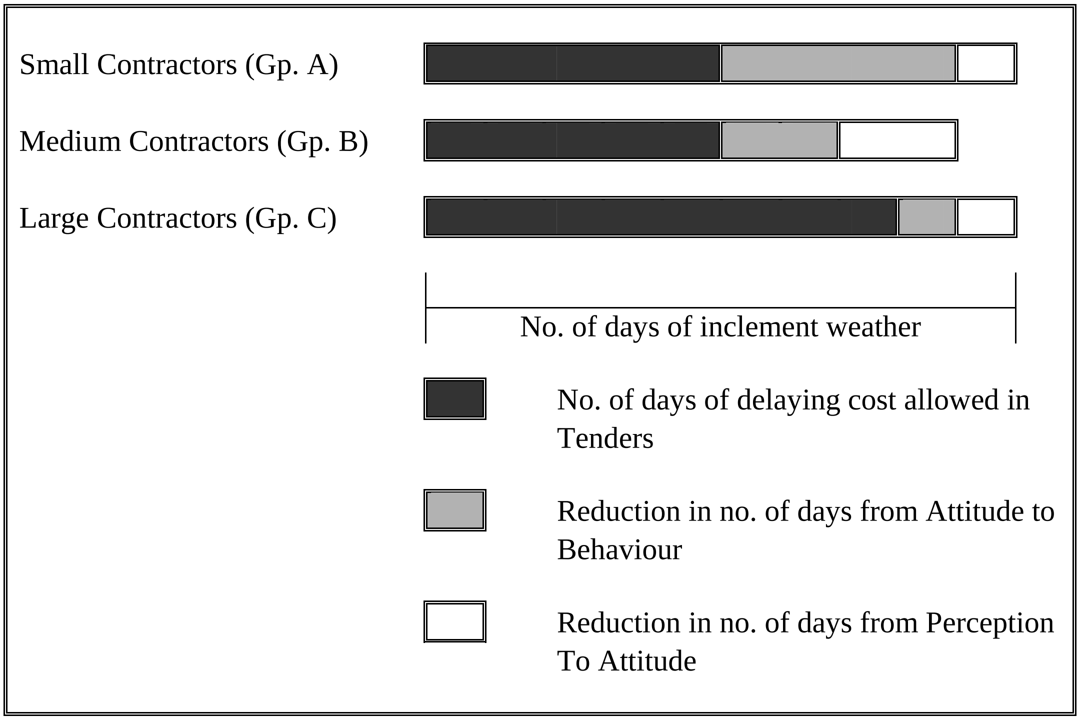

Figure 1. Illustration of the Risk Perception, Attitude and Behavioural Patterns of Small, Medium and Large Contractors

This study reveals that the behavioural patterns of differently sized contractors in pricing weather risks in returned tenders are different. The resultant priced delays by Group A and Group B contractors are similar, and those priced by Group C contractors are comparatively high. But in general, the priced numbers of days of weather-caused delays are less than the actual number of days of inclement weather obtained from weather records. Therefore, it is generally cost efficient to delete the E.O.T. provision due to inclement weather from contracts. It is logical as risk allocation to the party (i.e. the contractor) who is more capable to mitigate the implications of the concerned risk is more cost efficient to the entire contract.

5. CONCLUSIONS

The above only gives a preliminary analysis by graphical illustration and further statistical analysis can be carried out to identify the situations where the groups are significantly different. The findings obtained from this study can serve as a pilot study for future research, but for more accurate and detailed studies, one should include in the survey the consideration of contract period, scale of exposure to risk, nature of work, presence of other situational variables such as the good employer’s reputation, reasonableness of contract provisions, etc. that may affect one’s risk attitude or behavioural expression. As contractors of various sizes would behave differently in different tendering situations, a more effective questionnaire survey can be carried out setting out different predefined project scenarios mentioned in the above for collection of the contractors’ risk perceptions, attitudes and behaviours, so that contractors of different sizes can be tested on how they perceive or behave differently in the given scenarios.

6. ACKNOWLEDGMENTS

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APPLYING AHP ANALYSIS FOR ALTERNATIVE CONSTRUCTION PAYMENTS

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ABSTRACT

The current practice of alternative payment methods has received less attention from the construction practitioners. In general, practitioners have not yet responded to call of government and academia to adopt innovative payment systems. Traditional payment methods (e.g. lump sum and unit price) have found to be the most popular pricing and payment methods but encountered many faults that affect the construction operation and performance. Equally, the use of subjective decision support tool for the choice of alternative payments less popular in the current construction practice. The mere existence of decision-making tools for payments do not help practitioners to make decisions which require the application of professional judgement. Therefore, in both cases, research and support is necessary to promote the use of decision making tools which combine analytical and judgemental techniques to encourage alternative payment methods. This paper discusses the potential of Analytical Hierarchic Process (AHP) technique for multi-criteria decision making (MCDM) in the construction payments selection. The AHP consists of a MCDM hierarchy structure, pair-wise comparisons, and the calculation of the relative priorities of MCDM attributes. The MCDM model is simplified by using a spread sheet e.g. Microsoft Excel which is widely available for most computer users to assist in determining the alternative payment decision making process. The proposed MCDM model contains Explanation and Report worksheets and a ScoreChart sheet. The AHP analysis is performed in Virtual Basic for Applications (VBA) and results are shown in an Excel spreadsheet.

Keywords: AHP, alternative payment methods, decision making, MCDM, pair-wise comparison.

1. INTRODUCTION

It is generally recognised that the traditional construction payment methods in the UK construction industry (i.e. unit price and lump sum) which are detrimental to the relationships between client and contractors; client and consultants; contractor and sub-contractor and contractor; and suppliers. These difficulties include delay in payment, over measurement, up-front loading etc which have been documented by the National Specialist Contractor Council survey (Murdoch, 2005). The survey was found that average wait for payments to be made were: 63% for 30 to 60 days; 20% for 60 to 90 days; and only 7 % for less than 30 days. In addition to this, retention abuse (70%) and ‘pay when paid’ (74%) are among the highest contractual abuse reported by the respondents. Latham (1993) regards this as the issue of 'trust and money' which has a negative impact on the construction progress and has been strongly criticised in the Trust and Money report (Latham, 1993).

Clough and Sears (1994) concentrated on construction contracting found that cash flow is one of the major causes of failure for small construction firms. In order to avoid negative cash flow the project participants have to manage their working capital by means of overdraft, borrowing from financial institutions or securing other lines of credit. However, there is a potential to engage in sharp practice such as, pay-when-paid and over measurement. To overcome these oft-cited difficulties, alternative payment systems have been suggested by academia and government (e.g. Potts, 1988; Kaka, 2001; Egan, 2002; Njie et al, 2005; DTI, 2006). They recommended that the construction industry could move away from practices of non-productive, adversarial and conflict ridden payment practices with the adoption of alternative payment methods.

Research models related to construction cost forecasting and cash flow abound (e.g. Kaka, 1994; Fortune and Hinks, 1998; Skitmore, 1998; Kaka and Lewis, 2003), all recommend good practice for financial management in the early stage of construction cost advice and selection of appropriate payment methods. Furthermore, the call for good payment practice in construction reflects the Government's efforts to improve payment practices across the industry e.g. 'Trust and Money' (Latham, 1993), 'Constructing the Team' (Latham, 1994), 'Rethinking Construction' (Egan, 1998), and 'Accelerating the Change' (Egan, 2002). One example is the Department of Trade and Industry's (DTI) endeavour to amend the Housing Grants, Construction and Regeneration Act 1996 (Construction Act) and Scheme for Construction Contracts Regulations 1988 (England and Wales) to improve payment practices for the construction industry.

This paper focuses on the study of AHP analysis for MCDM in alternative payments. The project is funded by the Engineering and Physical Sciences Research Council (EPSRC). The findings represent part of the Re-thinking Construction using Payment Systems (ReCoUPS) research project. It discusses the potential of AHP technique to develop a MCDM tool in alternative payments. The tool uses Microsoft applications i.e. Virtual Basic for Applications (VBA) and Excel to develop an AHP model that consists of a MCDM structure for an analysis in decision making. The VBA codes were obtained from Albright's (2001) works and modified for use in this study. The full function of the MCDM tool will assist practitioners to make alternative payment decisions for most appropriate payment methods for the construction client, consultant, contractor, and suppliers of a project.

2. MULTI-CRITERIA DECISION MAKING TOOL

Belton and Stewart (2002) regard MCDM as " ….*an umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter*", meaning that the benefit of MCDM is to facilitate decision makers' understanding of the nature of the problem faced and their capacity to learn about the decision making process. More importantly, how individuals and organisations can articulate the values, objectives and priorities during a decision making process. So, MCDM involves intuitive judgments, individual experience and behaviours of a decision-maker. Such values and judgments vary between individuals. Further, complex decision making has many direct and indirect factors. Traditional decision making methods tend to model the issues which can be captured at the surface of the problem where as MCDM techniques enable greater depths to be explored. In the case of payment systems professional judgement is vital since the choice of decision criteria and the respective 'weights' given to those criteria and the 'trade offs' are an essential part of a judgemental decision environment.

The relevance and importance of decision-making in construction management has attracted much attention such as the use of multi-attribute value theory or multi-attribute utility theory (MAUT) for balancing multiple factors (decision criteria) to assist individuals or groups decision making in complicated environments. Belton and Stewart (2002) regard this as the concepts of **'**value measurement theory**'**. The idea of this approach is to construct a function or means associating a real number with each alternative to produce preferences of the alternatives that are consistent with the decision makers value judgements. Equally, in this study, the use of MCDM will be a value function method where a hierarchical decision value will be constructed to assess the performance of each alternative against individual criteria and the assessment of preferences for each criterion (i.e. the given weights for each criterion) to obtain overall decision maker's preferences. However, there is an abundance of MCDM techniques and other decision making methods found in the construction management research such as, AHP, Multi-attributes Utility Techniques, Fuzzy techniques, Multivariate Discriminate Analysis, Artificial Neural Network Analysis, Logistic Regression Technique, and Linear Programming Methods. Examples of these investigations are: Hwang and Yoon (1981); Fellows and Langford (1985); Holt et al (1994); Holt (1998); Boussabaine and Elhag (1999); Al-Harbi (2001); Al-Khalil (2002); Cheung et al (2002); and Wong et al (2003:2004).

Belton and Steward (2002) highlight the use of MCDM able to improve subjective judgements (explicitly) when individuals and groups are involved in using multi-criteria methods. Essentially, in order to perform subjective decision making, there are a number of key phases such as: (i) problem identification and structuring; (ii) model building and use; and (iii) the development of action plans. In this study, these key phases were modelled into a MCDM tool as follows: (i) identify and structure the construction payment problems; (ii) model the payment selection factors and alternatives in the AHP analysis; and (iii) analyse the results to provide most appropriate payment systems for further action (Figure 1). In this research, the AHP technique is used to develop an MCDM tool for alternative payment analysis. The AHP analysis is developed by Saaty (1980; 1996) and had been used in. marketing, medical, political, social, military, and other disciplines for MCDM research. It is one of the most comprehensive mathematic frameworks for MCDM environments and therefore was selected for this study.

3. METHODOLOGY

According to Saaty and Vargas (1991), human knowledge and behaviours can be explained in terms of relative comparison expressed in the form of ratios and yet the use of ratio scales for assigning weights are relatively easy and meaningful to measure qualitative attributes. AHP is a mathematical model for multi-criteria analysis to evaluate a complex MCDM on tangible and intangible attributes. AHP uses a hierarchy structure to model the MCDM process which involves prioritising MCDM attributes by means of pair-wise comparisons. The pair-wise comparisons syntheses the priorities into MCDM alternatives. The use of AHP in this research allows tangible and intangible elements to be included in a MCDM process. The assigned ratios for each MCDM element will then be analyzed by means of paired comparisons to derive a set of relative ratios/priorities. The advantage of paired comparisons method is that it allows decision makers to concentrate on a comparison of two attributes at one time when making the most preferred MCDM alternative and decision criteria. Therefore it enhances the objectivity when making a choice from a range of potential alternatives with defined constraints.

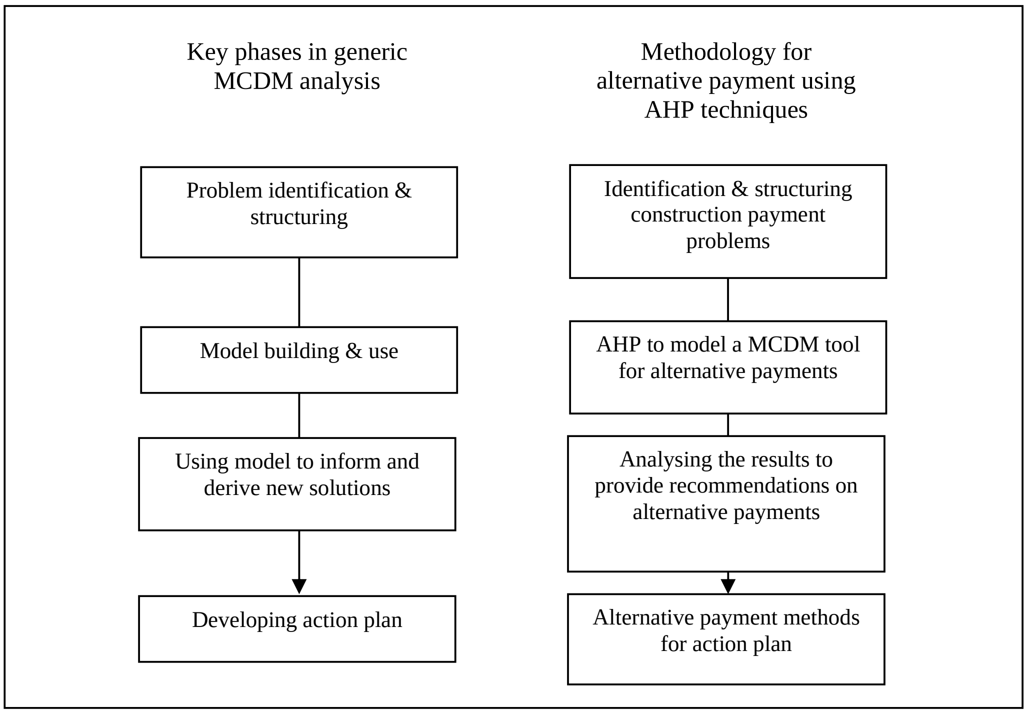

Figure 1: Drawing an analogy between MCDM key phases and AHP decision making tool

In this study the project objectives were identified in a preliminary study by a survey of construction professionals, these are shown in table 1. Each objective was scaled in its importance on a 9 point scale such that pairs of objectives could be compared for there influence upon selecting an appropriate payment system. In the paired comparisons exercise, there will be significant multiple judgments required. When eliciting judgments, it is quite common to have redundant comparisons and poor judgments in paired comparisons exercise. Inconsistency will inevitably inherent in the judgment process. Such inconsistent judgments during paired comparisons exercise will cause inaccuracy in AHP results. Therefore, a mechanism for systematically checking on the consistency of each judgment is required. Saaty (1996) recommends a value of consistency ratio (CR) less than 0.1 is a tolerable error in the paired comparisons judgments. That is, a ten percent of the inconsistency (error) from the overall paired comparisons judgments is accepted. Calculation of the CR can be done using the ExpertChoice™ and SuperDecisions (www.superdecisions.com) software. In this study, a MCDM tool was developed using the VBA and Microsoft Excel applications to perform the aforementioned mathematical calculations. The VBA associated programming codes were adopted from Albright's (2002) works. Albright (2002) uses VBA to design important programming codes for decision support systems in management science and operation research. For detailed AHP analysis the information can be found in Saaty's literatures (Saaty and Vargas, 1991; Saaty, 1996). The following concentrates on how the proposed MCDM tool can be constructed by an AHP analysis.

4. AHP ANALYSIS

In this study, the AHP analysis will be used to develop a MCDM tool for decision-making in alternative payments. A total of five different payment methods and seventeen factors affecting payment methods were identified from the previous studies and empirical surveys of the current payment systems (i.e. Njie, 2005; Sherif and Kaka, 2003:2004). The former represents alternative payment methods identified as price-based, rates-based and cost-based types of payments i.e. lump sum, unit price, cost-plus a fixed fee, cost-plus incentive, and fee as percentages of project value. The latter is a set of essential project objectives (PO) that give impact on the selection of most appropriate PS in regard to a given type of project and client characteristic. Table 1 summarises attributes, project and client types to be included in the proposed MCDM tool.

Project characteristics	**Types of client**
Project A: Housing type, conventional levels of technology	Public
Project B: Public buildings of some intermediate level of complexity	Private
Project C: Private commercial building of high levels of complexity	Public, Private Partnership
Project Objectives (Decision-making factors for PS)	
Accuracy of valuation and payment for works done, Achieving sustainability, Certainty of cash flow forecast, Client's involvement, Cost certainty, Exceeding health and safety requirements, Fairness in payment system, Lean construction- high level of prefabrication/preassembly, Minimised borrowing & capital cost, Opportunity for innovations, Pro-active risk management, Project completion on time, Quality enhancement, Support team work approach, Time certainty, Transparency / openness in payment system, Value for money	

Table 1: Project scenarios and objectives

Both payment methods/systems? (PS) and PO will be used to construct a hierarchical structure of the MCDM attributes in an AHP model. The first step in AHP is to compare the PO, which are the most important criteria for a given type of project and client characteristic for a PS. This is discovered through a series of paired comparisons. Then the second set of MCDM attributes (i.e. payment alternatives) are compared to each others in respect to a particular PO to derive the most appropriate PS. The final result is a score for each PO, and the PS with the highest score is identified as the preferred PS for a given type of project and client characteristic. Details of the step-by-step MCDM analysis explained in the following.

Functionality of the MCDM Application

The MCDM tool is developed using data collected from the UK construction industry practitioners in regard to industry's perception of the PO affecting the choice of payment system (PS) for a given type of project and client characteristic. The following summarises the key phases of the application to complete a MCDM process in alternative payments for a decision making.

Step 1: User to specify the PO that are relevant for making the PS alternatives. Clicking on the *Run the application* button in Figure 2 produces the dialog box as shown in Figure 3. This dialog box allows user to choose and/or type a *new* criterion. After a criterion is entered in the box, the user should click on the *Add* button to add the criterion to the list that will be used in making the decision and click on the *No* More button when all the POs have selected and added.

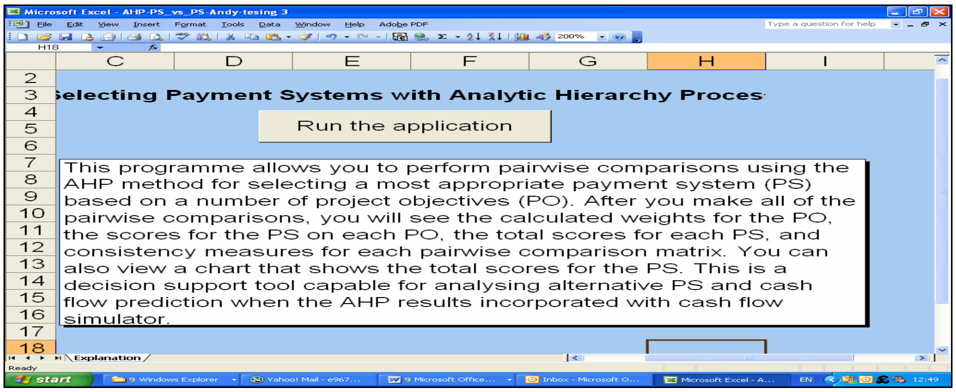

Figure 2: Running the MCDM application

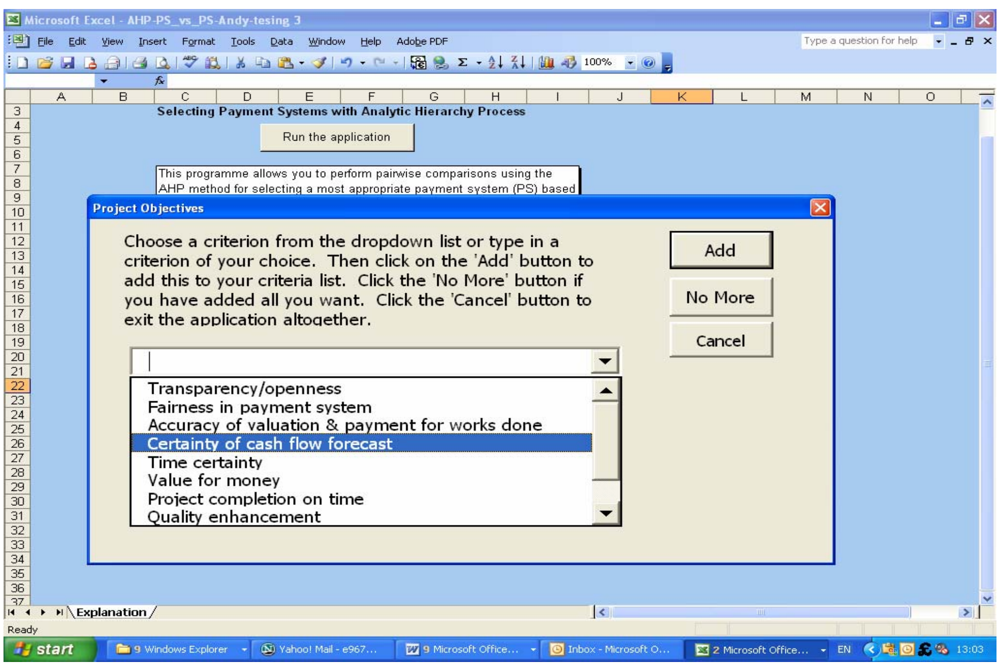

Figure 3: Dialog box for entering PO

Step 2: Similar to Step 1, when data input for PO is completed. There will be another data input dialog box for PS (figure 4).

Step 3: A series of paired comparisons exercises take place. First, between pairs of PO (Figure 5) and then between pairs of PS alternatives.

Step 4: The MCDM tool performs the AHP calculations for reports and results to highlight individual PS scores (Figure 6). The scores for the various PS alternatives can be also viewed graphically.

Finally, to check the consistency of MCDM judgements, a consistency index (i.e. consistency ratio) will be given in Step 4 (Figure 6). If the consistency indexes are reported as more than 0.1 then the user is required to repeat the entire analysis again.

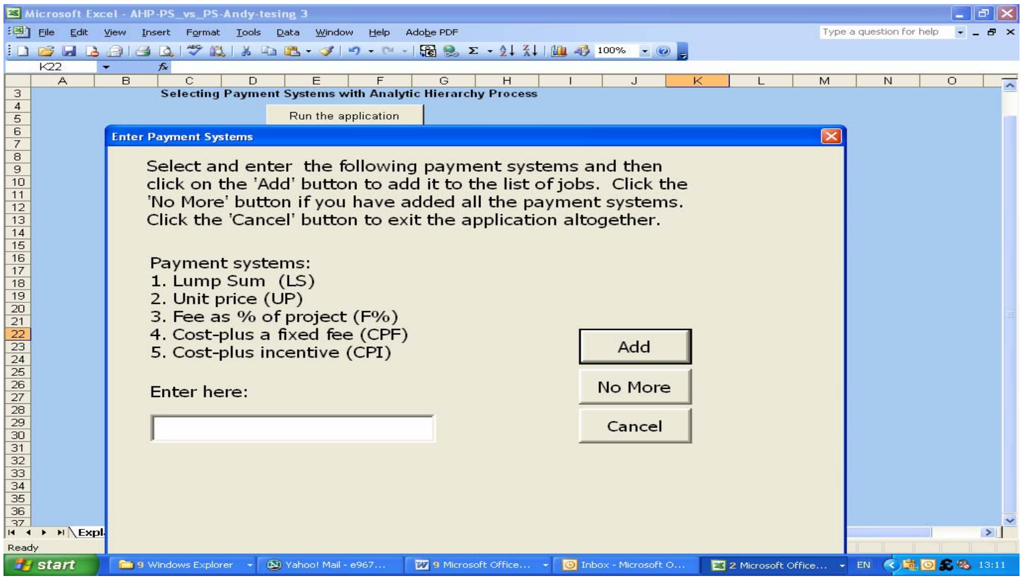

Figure 4: Dialog box for entering alternative payment systems

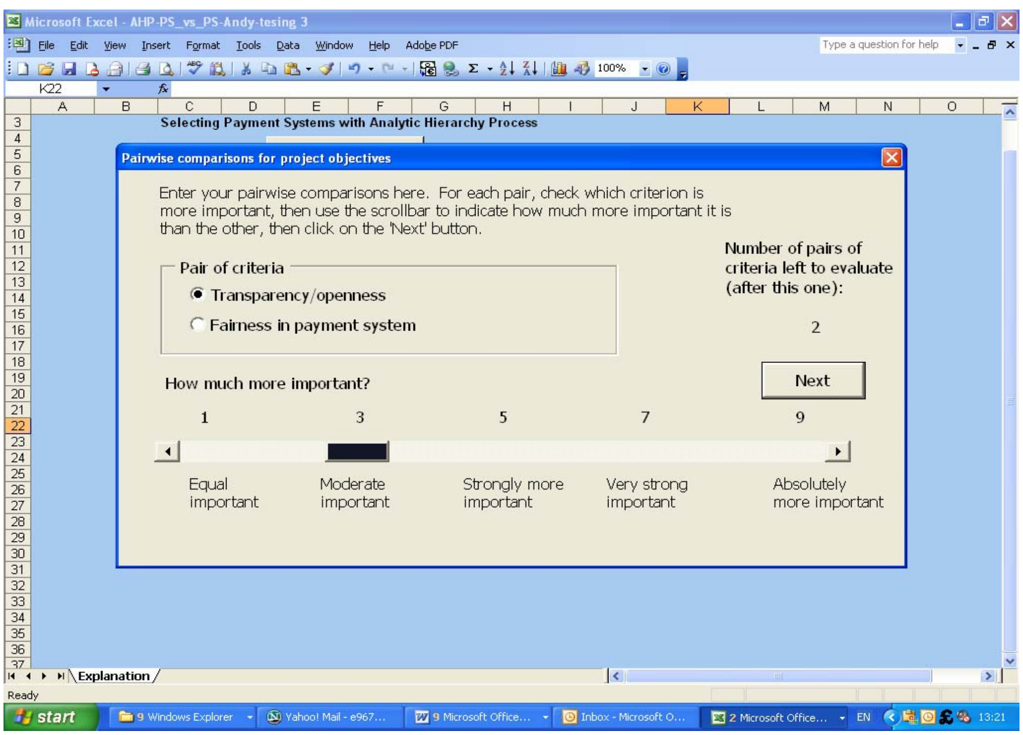

Figure 5: Paired comparison between two POs

5. FUTURE WORKS

The MCDM tool is currently being developed in a Microsoft application. Further modification and fine tuning is necessary. Amongst these will be to amend the syntax used in making the pair-wise comparison as shown in figure 5. More user-friendly applications will also be sought. Although the VBA programming codes somehow complex but the application is simple and straight forward when use in spreadsheet. The extended works from this application will be to develop a web-based version MCDM tool for practitioners' applications. This will help to reduce the cumbersome process in repeating the entire paired-comparisons exercises when the consistency indexes more than 0.1. The web-based MCDM allows user to revisit and revise the assigned 9-points ratio to improve their consistency in a particular paired comparison judgement. Further, it has a user profiling feature to allow capturing and storing previous decision making profiles.

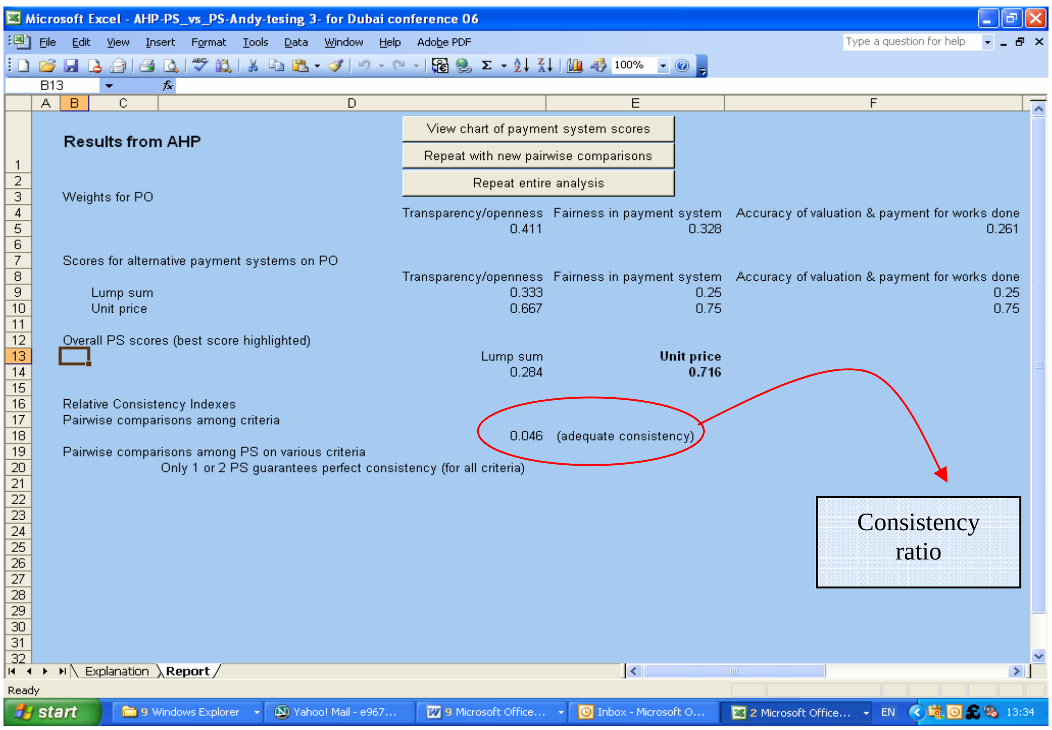

Figure 6: Results for the paired comparisons and consistency index

6. CONCLUSION

The application of AHP already found in management science and operation research, organisational decision makings, and in many other complicated MCDM settings. However, its application and adoption in construction research has yet been limited. The proposed MCDM tool shows a great potential for use in a PS selection and as a MCDM alternative to traditional decision making tools, in particular, its capability for analyzing both qualitative and quantitative judgments in construction alternative payment settings. The developed MCDM enables a user to provide inputs to the model through a series of dialog boxes and produces a non-technical report of the results. It was found that complicated MCDM settings can be explained and resolved in a systematic way through mathematic solutions using ratio scales and paired comparisons to derive the composite relative priorities for each decision-making option. The presentation of this paper also highlights the potential application of AHP for alternative payments in a web-based MCDM environment.

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KNOWLEDGE MODEL FOR KNOWLEDGE MANAGEMENT IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

A knowledge model is developed for structuring construction information for use in the construction industry. Construction information is complex due to the involvement of various disciplines spanning engineering data from exact sciences and qualitative data from architectural considerations. Complexity is not only due to the size of the information but also due to context dependency. The context dependency is dealt with the method known as *analytical hierarchy process* (AHP). For structuring the entire information a special feed-forward neural net tree structure is developed, which is based on an underlying matrix referred to as *knowledge matrix*. Taking a particular example from the construction industry, the development of the knowledge matrix and the corresponding neural tree as a knowledge model is presented, and its use for the management of the knowledge is demonstrated.

Keywords Analytical Hierarchy Process, Knowledge Model, Knowledge Management, Neural Tree, Ontology

1. INTRODUCTION

Construction industry deals with various kind of diverse information. Information spans engineering data from exact sciences and linguistic or qualitative data from soft sciences. Generally, knowledge is obtained from information in a suitable form for use. Since, knowledge is context dependent, from the same information different kind of knowledge models can be derived where each model has its own merits. The type of knowledge considered in this research is the relations of aspects of concern in a construction process. As to this issue, existing works are rather limited and the approaches are more or less the same. Namely, the taxonomy of information items are prepared in a user friendly software environment and this is considered to be a knowledge model where the management of this weak knowledge becomes rather trivial in the sense that it is subjective, and haphazard in the sense that its consistency cannot be verified. Taxonomy should essentially be considered as information although only in some special cases it can be considered knowledge, as there is no sharp borderline between information and knowledge. In this respect, taxonomy essentially plays the role of information representation. However, this representation has to be structured in such a way that some knowledge is induced out of it. This means the structured information is a source of knowledge from which further knowledge can also be induced. Consequently, information representation can be seen as a help to review the information at hand more conveniently and it may inspire some hints about the way that information should be handled toward knowledge acquisition. In this work, a building constructional taxonomy is considered as structured information which may serve as a knowledge model in a minimal sense. However, the substantial knowledge can be developed by quantifying the relations in this structure, as a *first step*, and developing this structure enhancing its merits in practicality as to construction industry, in the *second step*. In a complex construction environment the knowledge of attribute relations can be used to identify the significance of any component in the consideration of the remaining components under consideration. After the attribute relations are duly determined and a relational data base is desirably established, it is important to know the implications of a modification of any relation in this scheme of knowledge as to the rest of the scheme. In this way the existing knowledge is put in a manageable form since all the pieces of knowledge in the model are presented in perspective quantifying their significance as to the rest. The management is effectively exercised during decision-making process, as much as the construction process needs. The first step mentioned above, is tackled in previous works (Ciftcioglu and Sariyildiz, 2005a, 2005b), applying a general mathematical approach. The method is known as Analytical Hierarchy Process (AHP) which determines the hierarchical priorities of the taxonomic components. The subject matter of the present research is the second step mentioned above, namely enhancing the effectiveness of the AHP method as to construction by a knowledge model. For this aim, a knowledge model is adopted which is used in relation to transformable building structures (Durmisevic, 2006) where the underlying scheme is referred to as *feed-forward knowledge model* since its structure is similar to an artificial feed-forward multilayer neural network structure merely in a feed-forward sense. In the present work, a similar form is adopted where the precise structural form is known as *neural tree* which is additionally combined with the AHP that it serves for knowledge management. The structure of the paper is as follows. Section two briefly explains the AHP for the hierarchical priority assignments to items subject to pair-wise comparison. Section three presents the implementation of the method of AHP in the form of a neural tree which becomes eventually ontology. It serves for the management of the knowledge of construction. Section four exemplifies the use of the knowledge model and this is followed by conclusions.

2. TAXONOMIC RELATIONS IN BUILDING AND CONSTRUCTION

Analytical hierarchy process in brief

The AHP method is a technique developed by Saaty (1980) to compute the priority vector, ranking the relative importance of factors being compared. The only inputs to be supplied by the expert in these procedures are the pair-wise comparisons of relative importance of factors, taken two at a time. This means, in an environment of complex relationships among the variables, one follows the principle of “divide and rule”. If we denote the expert input comparing the *i*-th variable with respect to the *j*-th variable by $a_{ij} = w_i/w_j$, then the relative importance of the *j*-th variable with respect to the *i*-th variable is represented as $1/a_{ij} = w_j/w_i$. One notes that, in an environment with high number of complex relations to make a judicious relational assertion is not easy. However, to make a simple comparison between any two attributes and to make a judgment is much easier for an expert. The $[n \times n]$ matrix obtained by arranging these pair-wise comparison ratios is termed the reciprocal judgment matrix and designated as *A*. where n is the number of factors subjected to pair-wise comparison. The diagonal elements of *A* matrix are all unity. Since we take the reciprocals, we have to fill the upper diagonal elements which are altogether n(n-1)/2. The details of this technique are given by Saaty (1980). A comparison and highlighting its strengths can be found in Saaty and Vargas (1984).

$$A = \begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \cdots & & & \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{bmatrix} = \begin{bmatrix} 1 & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & 1 & \cdots & \frac{w_2}{w_n} \\ \cdots & & & \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \cdots & & & \\ \cdots & & & \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \tag{1}$$

The principal eigenvector W of ***A*** is computed by solving the eigenvalue problem, which is $AW=\lambda_{max}\, w$ where λ_{max} is the principal or largest real eigenvalue of ***A***. The normalized eigenvector corresponding to λ_{max} is the priority vector P. The beauty of the AHP operation can be appreciated by considering the tolerance of the method allowed during making the expert judgment. That is, some deviations in the expert judgments do not critically affect the final outcome. AHP is applied in many fields up to now, such as the economic analysis, urban or regional planning and forecasting etc, (Vargas, 1990), as well as knowledge model validation (Ciftcioglu, 2003).

Attribute relations in perspective

A number of attributes are involved in a construction process. It is essential to estimate the effect of each attribute to the result to keep the project under control to avoid probable uncertainties on the quality of the outcome. However, this simple statement is not an easy task to accomplish, due to the complexity involved. The complexity mentioned is twofold. Firstly, the number of attributes is generally high so that the number of attribute relations can be explosively high. Secondly, the relations themselves can be complex due to indirect relations, which appear to be seemingly direct. This situation occurs due to the attributes, which are never considered and therefore they are referred to as hidden attributes. The above mentioned complexity issues and associated attribute relations determinations are subject to determination. When these relations are established, they can be used for making a knowledge model, which can be used by an expert for a general use concerning the same categorical design. A firm clue addressing how to tackle this is still an issue due to the very soft nature of the problem. Terminologically, such issues are termed ill-defined problems, which require special treatment for solution. Such soft problems can effectively be treated by the special methods of the exact sciences. The method of interest in this research is the AHP, which primarily provides priorities among the elements by means of their pair-wise comparisons. This method is extended and it is applied for hierarchical attribute relations, the application area being architecture and construction.

Illustrative Example

Consider figure 1, which illustrates the interdependence of building constructional aspects in a construction process. To exemplify the utilization of AHP for the relational attribute determination relations among the structural aspects are considered. In the first step, let us make expert judgment for the structural aspects. The structural aspects are *Loads* (w_1); *Materials* (w_2); *Form and space geometry* (w_3); *Structural design approach* (w_4); *Structural behaviour* (w_5).

Only for illustrative purposes, we might do expert judgments about ratio with general building design considerations as follows:

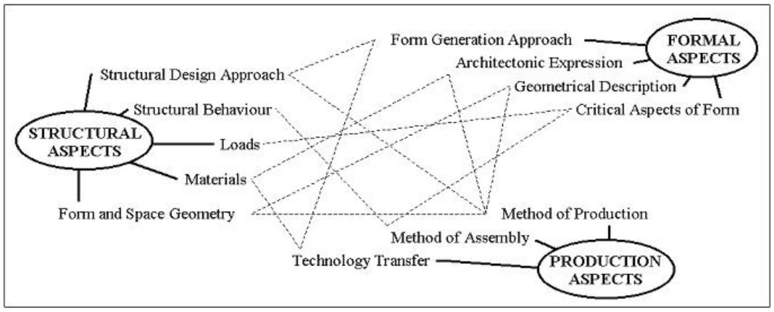


Figure 1: Illustrative description of interdependent relations among the design aspects in a construction process (Ciftcioglu and Sariyildiz, 2006)

$w_2/w_1=0.9$; $w_3/w_1=0.7$; $w_4/w_1=0.5$; $w_5/w_1=0.7$;
$w_3/w_2=0.8$; $w_4/w_2=0.5$; $w_5/w_2=1.0$;
$w_4/w_3=0.9$; $w_5/w_3=1.2$;
$w_5/w_4=1.5$;

The rationale about these ratios is due to expert judgment. Based on the expert ratio judgments given above, the reciprocal judgments altogether are shown in Table 1.

Table 1. Reciprocal ratios of expert judgments for the attribute relations among *Structural Aspects* attributes.

	Loads	*Material*	*FSG*	*SDA*	*SB*
Loads	1	1/.8	1/.8	1/.5	1/.7
Material	.8	1	1/.8	1/.5	1
Form and space geometry(FSG)	.8	.8	1	1/.9	1/.9
Structural design approach(SDA)	.5	.5	.9	1	1/1.5
Structural behavior(SB)	.7	1	.9	1.5	1

The reciprocal ratio judgment matrix, then, is given by

$$A = \begin{bmatrix} 1 & 1/.8 & 1/.8 & 1/.5 & 1/.7 \\ .8 & 1 & 1/.8 & 1/.5 & 1 \\ .8 & .8 & 1 & 1/.9 & .9 \\ .5 & .5 & .9 & 1 & 1/1.5 \\ .7 & 1 & .9 & 1.5 & 1 \end{bmatrix} \quad (2)$$

The largest eigenvalue λ_{max}=5.03 and the corresponding priority vector is

$$\begin{array}{lccccc} & \textit{Loads} & \textit{Material} & \textit{FSG} & \textit{SDA} & \textit{SB} \\ p^T = & [0.262 & 0.224 & 0.187 & 0.134 & 0.193] \end{array} \quad (3)$$

Another essential property of AHP method is the inbred consistency check in the method. Namely, for fully consistent expert judgment λ_{max} the same as the number of variables is being considered. In the above illustrative example the number of variables is $n=5$, and the largest eigenvalue is $\lambda_{max}=5.03$, which indicates the almost ideal consistency of the judgments, though this is a mere illustrative example

From Taxonomy to Ontology

For this study, we consider *loads, material,* and *form* as **structural aspects** and *form generation*, *architecture*, and *geometry* as **formal aspects**. This is illustrated in figure 2.

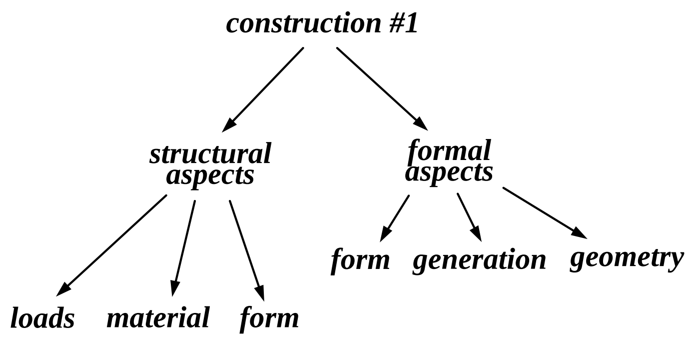


Figure 2. Indirectly related structural aspects and formal aspects attributes; the weights to be attached to the arrows are subject to determination by AHP.

The expert judgment ratios for structural aspects are asserted as

$w_2/w_1=0.5;\ w_3/w_1=0.6; w_3/w_2=1.2$

giving the expert judgement ratio matrix as

$$A = \begin{bmatrix} 1 & 1/.5 & 1/.6 \\ .5 & 1 & 1/.2 \\ .6 & 1.2 & 1 \end{bmatrix}$$

and the same ratios for formal aspects are asserted to be

$w_2/w_1=1;\ w_3/w_1=1.4; w_3/w_2=1.75;$

giving the expert judgement ratio matrix as

$$A = \begin{bmatrix} 1 & 1 & 1/1.4 \\ 1 & 1 & 1/1.75 \\ 1.4 & 1.75 & 1 \end{bmatrix}$$

so that ,the corresponding priority vectors are computed as

$$p^T_{structural} = [.327\ .167\ \ .231\ \ \ .275]$$
$$p^T_{formal} = [.291\ .270\ .439]$$

The relational matrix $R_{structural \to formal}$ as to from safety to comfort is computed from

$$R_{structural \to formal} = p_{structural} \times p^T_{formal} =$$
$$\begin{bmatrix} .327 \\ .167 \\ .231 \end{bmatrix} \begin{bmatrix} .291 & .270 & .439 \end{bmatrix} = \begin{bmatrix} 0.0952 & 0.0883 & 0.1436 \\ 0.0486 & 0.0451 & 0.0733 \\ 0.0672 & 0.0624 & 0.1014 \end{bmatrix}$$

In the same way, the relational matrix $R_{formal \to structura}$ from formal to structural aspects is computed from

$$R_{formal \rightarrow structural} = p_{formal} \times p^T_{structural} = \begin{bmatrix} .291 \\ .270 \\ .439 \end{bmatrix} \begin{bmatrix} .327 & .167 & .231 \end{bmatrix} = \begin{bmatrix} 0.0952 & 0.0486 & 0.0672 \\ 0.0883 & 0.0451 & 0.0624 \\ 0.1436 & 0.0733 & 0.1014 \end{bmatrix}$$

In the above example the bi-directional relations between the components of safety and comfort aspects are established. From construction technological viewpoint these relations are of high importance. It is clear that the computations can be extended to any complexity. Such an extension is illustrated in figure 3a.

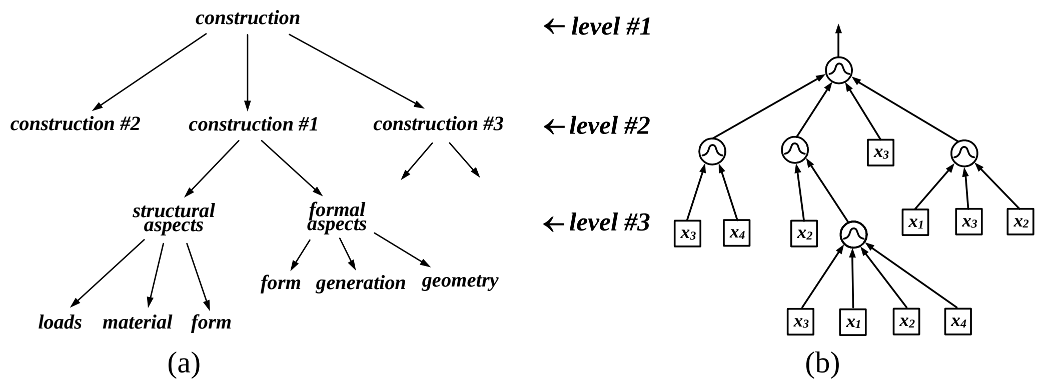


Figure 3. Structural aspects and formal aspects attributes as part of a taxonomy of a construction process (left); The structure of a neural tree (right); the weights to be attached to the arrows are subject to determination, for instance, by AHP.

3. NEURAL TREE AS KNOWLEDGE MODEL

A neural tree is composed of terminal nodes, and weights of connection links between two nodes. Each terminal node is labelled with an element from the terminal set $T=\{x_1,x_2,...,x_n\}$.where x_i is the *i-th* component of the external input vector ***x.*** The input ***x*** is connected to a node via a radial basis function provide an output for this node which is given by

$$f(x) = w_j \, \phi(\| x - c_j \|) \tag{4}$$

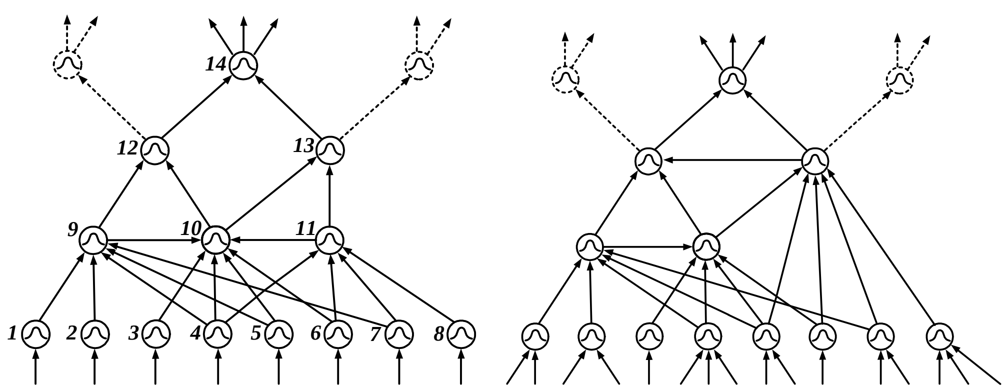
where $\phi(.)$ is the basis function, c_j is the centre of the basis function; w_j is the weight connecting the output of the basis function to the a terminal node in the form of an external input. c_j determined as a component of a priority vector and equal to w_j. Among several radial-basis functions, the Gaussian function

$$\phi(r) = \exp(-\frac{r^2}{2\sigma^2}) \tag{5}$$

is of particular interest and used in this research due to its relevance to fuzzy-logic. Above, σ is the width of the basis function and it is used to measure the uncertainty associated with the node inputs designated as external input vector ***x***. An instance of the neural tree is shown in figure 4b. For the model there can be as many basis functions as needed. The centres of the basis functions are the same as the terminal node inputs. Therefore for these input the radial basis function output is 1 and this is multiplied by the associated weight

Neural networks can represent a broad class of feed-forward networks with or without layered structure. The tree structure involved in this work is a layered one and it allows for easy exchange of substructures by standard sub-tree variation operators without affecting the building blocks. Input from any sublevel to any upper level is possible. Connection between the nodes at the same level is also allowed. However, feedback from any upper level to sublevel is not allowed. By means of this basic configuration, the levels are clearly defined in a structure of any complexity.

Two different configuration of the neural tree involved in this research are shown in figure 4a and 4b. Taking figure 4a as a particular example subject to analysis, we number the nodes to fix and trace the relations. The lowest level has 8 nodes. The immediate upper level has 3 nodes, which is followed by a layer with two nodes. The lowest level is a particular level since al the nodes have only a single input in this isolated configuration. We assume that they are stemming from fictive a layer that we can call it as zero-th level. If some inputs from the zero-th level are related through a priority vector, the inputs are equal to the components of this vector. Otherwise the inputs are equal to one. Considering the connections in figure 4, we can establish the matrix as shown in Table 2. This matrix is called *knowledge matrix*. One can easily note that, the knowledge matrix contains all the information exhibited by structure in figure 4a. The weights in figure 4 are the same weights to be determined by the AHP as indicated in figure 2. In this form, all the relations determined by AHP are represented in the neural tree form. In table 2, the relations are designated as the information flow from the horizontally enumerated nodes to vertically enumerated ones. Therefore the first column of weights contains eight values in a general case. Some of them may have a value as 1 if these inputs are not correlated with any others. Each weight is indexed with a number next to it. The index indicates the node to which an input is applied via the weight. In the example in figure 4a, there are 14 weights. The positioning of the weights in this figure forms the knowledge matrix given in table 2.



(a) (b)

Figure 4. Some possible structures of a neural tree with general connection schemes: starting from very first nodes (a) and a general scheme with cascade connections (b); the weights to be attached to the arrows are subject to determination, for instance, by AHP.

Table 2. Knowledge matrix.

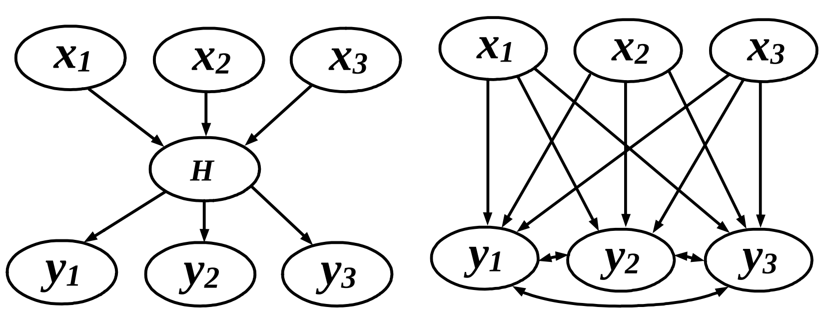
node	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	w1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	w2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	w3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	w4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	w5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	w6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	w7	0	0	0	0	0	0	0	0	0	0	0	0	0	0

8	w8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	w1	w2	0	w4	w5	0	w7	0	0	0	0	0	0	0
10	0	0	0	w3	w4	w5	w6	0	w9	0	w11	0	0	0	0
11	0	0	0	0	w4	0	w6	w7	w8	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	w9	w10	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	w10	w11	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	w12	w13	0

In table 2, the nodes are numbered in a hierarchical order in a feed-forward structure and each row in the table corresponds to the inputs attached to this node. In the case of any change of relations via the change of any weight in the neural tree, the inputs towards to the upper nodes change also. Before the weight change, these inputs are simply the associated weights. After a weight change, the upper weights relative to this node inputs in the tree structure are modified as the product of the weight and the associated basis function output which is originally 1, as mentioned earlier. In this way the implications of a weight change throughout the total net is established and the new relations can be computed as described in preceding section. One can note that, the weight values are always smaller than or equal to one that they comply with the requirements of being smaller than one as to the normalized priority vector elements.

One interesting feature of the knowledge model is the attribute relations as they can be interpreted in terms of fuzzy logic (Zadeh 1965, 1973), where the Gaussian membership functions play the role of membership functions. The important implication of fuzzy logical aspect of the computation is that the uncertainties and/or imprecision in the attribute relations are well taken care of with the elicitation of more precise outcomes.

Another interesting feature is the explicit consideration of the hidden variables, in the model. This is illustrated in figure 5, which is a knowledge model, where the dependent variables are y_1, y_2 and y_3 and the independent ones are x_1, x_2 and x_3. If the dependency is via a hidden variable shown as H in the figure, the model is represented by 6 relations in figure 5a. If the hidden variable is not considered, then the model has to be represented by 12 relations in figure 5b considering all possible relations although the relations among the dependent variables supposedly do not exist. This means, it implies some futile complexity in the model of this illustrative example case. In the knowledge model presented in this work and illustrated in figure 4, such situations are also circumvented.



(a) (b)

Figure 5. Illustration of modelling attribute relations with a hidden variable (fig. a) and without a hidden variable (fig. b)

4. IMPLEMENTATION OF THE MODEL

A knowledge model is developed for knowledge management and implemented for the analysis of a construction process. The particular aspect subjected to analysis in the present framework is referred to as *transformation capacity* (Durmisevic, 2006). In basic terms, it is defined as the potentiality of a building for transformation. This is directly related to the sustainability of the building with extended life cycle. The important feature of this concept is the possibility of effective decision-making in a construction process while decision-making on a complex building technological issue is boiled down a single parameter expressed in fuzzy logic terms. In the model, the total knowledge about the sustainability of a given construction is represented. After the knowledge model formation, the effect of changing the construction-related information is investigated by means of several test cases as to the transformation of the construction. In this way the effect of particular construction information on the construction itself is identified while the other constructional information items are inherently taken into account in this identification process.

Another application of the knowledge model is exercised using the available data (Durmisevic, 2002) on a metro station as to the effectiveness of this utility from the users' viewpoint. In this case the knowledge model contains the relevance of various design items and reveals the significance of any design variable change with respect to the other variables and ultimately the functionality of the station. The latter research is briefly reported before (Ciftcioglu and Sariyildiz, 2005b) as an application of information processing in a framework of decision-making process where AHP was central to that research. In the present research, the same application is considered in a framework of knowledge management, i.e. positioning the significance of each design variable in a taxonomic structure. In this form the present research presents ontology of a construction process particularly meeting the demand of knowledge management in the relevant project execution.

To illustrate the implementation of the model, we consider the interdependent structure shown in figure 1. We are aiming for to establish a relational knowledge model where the formal aspects are one side and both structural aspects and production aspects are at the other side. Among the formal aspects, we are interested in the *form generation approach* aspect and wish to model how both structure and production affect the formal aspects altogether via the aspect of *form generation approach*. The scheme is illustrated in figure 6. The structural aspects are represented by w_1, w_2, w_3, w_4, and w_5 which are given by (3) as *0.26, 0.22, 0.19, 0.13 and 0.20*. In the same way we assume that production aspects which are represented by w_6, w_7, w_8, are computed by means of the reciprocal ratio judgment matrix and found to be *0.30, 0.50* and *0.20*, respectively. With the same procedure, we assume that, w_9 and w_{10} are given by *0.4* and *0.6*; w_{11}, w_{12}, w_{13} *and* w_{14} are found to be *0.2, 0.1, 0.3 and 0.4* respectively. Referring to (4), for this scheme we write $w_1=c_1$, $w_2=c_2$; $w_3=c_3$, $w_4=c_4$ and $w_5=c_5$. In the same way $w_6=c_6$, $w_7=c_7$ and $w_8=c_8$. The centres c_9 and c_{10} are given by $c_9=m_1w_9$ and $c_{10}=m_2w_{10}$ where

$$m_1 = \frac{o_1}{o_1 + o_2} \quad , \quad m_2 = \frac{o_2}{o_1 + o_2}$$

Initially, $o_1=o_2=1$, so that $m_1=m_2= 0.5$ and consequently

$c_9=0.5w_9=0.2$ and $c_{10}=0.5w_{10}=0.3.$ (6)

Now, we assume that among the structural aspects, the material aspect for some reason has changed from $w_2=0.22$ to $w_2'=0.15$ while the other structural aspects remained the same. In the same way we assume that one of the production aspects changed from $w_7=0.5$ to $w_7'=0.3$, while the other structural aspects remained the same.

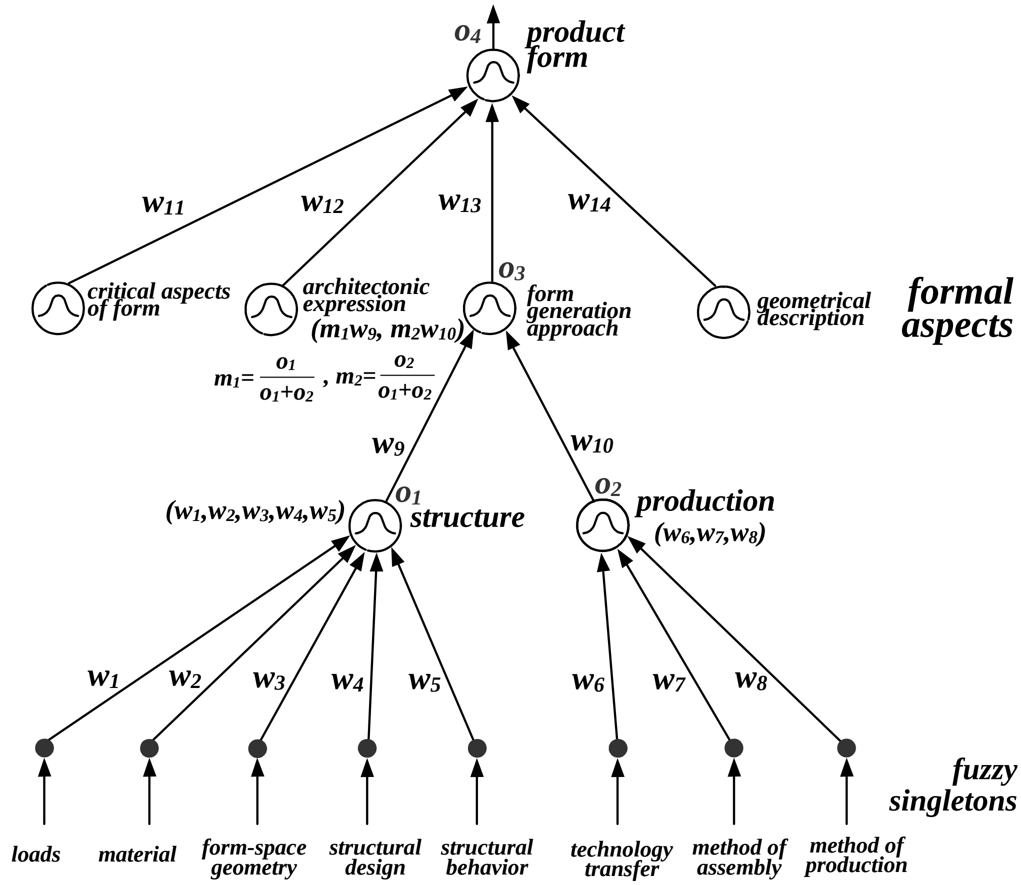


Figure 6. Illustrative example for computing the relational attributes of *product form* in connection with *structure* and *production* aspects

We can compute the effect of these changes on the formal aspects as follows: Using

$x_1=c_1=0.26;\ x_2=0.15,\ c_2=0.22;\ x_3=c_3=0.19;\ x_4=c_4=0.13;\ x_5=c_5=0.20$

and taking the width parameter as $\boldsymbol{\sigma=0.2}$, from (4) we obtain

$f(x)=o_1=0.95,$

and using $x_6=c_8=0.3;\ x_7=0.3,\ c_7=0.5;\ x_8=c_8=0.2$ in (4), we obtain

$f(x)=o_2=0.74$

Correspondingly

$$m_1 = \frac{o_1}{o_1 + o_2} = \frac{0.95}{1.69} = 0.56 \quad , \quad m_2 = \frac{o_2}{o_1 + o_2} = \frac{0.74}{1.69} = 0.44$$

$$m_1 w_9 = 0.56 \times 0.4 = 0.22$$

$$m_2 w_{10} = 0.44 \times 0.6 = 0.26$$

Considering that $c_9=0.5w_9=0.2$ and $c_{10}=0.5w_{10}=0.3$ as given above, and using $c_9=0.2$, $c_{10}=0.3$, as given by (6) and $x_9=0.22$ and $x_{10}=0.26$ as computed above, from (4), we obtain $f(x)=o_3=0.51$.

$$o_3 w_{13} = 0.3 \times 0.51 = 0.153$$

so that the formal aspects which are originally given by $w_{11}=0.2$, $w_{12}=0.1$, $w_{13}=0.3$, $w_{14}=0.4$ take the new values as

$w_{11}'=0.23$, $w_{12}'=0.12$, $w_{13}'=0.18$, $w_{14}'=0.47$ due to the changes on w_2 from 0.22 to 0.15 and w_7 from 0.5 to 0.3, as described above. Above, for example w_{11}' is computed from

$$w_{11}' = \frac{w_{11}}{0.2 + 0.1 + 0.153 + 0.4} = \frac{0.2}{0.853} = 0.23$$

and in the same way we obtain,
$w_{12}'=0.1/0.853=0.117$, $w_{13}'=0.153/0.853=0.178$, $w_{14}'=0.4/0.853=0.469$.

The computational results are indicated in figure 7.

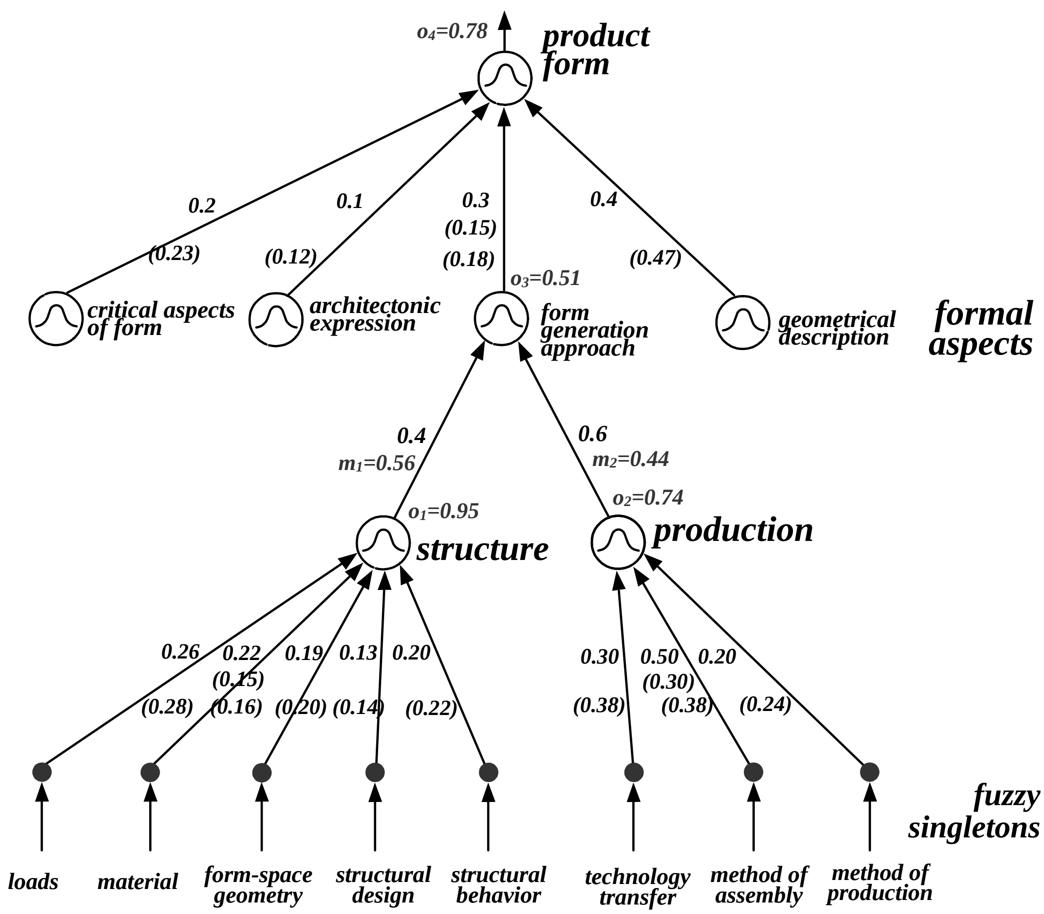


Figure 7. Illustrative example for computing the relational attribute alterations due to change of *material aspect* in the *structure* and *method of assembly* aspect of *production*; the numbers in the brackets at the lowest rows are the final modified weights

The illustrative example above indicates how certain decisions in structural aspects and production aspects affect the formal aspects, which are obtained by computation and not by human assessment. The computations are carried out in a straightforward way for any complexity of the scheme, while such objective assessments of the implications in such a complex scheme are beyond comprehension for a human expert or actors dealing with the process. In the case of determining the transformation capacity of a building one should calculate also o_4 in figure 6. With the present numbers $o_4=0.78$ as indicated in the figure. However, figure 6 six is not meant for transformation capacity calculation, and therefore the output o_4 is out of interest in the present relational attribute determination.

5. DISCUSSION AND CONCLUSIONS

Considering the rich information environment in the construction technological areas, to deal with this information is an essential task. The AHP provides a systematic approach especially converting this information to partial construction knowledge in the form of attribute relations. AHP has deep implications in the construction technology and the counterpart industry. This includes also the way of integration of intelligent technologies into the construction technologies. In this work, AHP is especially implemented for modelling hierarchical attribute relations as novel implementation in construction. The model is developed in the form of neural tree, where the nodes in this structure are represented by artificial neurons. This is essentially a taxonomic structure having detailed description. The mathematical representation of the knowledge model, that is, the weights among the nodes are contained in a matrix, which is referred to as knowledge matrix. The knowledge matrix having been determined by AHP, the final form of the knowledge model is established via the basis function centres of the nodes. For the detailed description process, the method determining the bilateral relations among the aspects and their sub-components is presented above with illustrative examples. By means of this, the taxonomic structure is converted to ontology for the purpose of knowledge management. The main goal of knowledge management is to assess the relations among the various construction process components and to assess the significance of each component during the presence of others. For instance, if the presence of one component is found to be insignificant, this component can be omitted for the sake of any convenience; say, convenience of cost, for instance. This simple example clearly hints the nature of the knowledge management activity in a construction process; namely, the knowledge management is about decision-making and successful management can be exercised by means of proficient ontology developed for this purpose. The taxonomic structures without ontological elaborations cannot serve for essential issues of construction since these issues are complex enough beyond taxonomic comprehension. It is noteworthy to mention that, the method of ontology presented in this work works with fuzzy logic concepts to absorb the uncertainties and imprecision of the construction information thereby enhancing the integrity of the decision-making. This is accomplished by using Gaussian radial basis functions at the neural tree nodes where the representative centres are defined by the key knowledge at hand as to the construction in question. The paper presents the development of this knowledge model leading to a knowledge management tool in the form of ontology to cope with the heavy demands which do occur in a construction environment.

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FRAMEWORKS FOR KNOWLEDGE MANAGEMENT INITIATIVES IN THE FIELD OF PROJECT MANAGEMENT-USING METAPHOR FOR IMPROVED VISIBILITY

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ABSTRACT

Collection and sharing of information and knowledge has remained a source of concern over the years. With better visualization tools at our command, we have the medium to allow knowledge sharing to take place conveniently and effectively. Knowledge management in most organizations is more left to individualistic initiatives of managers rather than having a structured system or process to be followed. Frameworks and models can provide a way of trying to tie together disparate initiatives and to also provide overarching strategies.

In *The Myth of Metaphor* by Turbayne (1962), Mr. Hayakawa introduces the volume by saying "no one, to my knowledge has taken the position so boldly expounded in this volume that metaphors are the very stuff with which human beings make sense of the universe." Turbayne states that all overt acts may be thought of as a metaphor expressing some inner condition. Among the many citations of literature, art, music, architecture, and poetry, the author cites Hamlet as saying before speaking with his mother "I will speak daggers to her, but use none." This is a use of language to indicate far more that just the overt interactions between mother and son, and as a larger view of how people pursue the reconciliation of social differences. Weaving metaphors into models or frameworks are useful ways of creating a highly understandable form of describing these in a way that is both context rich and resonates with the receiver's cultural perspective. Understanding a plan or framework for advancing innovation through knowledge should be made more tangible even though it may embed tacit cultural knowledge.

To help in this direction, this paper aims at discussing three frameworks which would assist project management teams to conceptualize and thus grasp the value in executing knowledge management initiatives. We offer a generic framework for promoting knowledge management implementation initiatives as it relates to project management. The aim of this paper is to provide a broad outline on which specific knowledge management initiatives, as applicable to different project scenarios, can be described to those that will ultimately undertake them.

Keywords: Knowledge Management, Project Management, Innovation

1. INTRODUCTION

Knowledge management (KM) has attracted increasing interest by construction industry and project management academics and practitioners over the past five years or so. This has resulted in several books on the subject being produced that is specifically targeted at this sector (Kazi, 2005; Love, Fong and Irani, 2005) and (Anumba, Egbu and Carrillo, 2005), additionally, research reports have also focused on KM in construction for example in Australia (Walker, Wilson and Srikanathan, 2004). And in the UK with small and medium enterprises (SMEs) for further information see http://www.knowledgemanagement.uk.net/sme_intro.htm for the website developed by Professor Charles Egbu who has undertaken much collaborative work in this area at Glasgow Caledonian University. Part of the problem that these and other academics have found in communicating frameworks and models has been finding ways to describe KM initiatives that resonate with intended users.

While the field of KM gained substantial impetus from the late 1980's and early 1990's in the general management literature it has taken some time to be readily recognized within the construction project management community. The early models of KM proposed by (Nonaka, 1988) and later expanded upon (Nonaka, 1991; Nonaka and Takeuchi, 1995) revolved around what has become to known as the SECI process. Knowledge management is seen in terms of a knowledge creating cycle of: individuals sharing tacit knowledge through socialisation (S); articulating this either verbally or textually to make tacit knowledge explicit (E); combining the explicit knowledge shared with existing explicit knowledge such as operating procedures, manuals, and information bases (C); and then through reflection and embodying that re-framed explicit knowledge, internalising it so that it becomes refined tacit knowledge for many individuals across the organisation (I) (Nonaka, 1991). Further, the need for a supportive environment created for the knowledge creation, transfer and use was stressed and the concept of the importance of 'ba' or a shared space where learning and knowledge work takes place was offered (Nonaka and Konno, 1998; Nonaka, 2001).

At this time other concepts were being offered around the issue of providing a place, real or virtual, where people meet to create and share insights about knowledge. The community of practice (COP) was one such idea that extended the original concepts of guilds and collections of workers that used these gatherings as a means of creating and sharing knowledge (Lave and Wenger, 1991), this work started a new wave of KM thought and the COP ideas took hold with a widely cited book by Etienne Wenger and his colleagues (Wenger, McDermott and Snyder, 2002) along with others who also stressed the social side of KM (Sveiby, 2001), the strategic side (Zack, 1999) and the leadership side (Cavaleri and Seivert, 2005). Interestingly perceptions of the technology dominance of KM has been slipping as more and more KM thinkers explored the how knowledge is created and used with the view that KM initiatives should be 33% technology and 67% people-oriented (Davenport and Prusak, 1998).

Now, as information communication technology (ICT) and technology is seen primarily as an enabler, and more tools are offered on the marker, it is clear that the primary focus should be on KM work being driven by people supported by both technology and all this should be supported by sound leadership driving a knowledge advantage strategy (Walker, 2005). The SECI model has been supplemented by refinements that show how individuals and groups and corporations attempt to manage knowledge. The 4 I's model- Intuiting, Interpreting, Integrating, and Institutionalizing put forward by Crossan, Lane and White (1999) in which knowledge flows forward from individuals to groups then to the entire firm to be recycled through feedback loops. This was augmented by a better understanding of the role of power and influence and how organisational culture mediates this process (Lawrence, Mauws, Dyck and Kleysen, 2005). Thus models of KM also take on a metaphor of stocks and blows of knowledge (Bontis, Crossan and Hulland, 2002).

With all these increasingly interesting ideas of complex interactions between the various players and elements of KM, it is worth trying to find some framework for KM that short circuits the complexity and provides a simpler way or visualizing what may be going on in KM work. Grisham, argued that metaphors are ideal ways of capturing complex, rich and knowledge-embedded concepts into simple to grasp symbolic representations (Grisham, 2006). He cites Gannon (2004: xiii):
"A cultural metaphor is any activity, phenomenon, or institution with which members of a given culture emotionally and/or cognitively identify. As such, the metaphor represents the underlying values expressive of the culture itself…Culture allows us to fill in the blanks, often unconsciously, when action is required, and cultural metaphors help us to see the values leading to action."

While metaphor and symbols are perceived through an appreciation, filtered by experience and culture, they can be dangerously misleading as well as useful. They should be applied within the context of the receiving group so that short cuts do not cut right across meaning. The frameworks and their metaphors presented in this paper are directed towards those with a construction or heavy engineering project management background.

We present three examples of metaphors to describe a KM initiative developed by three of the authors with a predominantly academic background. Our fourth author, being predominantly a practitioner, then briefly comments on the usefulness of this approach in presenting to senior management the concept behind the initiatives.

2. METAPHOR 1 – A FRAMEWORK OF KNOWLEDGE FLOWING THROUGH PIPES

The first metaphor uses the 'stocks and flows' idea of KM. The metaphor illustrated in Figure 1 depicts a metaphor of knowledge transfer taking place through knowledge flows between contract parties. In this structure there is no contractual relationship between Company A and Company B, but there are contractual agreements between each of them and the Customer. In the construction industry Company A might be the designer and Company B the Constructor. In the information technology (IT) industry Company A might be the programmer and Company B the hardware supplier. In more complex procurement structures, Company A might be an end user, and company B might be a consortium, partnership, or alliance of firms. In these more complex structures the Knowledge Pipeline structure is repeated to include more and more valves and filters depending upon the procurement structure existing between the respective companies.

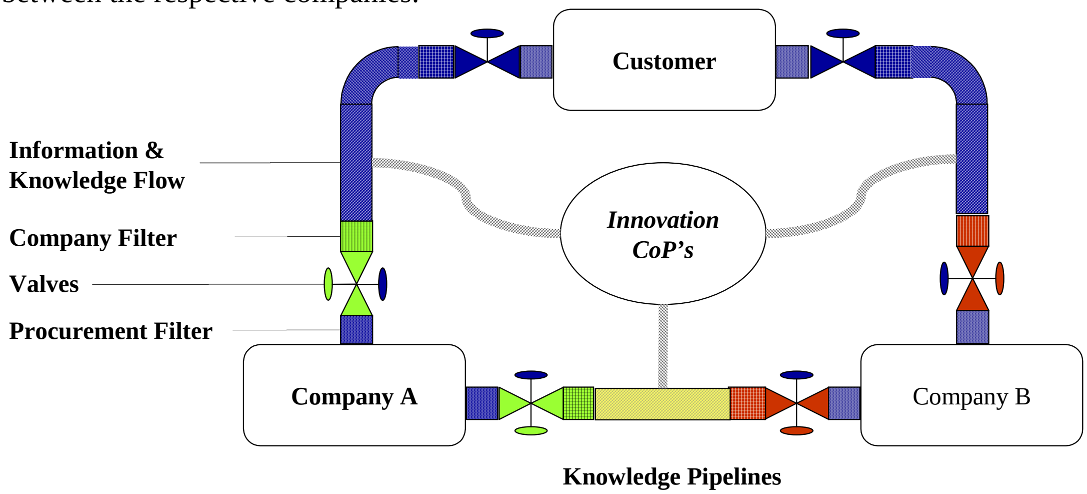

Figure 1: A Knowledge Pipeline Metaphor

The pipelines (customer to company A and customer to company B) that pass information and knowledge are installed by the contract agreement, and described in the general and special conditions. The pipeline (horizontally company A to company B) relies more heavily for definition of how to transfer knowledge and information between Company A and B to construct the project after contracts have been awarded. It also shows a Company Filter that is determined by the individual company (customer, designer, contractor, supplier, etc.). The culture of the company can often affect communication that is permitted and encouraged.

The Company Filters also include ethics, market forces, personalities etc.—some firms are open to improvement and change, others believe that they lead their professions and deserve to be followed; some firms are authoritarian, while others democratic; some firms empower their employees, others discourage personal risk taking; some firms are culturally diverse, others are not. The endless varieties of corporate cultures that exist determine the degree to which communications are actively encouraged or passively discouraged. Issues of profit, risk and power (to mention but a few) also filter information that is shared. The valves shown in Figure 1 are controls on the information and knowledge that can flow between the parties.

The customer to some extent, by reason of the General and Special Conditions, can control all valves. Valves can also be controlled by exercise of the customer's power to punish or reward, or by their right to change the contract agreement. However, the companies can also control the respective Company Valves. For example, Company A is a contractor that may cease providing information to the customer and/or Company B if it feels threatened by an impending lawsuit. This metaphor can be useful in developing the framework of COPs described by Grisham and Walker (2005) where the object is to link people within a variety of teams across and within large projects to achieve innovation. This metaphor describes a fixed contracting relationship that is likely unique and time constrained. If the relationship between Company A and Company B is a joint venture or partnership then a longer view must be taken. If the relationship is an alliance however, then the there is a need for the relationship to grow, and be nurtured. The next metaphor considers this dimension.

3. METAPHOR 2 – A FRAMEWORK OF KNOWLEDGE AND INNOVATION

The second metaphor uses the metaphor of porosity, permeability and KM through effective experimentation and continuous development of absorptive capacity. Cohen and Levinthal (1990) describe absorptive capacity as the ability of a firm to recognize the value of new external information, assimilate it and use it for commercial ends. It is a measure of an ability to absorb ideas, information and knowledge and applies to both external and internal sources of information and knowledge.

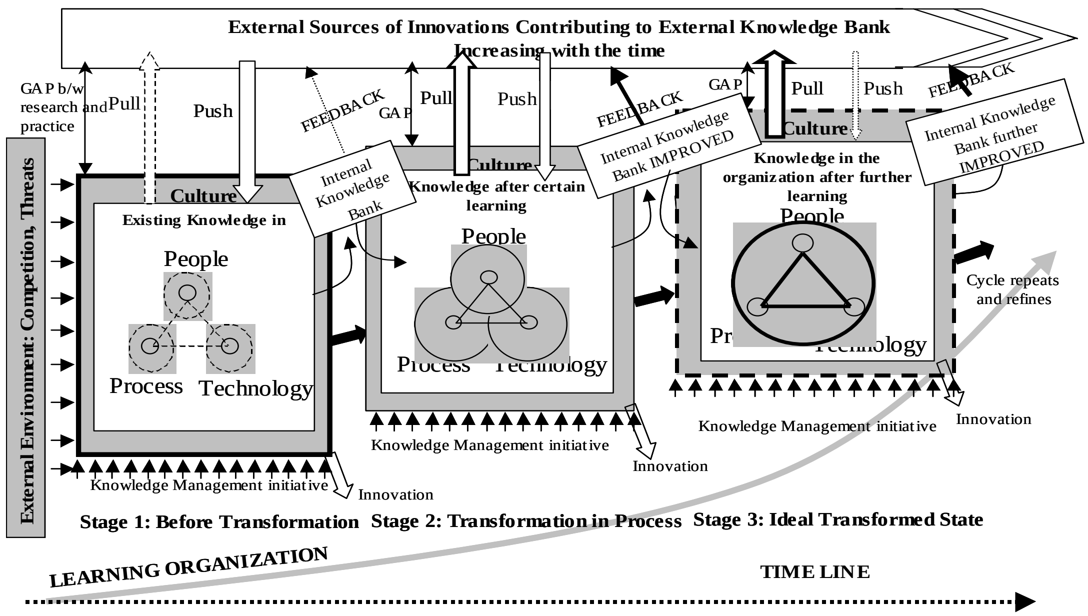

Figure 2: An Absorptive Capacity Metaphor

The framework for increasing absorptive capacity and through it developing a learning organisation that can increase its capacity to innovate and better manage knowledge is presented in Figure 2 that is explained by organisational learning and interaction with external sources of innovation (Maqsood, 2006). This KM framework model illustrates a number of interesting ideas presented as a metaphor. Within each of the boxes there is a progressive drawing together and closer interaction between people, processes and technology from the first stage being almost independent (very loosely coupled) move through subsequent stages of being more closely linked until they are wholly aligned and coherently deployed. Another aspect of this permeability metaphor is the nature of the boundary between the organisation and its surrounding environment. Initially it is isolated by a thick impermeable skin and that gradually dissolves to the third stage which is presented as being gossamer-like with a broken line.

The explanation for the transformation idealized in the framework is the interaction between the organisation and organization-external sources of knowledge. The metaphor is further developed through the degree of push and pull (feedforward and feedback mechanisms) illustrated by size and porosity of the arrows. Figure 2 indicates that KM initiatives place the illustrated organization along an upward innovation trajectory. This figure illustrates a complex theory or framework of how KM, innovation and learning impact and is impacted upon by external knowledge sources in a way that uses rich imagery. This is developed around the metaphor of transparency (the dissolving boundaries) and absorption (merging of the three components of people, process and technology). The model provides a more tangible and vivid description of absorptive capacity that can be expressed in a textual hypothesis, assertion or definition and illustrates the power of visual metaphor. We all share experience of seeing things gradually melt or dissolve and so can better imagine what forces may be at work.

Given the first two perspectives, a major question exists about how to go about creating a model that would facilitate the necessary processes to facilitate, encourage, and nurture the SECI. Moreover, how to accomplish this in a world where teams can be spread across numerous countries and cultures is a challenge. The next metaphor addresses this dimension.

4. METAPHOR 3 – A FRAMEWORK FOR A KNOWLEDGE ADVANTAGE

Prusak (1996) described a decade ago how knowledge can provide sustained competitive advantage and questioned how knowledge could be measured. Over the past ten years a number of research groups have presented answers to that question.
One KM approach came from a 4-year Australian study presenting a capability maturity model that can be used to describe the 'as is' as well as 'preferred' situation to measure KM initiatives (Walker, 2005) that can be linked into a web portal tool that identifies knowledge assets as well as navigate knowledge users to these assets (Walker, Maqsood and Finegan, 2007). The metaphor illustrated in Figure 3 describes the concept referred to as the Knowledge Advantage (K-Adv).

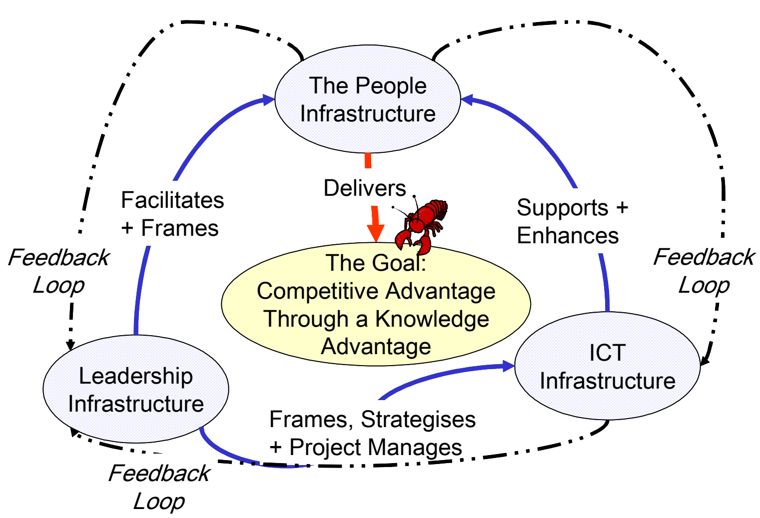

Figure 3: A Knowledge Advantage 'Lobster Pot' Metaphor

The model described in the K-Adv has three major infrastructure components. The key to this concept is competitive advantage. A number of metaphors could describe this, a Holy Grail, Rainbow or something that indicates the trickiness of achieving the result. A lobster pot symbol was used as the metaphor because the lobster is a prized and valuable item, it requires coaxing and tempting to be captured. Figure 3 illustrates the key to delivering the goal as clearly being the result of the efforts of the people infrastructure. This is supported by a leadership infrastructure that provides resources and the necessary organisational support. An ICT infrastructure provides the linking support that allows people use business process to better collaborate and create, share and use knowledge.

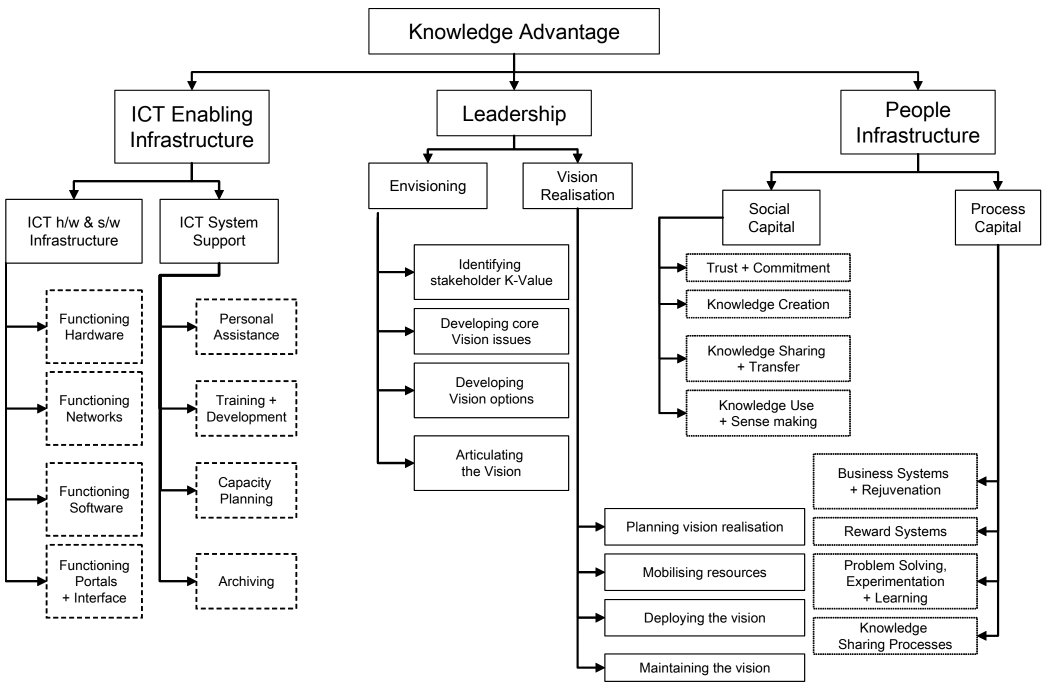

Figure 4: The K-Adv Model

Figure 4 illustrates the details of this model and provides an extension to the high level concept model presented in Figure 3. Figure 4 attempts to present no metaphor.

5. DISCUSSION

Three high level concept models and frameworks involving KM were presented with Figure 4 providing a contrasting more detailed and prosaic representation of the concept illustrated in Figure 3.

As this is a conference paper, and as such is aimed to trigger debate and discussion, we have chosen to use a single representative of senior management to comment on the efficacy of metaphors in this context. That said, two of the three 'academic' authors have also served in senior project management team roles on major construction and engineering projects around the world so the questions we ask and seek to answer are ones that we have personally grappled with.

The question we pose as worth answering is, can such models, when using a theme derived from a suitable metaphor, provide an engaging tool for senior managers who need to be convinced of the advantages and value of any KM initiative to provide the supporting leadership infrastructure intimated in Figure 3 and described in slightly more detail in Figure 4? Can metaphors release the values illustrated in Figure 1 and provide the means to encourage engagement in knowledge sources 'out there' to help dissolve boundaries that inhibit an organisation from adopting KM to become more innovative and grow into a learning organization? How can such an approach be useful to senior managers? These answers are briefly addressed below.

Knowledge Management initiative in the current business scenario is inevitable. The quicker the organization and senior managers (the enforcers) accept this it is better for all. Metaphor 1 is pretty much in existence with the customer insisting for greater interface between the parties engaged. However, the valves are pretty much throttled and at times totally shut off making the process ineffective. Greater realization that working together will not only help achieve customer goals but will also benefit the individual contractors needs to come. At times people learn the hard way only.

Metaphor 2 is not all that successful currently, possibly because many of the organizations are very inward looking in nature. Real sharing of knowledge amongst the organizations is still not very effective especially in the scenario of competing organizations engaged in the same or similar business. It would need lot more appreciation/awareness of the top/senior management that the industrial scenario today is a huge canvas in which multiple artists can paint simultaneously sharing the same colors. As regards Metaphor 3, most progressive organizations have the KA setup in some fashion or the other. Its effectiveness however will depend on the close linkage of the three key elements - people, leadership and ICT setup. In many cases these act independent of each other especially at working level with each group focusing on their own limited objectives. They do not take the time out to do due diligence to share, their ideas across all levels to enhance/leverage the knowledge initiative. An inter link to figure 4 linking the people leadership and ICT set up with the leadership taking the lead and setting an example in making this effective and real time will do the organization a world of good.

6. CONCLUSIONS

This paper provides three examples of KM frameworks and uses a metaphor-based approach to present the concepts as means to encourage senior management support and buy-in from project team members. This preliminary testing of the use of metaphor, while not extensive and experimental in nature, indicates a promising approach to developing a high level way of communicating innovative plans, in this case for KM initiatives in project environments.

We conclude that metaphors can be powerful in their potential to engage and convey rich hidden meanings. There is a danger of using a mixed-metaphor or poorly thought through one that does not culturally resonate with the intended audience so care must be taken when choosing a suitable metaphor. Figure 1 used a simple knowledge-as-flow metaphor using pipes and valves. Figure 2 used absorption and links through varying intensities of pull push forces to describe the way that organisations can draw in knowledge from external sources to transform their innovation and learning capacity. Figure 3 used a lobster pot metaphor for capturing valuable knowledge that can yield a competitive advantage.

Senior managers may find such approaches both appealing and engaging or confusing depending on the nature of the audience and the culture (organizationally and national) in receiving the message clearly. We suggest that metaphor could be more bravely and thoughtfully used by academics and though leaders to encourage and facilitate support for innovation, particularly concerning KM initiatives.

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CROSS-CULTURAL LEADERSHIP IN CONSTRUCTION

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ABSTRACT

The construction industry is slow to change, and the Project Management profession is slow to emphasize the soft skills that are so difficult to discuss, improve, and manage. Since cross-cultural leadership skills are a necessity in all construction markets today, a model for cross-cultural leadership is needed.

Earlier this year as part of the Doctor of Project Management program, research was undertaken to explore the hypothesis that there are cross-cultural leadership dimensions that are effective internationally, regardless of culture. This paper will provide an overview of, and report on the results of that research. The research was based on a definition of leadership as the ability to inspire the desire to follow, and to inspire achievement beyond expectations.

Keywords: Cross-cultural leadership, Culture, Leadership

1. THE INTERNATIONAL CONSTRUCTION INDUSTRY

The mobility of capital, expertise, and resources has led to a market that is dynamic, yet the industry remains staid and conservative (Murray and Langford, 2003). Most all construction projects are unique endeavors because of their technology, location, and people. On many construction projects, the infrastructure for communications and authority must be created rapidly, and placed into operation before testing or improvement can occur. Teams must be built and progress through the forming, storming, norming, performing, adjourning phases described by Tuckman and Jensen (1977). On international projects, the teams are both inter-organizational and intra-organizational. This team building is most often accomplished when the execution of the project has already begun.

In such a dynamic environment, cross-cultural leadership skills are essential for there is seldom adequate time for training and exploration of political, social, cultural, contractual, and technological issues. As the saying goes, the team must *hit the job running*. A leader must have cross-cultural leadership skills to depend upon, and must be able to build *quick trust* (Jarvenpaa, Knoll and Leidner, 1998). One of those strategies was Leadership.

Panteli and Duncan (2004) considered trust in virtual teams from a *dramaturgical* perspective based on the theory of impression management. In this interesting article the authors argue that (Pg. 425): ”when virtual interactions are examined through the dramaturgical perspective, a distinctive type of trust, different from traditional conceptualisations of trust, emerges from players’ actions and interactions, one that is situated within the virtual context that characterises temporary virtual teams.” The authors also point out that Contractual Agreements have been found to be one of the main characteristics of virtual work arrangements and influence (Desanctis and Monge, 1999), (Grisham and Walker, 2005).

Suffice to say that on international construction projects cross-cultural leadership is a key ingredient into the realization of successful projects. The following section of this paper describe the components of what a Cross-Cultural Leadership Model, or XLQ Model.

2. INTRODUCTION

From practice in the international industry, that there are cross-cultural leadership dimensions that are recognized globally (*etic* (Pike, 1967)) trust, empathy, power, and communication skills. As the doctoral coursework and research progressed, the added dimension of transformation emerged. Also, there is a serious lack of published Project Management literature. In a search between 1995 and 2005 of the literature in the Project Management Journal and the international Journal of Project Management there were 1,173 citations, of which 77 addressed leadership or culture, and zero addressed cross-cultural leadership.

Compare this to a search for the word leadership at www.amazon.com for books that yielded over 16,000 references, and for culture over 55,000 references. A search conducted in the electronic EBSCO database for articles at RMIT University yielded over 57,000 articles relating to leadership, and over 62,000 articles relating to Culture.

From experience, there are three aspects to leadership interaction – the leader, the follower, and the situation. The characteristics (personality, intelligence, education, will power, experience, etc.) of the leader are the foundation to the transaction, for the leader must (to use a metaphor) hold the mirror for the followers and situation. The characteristics of the leader have no context without the followers and situation. Therefore, the thesis considers the validation of trust, empathy, transformation, power, and communication to be the domain of the follower and the transaction. The definition of leadership is the *ability to inspire the desire to follow, and to inspire achievement beyond expectations*.

The following sections summarize the finding from the thesis that prepared at RMIT University under the tutelage of Dr. Derek Walker.

3. CULTURE

Cultural theory has predominately been the domain of sociologists, psychologists, and anthropologists. Project Management has paid little attention to the topic in the last ten years. Cultural intelligence (CQ) is a critical attribute for leaders. Cultural

Intelligence influences, and is influenced by, each of the five leadership dimensions of trust, empathy, transformation, power and communications.

The starting place for a review of culture is naturally with Hofstede (2001) who performed his original study in 1968 and a subsequent study in 1972. The version of the text referenced thus incorporates his original work. The dimensions are Long/short term orientation, power distance, uncertainty avoidance, masculinity/femininity, and individualish/collectivism. The restrictions of this paper prohibit a discussion of each, but they can be found in the thesis at www.thomasgrisham.com.

There are numerous other authors who have contributed to the body of work on culture such as ((Hall and Hall, 1990), (Arrien, 1993), (Goleman, 1995), (Darlington, 1996), (Luthans and Hodgetts, 1996), (Earley and Erez, 1997), (Gibson, 1997), (Inglehart, Basanez and Moreno, 1998), (Trompenaars and Hampden-Turner, 1998), (Den Hartog, House, Hanges, Ruiz-Quintanilla and Dorfman, 1999)), and (Jarvenpaa *et al.*, 1998) to mention but a few. The range of perspectives includes numerous disciplines and perspectives, and recently more international research.

Another mammoth study was the GLOBE Survey (House and Javidan, 2004). In one of the broadest and most thorough studies of leadership and culture, House and Javidan (2004) reported on Global Leadership and Organizational Behavior Effectiveness Research Program (GLOBE) survey of 17,300 mid-level managers representing 951 organizations (financial services, food processing, and telecommunications) in 62 cultures. The research addressed how organizational practices are influenced by societal forces, and they cross referenced their work with that of Hofstede (2001), and Schwartz (1994). The editors found that leadership is culturally contingent upon the culture in which the leader functions. The dimensions for culture were uncertainty avoidance, power distance, institutional collectivism, group collectivism, gender egalitarianism, assertiveness, future orientation, and performance orientation.. The *practice* was established by asking how things actually are, and the *values* by asking how things should-be. The work on the thesis connected the leadership dimensions back to each of these cultural dimensions.

4. KNOWLEDGE

In the global economy, it is important that people develop the ability to empathize with other cultures, rapidly. In an environment that relies heavily on virtual communications with teams spread around the globe, building trust and providing leadership are critical business and project management skills. There is a significant body of literature on cross-cultural issues, but often it focuses on a thin band of customs and business practices. While this knowledge is essential, it generally is only durable enough for short business engagements. It is not adequate for extended expatriate assignments, or for extended projects with virtual teams. Another method is needed if one is to learn more quickly about other cultures.

One potential method that has emerged is the use of metaphors to provide a window into other cultures that is rich and informative, not judgmental. The literature on metaphors begins with Aristotle, and has a long history of debate between those who believe metaphors to be a knowledge transferable representation of complex ideas, and those that believe it to be an intellectually lazy way to avoid detailed descriptions of complex ideas. There are also those that have argued that metaphors in the cultural domain are in danger of crossing the line into stereotypes. Metaphors are a way to increase the understanding of other cultures, and thus empathy. Further, the study of metaphors will help those from low context cultures, like the Unites States, to develop sensitivity for communications in high context cultures.

The work of Gannon (2004) is most useful in understanding ways to expedite the learning curve and provide richer insights into cultures. It provides far more than just the normal considerations for gift giving, meeting timing, and social etiquette. A model based on six-sigma terminology was developed. Green belt level meaning a person has an understanding of basic etiquette, black belt level meaning a person has a Gannon level of understanding, and master black belt meaning a person has lived in the culture.

5. LEADERSHIP

There are no shortage of leadership theories and studies, and there are numerous overlaps in terminology relating to the differences between leadership and management. This section of the paper will focus on published leadership issues, research, and theory. The starting point for leadership research is Bass & Stogdill (1990), not because they were the first, but because their work was such a complete review of the literature, and such a thorough consideration of the issues relating to leadership. The work of so many top writers of the last century addressed this issue including ((Yukl, 1998), (McGreggor, 1960), (Drucker, 1973), (Goldsmith, Greenberg, Robertson and Hu-Chan, 2003), (Heifetz and Laurie, 1997), (Burns, 1978), (Yeung and Ready, 1995), (Bennis, 1989), (Turner and Henry, 1996), (Hoppe, 1990), (Mullavey-O'Brien, 1997), (Kluckhohn and Strodtbeck, 1961)), and many more.

Turner and Müller (2005) were commissioned by the Project Management Institute (PMI) to conduct research to determine if a projects manager's leadership style was a success factor on projects, and if it id different on different types of projects. The authors started with a literature review and found (Pg. 49): "surprisingly, the literature on project success factors does not typically mention the project manager and his or her leadership style or competence as a success factor on projects. This is in direct contrast to the general management literature, which views effective leadership as a critical success factor in the management of organizations, and has shown that an appropriate leadership style can lead to better performance."

This section of the thesis provided a review of the literature on leadership from 1862 through 2005, and highlighted the connections between the works referenced and the hypothesis of the thesis. There is a very rich body of knowledge in leadership that has been explored by psychologists, sociologists, anthropologists, religious scholars, political scientist, business management thinkers, and many more. The research attempted to provide a wide range of perspectives on leadership rather than an exhaustive study of a limited number of authors, for it is believed that this approach is better suited to a study of cross-cultural leadership. It provides diversity of opinion and viewpoints.

6. CONFLICT

Conflict is an integral part of human interaction between people, groups, cultures, sects, firms, and countries. Conflict can, if guided, be healthy and productive. However, if ignored may lead to disastrous consequences, and the deterioration of long-term relationships. In the international marketplace, the potential for conflict is extremely high as cultural beliefs and customs collide with regularity. Therefore, cross-cultural leadership must attend to the inevitability of conflict with guidance, knowledge, patience, and a celebration of diversity. Part of cross-cultural leadership intelligence, is the ability to manage conflict. A strong leader will avoid avoiding conflict, and will imbue this attitude in his/her followers.

As with all of the other section of the thesis, there was an abundance of literature on conflict. One book that is particularly well researched and assembled was by Michelle LeBaron (2003). Ms. LeBaron provides a superb review of the literature, and a concept of lenses that corresponds well to the types of issues that are actually encountered in international disputes. Experience as an arbitrator for the International Center for Dispute Resolution confirms her approach as being a solid and practical way to think about cross-cultural conflict resolution.

Other authors discovered in the research included ((Rahim, 1983), (Augsburger, 1992), (Habib, 1987), (Levinson, 1994), (Singelis and Pedersen, 1997), (Avruch, 1998), (Levine, 1998), (Ting-Toomey, Gao, Trubisky, Yang, Kim, Lin and Nishida, 1991), (Deutsch, 1973), and (Lederach, 2000)) to mention a but a few.

The research led to the creation of the Hourglass model for dispute resolution. The lenses of the hourglass mode start with knowledge, progress through diagnosis, and then intervention. From the intervention will flow lessons, through diagnosis again, and extend knowledge. The model is a general process and is not intended to be a dogmatic or static approach. For example, as knowledge is consulted there will be a possible recognition that more information is required and therefore some diagnosis may be required. Following this same approach there may be a need to engage (subtle intervention) in preliminary dialogue to facilitate the diagnosis and knowledge. The perfect world would be 100% knowledge at the start, with a mindset to acquire as much knowledge as possible. The size of the ellipses represents the amount of time that should be applied to each of the lens. On the output side, lessons are learned and they need to be diagnosed, and then the knowledge base can be increased - this could be from an individual to an institutional perspective.

It is suggested that the model be applied using a preventive approach, but it may be utilized just as well in a responsive way. The key is that the acquisition of knowledge and diagnosis of the conflict are the most important lenses. Many conflicts occur from a lack of understanding or a failure of communications. Both of which can be moderated by increasing the knowledge and diagnosis prior to a formal or structured intervention.

In the knowledge lens, the use of metaphors is a critical technique for developing a richer knowledge of cultures (personal, societal, commercial, etc.). A cultural knowledge of the cultural individuality of the contestants including religion, customs, folklore, music, art, literature, philosophy, language, history, geography, ethics, power, gender, and economic status are critical. Knowledge of the structure of the economic agreement is also important to know whether it is a fixed price contract or an alliance. For diagnosis, an example of a necessary technique would be to employ active listening skills to increase the knowledge of the details or feelings of the contestants. This would also be a skill of great importance with the intervention lens. During intervention, negotiation skills are primary, after communication and effective listening.

7. TESTING AND RESULTS

The hypothesis was tested using a Delphi panel of experts. Two rounds of questions regarding leadership, culture, knowledge, and conflict were posed to the panel. After the first round, the results were shared with the entire panel, so that they could be utilized in the second round. The Delphi panel consisted of 23 panelists with almost 700 years of international cross-cultural experience. The hypothesis was confirmed by the panelists, as were the connections to the GLOBE survey dimensions of culture. The detailed procedures utilized and the test results are available at www.thomasgrisham.com.

8. XLQ MODEL

The goal of the thesis was to develop a model for cross-cultural leadership. To meet this goal the first step was to explore the existing literature on cross-cultural leadership, knowledge transfer through metaphor, and conflict management in a multi-cultural environment. The review included multi-disciplinary sources, and utilized an exegetical approach in the evaluation of the literature.

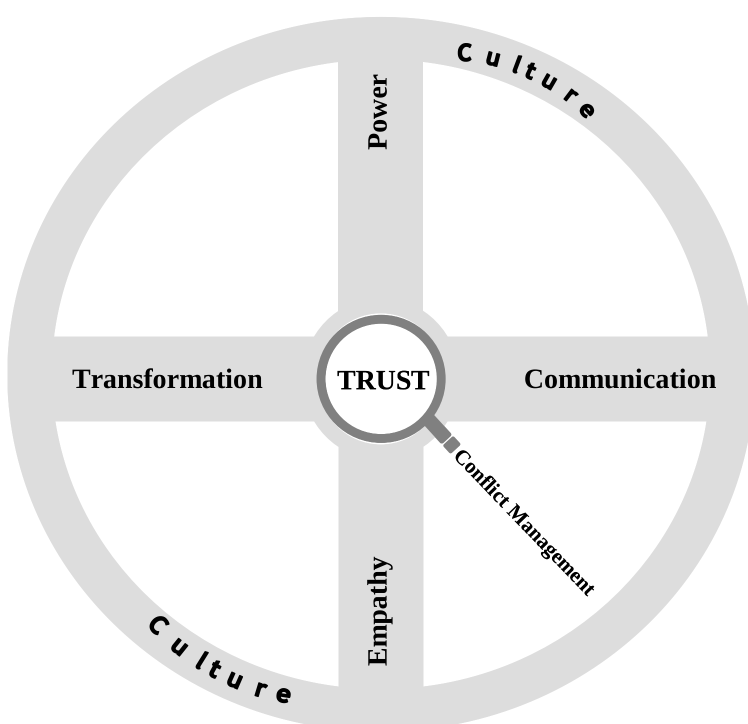
The results of the thesis were the XLQ Model that is shown in Figure 1. The hub of the steering wheel is Trust, without it, leadership cannot function. The spokes of the wheel are Transformation, Communication, Power, and Empathy. The wheel itself is culture for without the effective use and coordination with the other aspects, the wheel would in fact not be a wheel, and would be ineffective. The lubricant for the wheel is Conflict Management. Conflict can be used to stimulate creativity, but if not managed can cause enough friction so that the wheel cannot turn.

The wheel also assumes that the leader has knowledge of each component of the wheel, and of the destination or goal of the drive. A weakness in any component will reduce the effectiveness of the leader, and will potentially lead to a non-sustainable business model. The XLQ Model was constructed from the XLQ Aspects of Leadership and Culture. The XLQ Leadership Dimensions (Trust, Empathy, Transformation, Power, and Communications) are made up of Descriptors and Sub-descriptors that are detailed in the thesis.

International Project Management, and business management, has suffered from a lack of a codified approach to the training of people to work in multi-cultural environments. There are no shortages of cultural training programs in existence, and certainly no shortage of leadership and cultural theories. What the thesis has attempted to do is to provide a simple model for cross-cultural leadership that can be used for evaluating and improving leadership skills, resulting in improved performance. The model provides a simple outline of leadership attributes that can be utilized to structure assessment and training for Project Managers in a consistent and systematized manner. For the model, it does not matter if the Project Manager was born in China and raised in the USA, or born in the USA and raised in Japan since it is a universal *etic* template. So training for leadership skills in Malaysia or Botswana can be structured in the same way, with the emphasis on the XLQ Leadership Dimensions.

The model also provides a structure for future research and testing. For example, if testing a group of executives from three countries for the importance of face, the relationship of face to XLQ Leadership can be linked. Future research can be connected back to XLQ Model to further amplify and confirm/reject the Descriptors and Sub-descriptors. Or research on metrics for evaluation and training can utilize the Delphi panel scores as a benchmarking system.

Figure 1. XLQ Model



9. CONCLUSIONS

International Project Management, Construction Management, and business management, has suffered from a lack of a codified approach to the training of people to work in multi-cultural environments. There are no shortages of cultural training programs in existence, and certainly no shortage of leadership and cultural theories. What the thesis has attempted to do is to provide a simple model for cross-cultural leadership that can be used for evaluating and improving leadership skills, resulting in improved performance.

Furthermore, hhe model provides a structure for future research and testing. For example, if testing a group of executives from three countries for the importance of face, the relationship of face to XLQ Leadership can be linked. Future research can be connected back to XLQ Model to further amplify and confirm/reject the Descriptors and Sub-descriptors. Also, research on metrics for evaluation and training can utilize the Delphi panel scores as a benchmarking system.

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A KNOWLEDGE MODEL FOR ASSESMENT OF TRANSFORMATION CAPACITY WITH RESPECT TO SPATIAL FLEXIBILITY

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ABSTRACT

At present, there is in the Netherlands a mis-match between the existing housing stock and the demand. On one hand, clients (residents) require more spacious living units as well as a sufficient typology variation. On the other hand, there is a substantial existing housing stock which does not meet these requirements and needs either to be transformed of demolished. Before any design decision can be made, the analysis of the buildings should be carried out as to determine whether the existing buildings have some future value. At present there are no methods to deal with this problem and decisions are very often made *ad hoc* and sometimes even without such analysis. In order to avoid such solutions there is a need for a systematic approach to evaluation of existing buildings. This paper proposes a method that can be used at every project start-up where a question regarding demolition or transformation appears. Firstly, building transformation in relation to spatial flexibility will be discussed followed by brief explanation of steps needed for knowledge modeling. Secondly, input and output aspects for knowledge modeling will be explained. Finally, knowledge modeling by neuro-fuzzy system will be described followed by a practical application.

Keywords Demolish or transform, neuro-fuzzy approach, knowledge modeling, transformation capacity

1. BUILDING TRANSFORMATION AND SPATIAL FLEXIBILITY

A transformation of the building can be measured on different levels of building composition such as: spatial, structural and material level. Taking into account more frequent demands for transformation of buildings it can be expected that in a future a quality of the building will be measured by its ability to transform on all levels of its composition [Durmisevic 2006]. This is related both to changing user requirements but also to environmental issues. However this paper will discuss the assessment of transformation by measuring spatial flexibility of housing projects since spatial capacity of buildings will determine whether a building has a potential to accommodate different layout typologies. Consequently the technical systems will determent the environmental and economic costs related to the changes from one typology to another. This implies that the economic life-span ends when the functional requirements are not met by the technical specifications. This results in reinvestments related to a building such as replacement of components or demolition of structure. The top graph in *Figure 1* shows the sequences in functional change within a user's organization. The changes occurred three times over 30 years. In relation to this, a second graph shows the technical performance required for these changes. The technical life-time is a life-span within which a building meets the technical performance requirements in a given maintenance strategy.

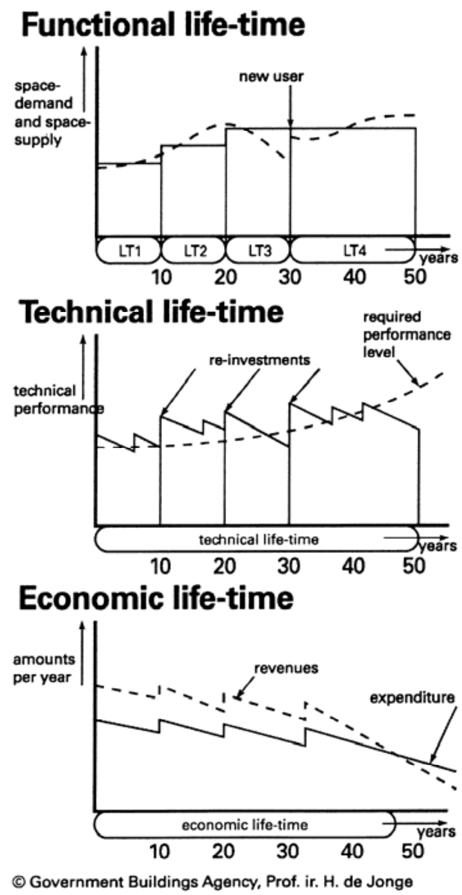

Figure 1: Functional, technical and economic life-time of buildings [Jonge, 1994]

A third graph shows the economic life-time of a building. Economic life-time is the time-span within which a building meets the return on investment criteria of the owner [Ang & Wyatt 1999]. Each time a functional and technical change is made, the revenue and expenditure graph changes. Recent research by housing corporations in the Netherlands indicates that by taking into account the increasing number of functional changes the total life cycle costs of a building would become less if a building would have higher spatial flexibility. This implies that besides the operational costs, which have an influence on total life cycle costs primarily thorough energy use and maintenance, spatial flexibility to change is equally important when it comes to the Life Cycle Costing of one building.

In this paper a development of a knowledge model that can assess a transformation potential of a building regarding spatial flexibility will be discussed. In the next section a brief overview will be given of required steps for knowledge modeling.

2. STEPS FOR KNOWLEDGE MODELING

The rules of decision making process are seldom made explicit. Yet in order to make the evaluation of buildings more efficient there is a need for knowledge modeling which captures and learns the rules and more or less automates decision-making process (*figure 2*). In general, there are five phases of knowledge model development:

1. determination of input and output variables (specifying aspects that can have an affect on the output, a sort of knowledge representation)
2. data acquisition (depending on a type of problem various approaches are possible, this can be qualitative or quantitative data)
3. knowledge modeling (by soft computing technologies such as fuzzy logic and neural networks)
4. knowledge exploitation (tacit knowledge becomes explicit)
5. knowledge visualization (various ways to exploit the knowledge by means of calculations, tables, relationship presentation, graphs etc. with use of a user friendly graphical interface)

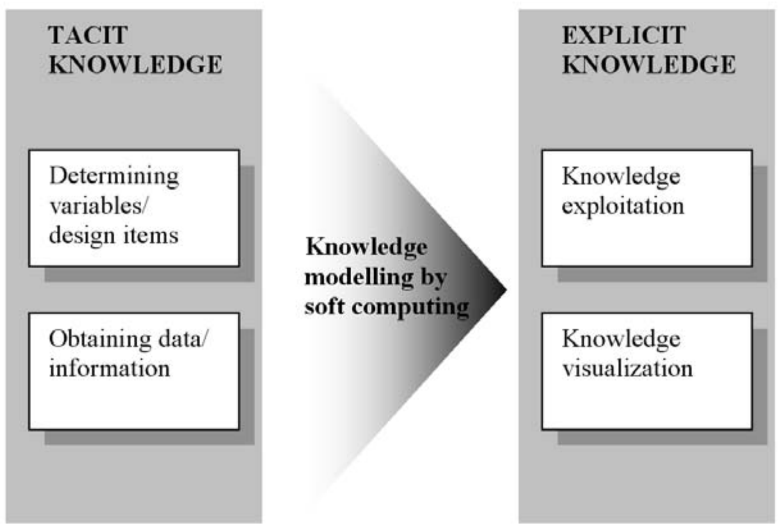

Figure 2. From tacit to explicit knowledge by means of soft computing techniques

The focus of this paper will mainly remain with the first and third step of knowledge modeling ending up with a practical application. In next section, the aspects that form a base of a knowledge model will be given.

3. ASPECTS RELATED TO SPATIAL FLEXIBILITY

It is our intention to assess building's transformation potential by establishing relationships and impact that each single aspect related to spatial flexibility has on transformation potential. For knowledge modeling this means that the aspects related to spatial flexibility represent the inputs and transformation potential represents the output.

A building's transformation potential based on a spatial flexibility has been defined as a function of:

- dimension (span) of the load bearing structures;
- typology of the load bearing system;
- position of main and distribution service installation net;
- an integration of the services with building components.

According to this an evaluation model is designed, in order to assess the Transformation Value ($\sum T_v$) which indicates the spatial possibility of an apartment to transform. Main purpose therefore is to evaluate a building in respect to its spatial transformation. In order to achieve this all building elements can be classified into two groups: *fixed* and *flexible*.

Under the fixed elements the following aspects are considered:

a. *load bearing structure (support)*

a.1. type and dimension

a.2. type and material (T_{v1} value is obtained by considering a.1 and a.2).

In this paper following types following types of load-bearing structure are distinguished: tunnel system, post and beam structure, panel and combination of both. Regarding materials used, very rough distinction is made, meaning that only poured concrete (as a material that is difficult to tear down and replace) and prefab elements (all other materials, which are easier to tear down and replace) are considered. When discussing load bearing structure the following aspects are of importance: materials, dimension (span) and type of structure. Interdependence of the *dimensions* (span of load-bearing structure) and *types* of load-bearing structure influences the spatial flexibility, while the interdependence of the materials and types can influence the capacity of structure to be transformed and therefore the spatial flexibility as well.

b. *main service net/ vertical installations*

b.1. positioning - central or peripheral positioning.

b.2. accessibility - build in construction or independent of construction (T_{v2} value is obtained through consideration of b.1 and b.2).

Another element that is considered as fixed is main installation net. Its position and accessibility of installations will have great influence on spatial flexibility.

Under flexible elements the following aspects were considered:

a. *inside partitioning*

The materialization of the walls in the apartment and the possibility to remove them, or change their position depends greatly on the fact weather they are made of masonry or system walls (T_{v3}).

b. *distribution service net installation servicing – horizontal and vertical distribution*

In this context the accessibility and positioning were taken into consideration, such as for example, whether the installation servicing is build in construction or separated from it (T_{v4}).

Recent IFD program by the Dutch government has stimulated a development of flexible systems that provide separation between structure, services and partitioning element. Therefore, today we can talk of inside partitioning and installation servicing as being separate from the main construction, while in the past this was not a case, which made buildings very difficult to adapt to new requirements. Whether the vertical installations on a building level and servicing distribution on a dwelling level are either build in construction or separated from construction, influences greatly the transformation value.

All the above-mentioned parameters together define the transformation potential with respect to the elements that determine spatial flexibility of a dwelling. They are basic components that were used for network training. This training is done by neuro-fuzzy system which will be briefly explained further in the text. More details regarding this training and method validation can be found in Ciftcioglu *et.al*. [1999] and Durmisevic, S. [2002].

4. KNOWLEDGE MODELING BY SOFT COMPUTING

In general, knowledge can be placed in two categories: explicit and tacit. Explicit knowledge can be relatively easy modeled using computer languages, rule-based systems or decision trees. This type of knowledge can be expressed into formal language including manuals, guidelines, mathematical expressions etc. On the other hand, tacit knowledge, first introduced by Polanyi [1958], is a personal knowledge which is rather difficult to express with formal language since it is embedded in personal experience which involves subtle aspects such as personal beliefs, views and value system. In that respect, neural network in combination with fuzzy logic can be used to model tacit knowledge, taking a form of an expert system. But here a distinction must be made between traditional expert system and to be expected a new generation of intelligent expert systems. The main problem of the traditional existing expert systems which are mainly rule-based systems is that they are deductive rather than inductive. In most applications where an expert system with intelligent capabilities is desirable, the knowledge is not or may not be exact. This is most definitely a property of decisions related to design. Rather much of design knowledge (which is necessary in order to evaluate buildings regarding some design issues) is inexact and imprecise. Especially in evaluation process, in place of exact reasoning the approximate reasoning is desired. An influential method of approximate reasoning is fuzzy logic, which is a method of reasoning with inexact propositions. It is a method of choice for handling uncertainty in expert systems, in the sense of artificial intelligence for inductive outcome. Here the main task is the establishment of consistent rules. To reduce the complexity of such a system, the rules should be established in an intelligent way through learning in any degree of complexity needed by machine learning techniques.

Therefore to facilitate a decision-making process, a systematic approach with the application of artificial intelligence (AI)-based information processing is required. In this approach, a human expertise is cast on a knowledge representation in a computer-based system, which is made available to external inputs for human-like decisions. Therefore, the outcome is consistent with the knowledge-base established within the system and the decisions made are instant, compared to comprehensive “human-deliberations”. In other words, tacit knowledge is captured in a neuro-fuzzy system, which is a hybrid system that combines efficiently Artificial Neural Networks (ANNs) and Fuzzy Logic. This requires some further explanation. The direct application of

ANNs in architectural domain is in general difficult, since it requires crisp inputs. The direct application of fuzzy logic (FL) in architecture is difficult since it needs well defined membership functions to operate with well-defined rules. The problem can be overcome by using both neural and fuzzy system together. In such way the difficulty of ANNs is evaded by FL and the difficulties by FL are overcome by machine learning. In other words, the positive characteristics of FL are utilized, such as the possibility to deal with linguistic variables as well as the advance fuzzy information processing method. The learning and the generalization are provided by artificial neural networks. This is a so-called neuro-fuzzy system, or a hybrid system [Rao and Rao, 1995; Kasabov, 1996; Turban and Aronson, 1998] that utilizes the positive features of both systems and integrates them into one.

The Radial Basis Function Network (RBFN) form one of the essential categories of feed forward neural networks. The main architectures, learning abilities, and applications are described in literature [Brommhead and Lowe, 1988; Moody and Darken, 1989; etc]. In particular some interesting equivalence between RBF networks and fuzzy rule-based systems have been established [Jang and Sun, 1993; Hunt et. al., 1998]. In this equivalence, the normalized Gaussian function plays the role of membership functions.

$$\varphi(r) = \exp(-\frac{r^2}{2\sigma^2})$$

The RBF network has appealing properties for soft computing. Next to their equivalence to fuzzy inference systems under lenient conditions, they can be used for multivariable functional approximation using basis functions. In this case, the learning is equivalent to finding a surface in a multidimensional space that provides the best fit to the training data [Haykin, 1999] and that can later be used on a test cases provided that it has sufficient generalization capabilities obtained during the training process.

For this research we have used qualitative data, exploiting 22 data sets for training and thereafter using a several test cases to validate the knowledge model. This procedure is already explained in [Ciftcioglu, *et. al.*, 1999] and will not be the scope of this paper. Instead of that, later in the text, we will explain how this knowledge model was applied for a practical problem and was a part of decision-making process for housing corporation 'Rondom Wonen' and EGM architects.

5. APPLICATION OF KNOWLEDGE MODEL: THE PIJNACKER CASE

A housing corporation 'Rondom Wonen' together with the municipality Pijnacker-Nootdorp whished to redevelop the northern district of Pijnacker and to improve the quality of apartments and its surrounding [Zoet et.al. 2003]. The required redevelopment was needed at three levels: 1) district, 2) street and 3) apartment level. EGM research (where S. Durmisevic was employed at the time) supervised decision-making process during project start-up and EGM architects integrated research results in a design proposal. This project includes 442 apartments divided over 16 housing blocks that were built in 1968. The flats lie in a beautiful, green district but look somewhat monotonous and dull. There are also rather few housing types available. Some photographs of the current situation are given in *Figure 3a* and *3b*.

Figure 3a and 3b: Three and five stories high apartment blocks (current situation)

In order to support the decision making process regarding a question as to whether the existing housing stock has the potential for future use or not an assessment of transformation potential with respect to spatial quality of the building has been done.

In Pijnacker flats the main load-bearing construction is a tunnel-like structure which provides a certain degree of flexibility due to a larger span of 4.0 and 4.5 meters. This has an influence on T_{v1} value. The installations are placed on a periphery which has advantages in relation to the spatial flexibility (T_{v2}). Depending on the apartment type the tunnel can be to some degree opened as to spatially connect two areas (T_{v3}). The vertical installations are easily accessible, but disadvantage is that all horizontal installations are built in construction which makes them less accessible (T_{v4}). All T_v values were evaluated on a scale from 0 to 1, with 0 being the worse score and 1 the best:
T_{v1} = 0.8273; T_{v2} = 0.8173; T_{v3} = 0.6454; T_{v4} = 0.5136.

A typical apartment layout (*figure 4a*) and its corresponding assessment values is given in *figure 4b*.

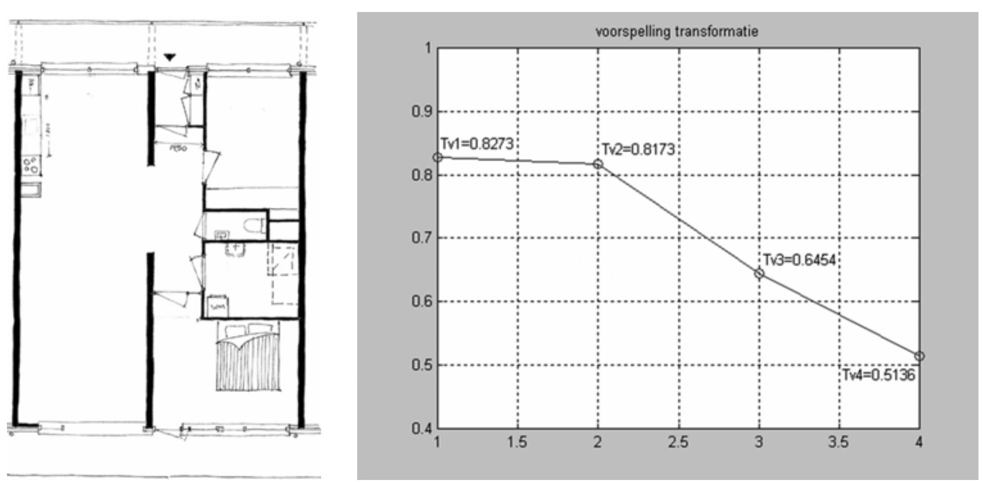

Figure 4a and 4b: Apartment layout and an assessment of transformation value of the same apartment based on neuro-fuzzy knowledge model

As it can be seen from the assessment, the T_{v4} value is lowest, but considering other T_v values it can be stated that transformation is meaningful, especially due to a fact that spatial transformation is rather high which implies that a variety of apartment layouts can be accomplished. This is rather important for the users (possibility to choose), municipality (providing opportunity for social mix) but also in the exploitation of these buildings in the future (a housing corporation Rondom Wonen who is at the same time the owner of the apartments).

Figures 5a and *5b* give some impression of the redevelopment. This was a first proposal and in a meanwhile the project undergone some minor changes. For this project various apartment layouts were designed as to provide a social mix in a new redeveloped neighbourhood. Taking into account the assessment of T_v values, together with separate cost estimation, it was systematically determined that 382 apartment had a future value and could be transformed while 60 apartments had such low T_v values that the demolition was the best option.

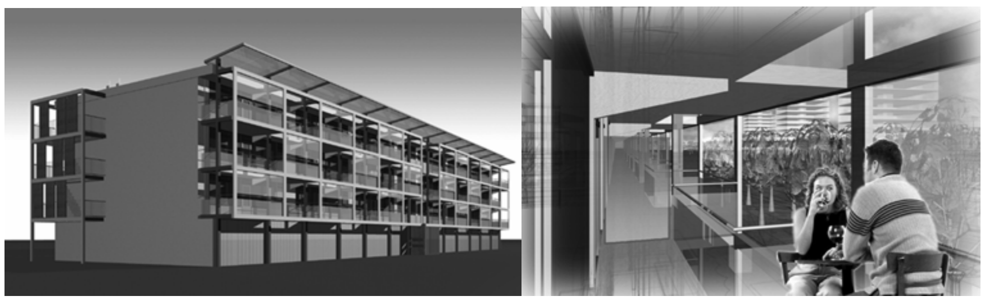

Figure 5a and 5b: A transformation of façade (three stories high) and the artist impression of the enlarged balconies

6. CONCLUSIONS

The method proposed in this paper has a high potential since it enables modeling of interdependencies of practically an infinite number of aspects. The quality of the outcome is dependent on the quality and the quantity of input data used for network training. At present, not all aspects related to transformation capacity are integrated in a model (like for example technical aspects and costs) but due to a dynamic structure of this model addition of any new aspect, or an improvement of the existing is possible at low cost. The rules are established in an intelligent way by machine learning techniques which make it possible to deal with any degree of complexity, rather than establishing the rules after careful deliberations on existing information. That is the main advantage of this neuro-fuzzy model compared to conventional expert systems. The described knowledge model provides necessary support in order to asses the transformation potential of the apartments. It can be used for evaluation of the existing housing projects as well as for the evaluation of the design solutions. Knowledge modeling by soft computing, as demonstrated in this paper, can speed-up decision making process and improve decision quality regarding transformation or demolition of the existing buildings.

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EVALUATION OF A REAL-TIME CONSTRUCTION PROJECT PROGRESS TRACKING

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ABSTRACT

Effective project management requires controlling all aspects of a construction project: quality and quantity of work, costs, and schedules to guarantee the success of the project. Performance monitoring of the entire construction project is crucial. One way of measuring overall performance is by using an aggregate performance measure known as Earned Value. All work is planned, budgeted, and scheduled in time phased planned value increments constituting a cost and a schedule measurement baseline. Earned Value is mainly used to monitor the progress of work and compare accomplished work with planned work. A proposed new model based on wireless communications technologies, to track the progress of percentage completed in a construction project is being presented in this paper. The model is based on the application of smart chips with wireless communication. It will greatly increase productivity and efficiency, reduce labor hours and time required for tracking, and give more accurate results in estimation. This new technology includes an automated system of reading RFID tags placed on items that send out either a tracking number, or other information for that item, directly to the reader. Keeping track of the material used on site, based on the estimated quantity will permit making a better estimate of the amount of work done on a construction site. A life cycle cost of the system will be presented. The model is evaluated using a utility function method.

Keywords: IT, Life Cycle Analysis, RFID, Wireless technologies,

1. INTRODUCTION

The evolution of Information Technology (IT) has changed the way that nearly all industries do business. Since desktop computers became affordable, management of information within organizations has transitioned from paper-based to electronic formats. The development of the Internet has also changed the way the world accesses and shares information. The construction industry has seen a similar penetration of IT and has in part changed due to IT (Tucker et al., 1994).

A construction project is considered as a process that involves many activities that are related to each other. During the construction phase of a project it is essential that good and timely flow of information prevail throughout the process. The desire for greater collaboration among construction participants must be aided by improved communication throughout the construction process. Unless current communication technologies and practices are improved dramatically, greater integration of design and construction could actually increase waste as it increases the corresponding need for communication (Elvin, 2003). Wireless technologies have the potential to solve this communication problem, increase collaboration, and provide new capabilities through evolving technologies. The basic premise of Wireless Construction is to network previously stand alone islands of communication on a construction site to allow for the network to be seamlessly interfaced with the ever growing world-wide-web. Still construction industry has been slower than other industries in adopting new technologies into its business processes due to the high cost associated with its implementation and lack of good evaluation methods to help as a decision tool.

Firms have to continuously improve their productivity and efficiency in order to maintain a competitive advantage. Monitoring the performance of the entire project is crucial. One way of measuring overall performance is by using an aggregate performance measure called Earned Value. Conventional methods relied on feedback given by superintendents on the construction site. Based on their experience and amount of work done per day, superintendents submit a report at the end of the workday so that progress of work based on a schedule developed earlier can be updated manually. This method is not efficient because it lacks accuracy in tracking progress, has delays in acquisition of information, and the schedule is updated manually. Once some problems on the construction site are identified, a new model based on wireless communications technologies, to track the progress of percentage completed in a construction project is presented. The model, based on a combination of Radio Frequency Identification tags (RFID), PDAs, and wireless technologies, in tracking the progress of percentage complete in a project; is being investigated in this research. An evaluation approach is also presented to prove its efficiency and benefits to the construction industry.

2. TECHNOLOGY OVERVIEW

The use of technology to improve the efficiency of construction site is a novel concept. Construction firms began to examine the use of barcodes for tool management by the beginning of 1990’s (Goodrum et al. 2005). Later in the mid nineties, RFID was introduced to the construction industry. RFID can be viewed as a sister technology to bar code labels which use radio waves instead of light waves to read a tag (Jaselskis and El-Misalami, 2003). Data may be stored on the tag or transponder for the purpose of providing identification and other information relevant to the object carrying the tag. The RFID system is composed of tags that carry the data in transponders, and RFID readers that retrieve the data from the tags (CII, 2002).

Wireless communications have sustained a tremendous growth rate over the past decade. Significant strides have been made in the technology and by the communication community to provide reliable services (Padgett et al., 1995). There are numerous applications for all different wireless technologies. Application of wireless technologies can be categorized into voice messaging, handheld and internet enabled devices, and data networking. With the advancement of wireless network comes the application of handheld computers at a construction site. Various construction firms started implementing handheld computers on the jobsite for gathering data, scheduling, quality inspections, layout, and other type of information exchanges (Inglesby 2000).

3. MODEL FRAMEWORK

The objective of the model presented in this paper is to track the quantity of materials and equipment usage on the construction site on real-time, and be able to calculate the percentage complete of the activities based on the tracking information. The main components of this system are RFID tags and readers, handheld computers, and a wireless network. Figure 1 presents the problem statement and potential solutions for these problems.

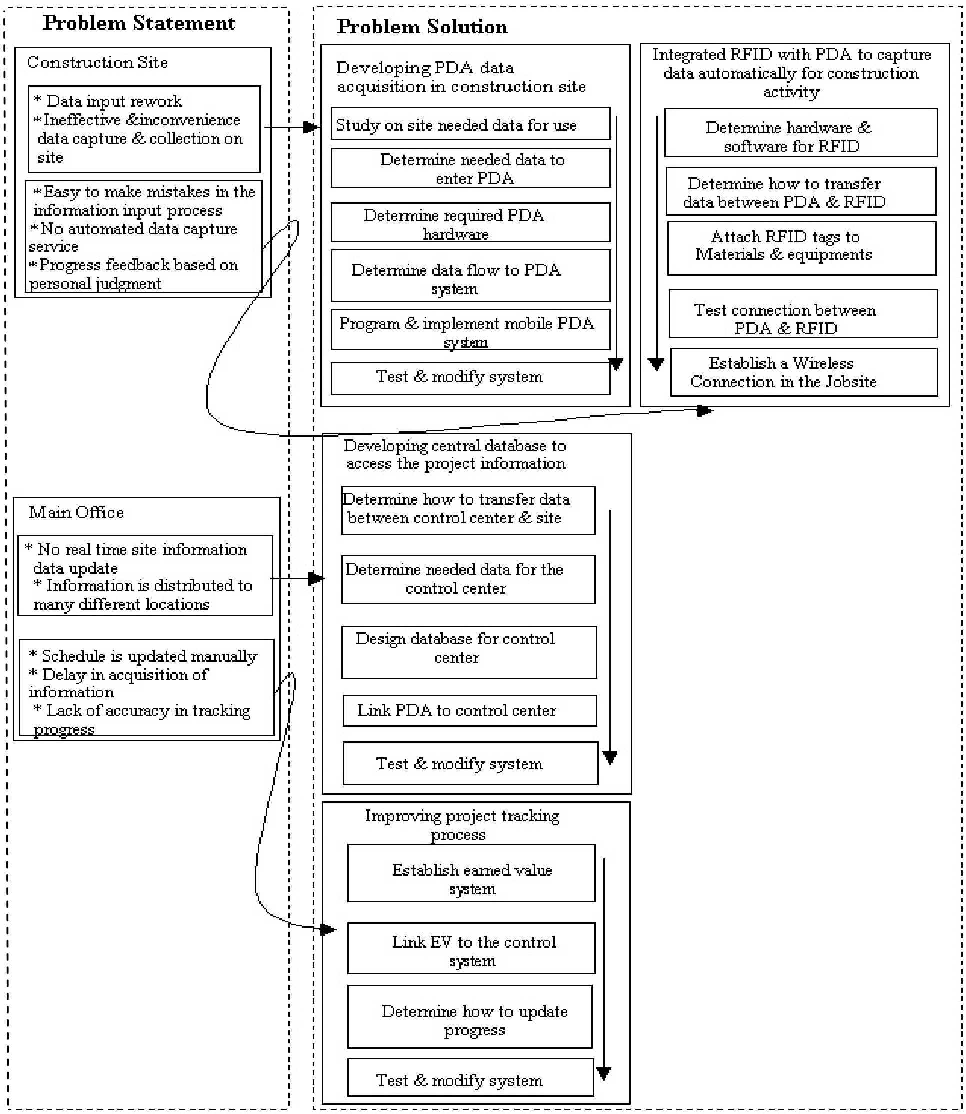

Figure 1: Problem Statement and problem solution

3.1 Model Description

Individual objects scheduled for arrival on the construction site are either tagged at the vendors or at the job site using radio frequency identification tags. The encoded information is scanned directly into a portable computer and wirelessly relayed to a remote project database. This database has dual functions. A database query returns graphical representations (e.g. computer aided design CAD) like where to install the materials and the method used for installation. The second function of the database is to relate the materials to the corresponding activities in the project schedule. Based on the percentage of usage of the materials installed on the construction site and the related activity, Budgeted Cost of Work Performed (BCWP) is updated and in turn the schedule will implement the changes automatically every time information is recorded in the Personal Digital Assistant (PDA) and sent through the wireless connection to the database.

The same thing is applied to the equipment on the construction site. The activities that involve only equipment work, like excavation, hauling are tracked through the number of hours these equipments are used. Based on the productivity of the crew and machines, the quantity of work to be done, and the total number of hours BCWP can be updated. Figure 2 represents the basic components of the system.

By the time this paper is written, only application of IT is evaluated. The model is not yet fully integrated in the construction site.

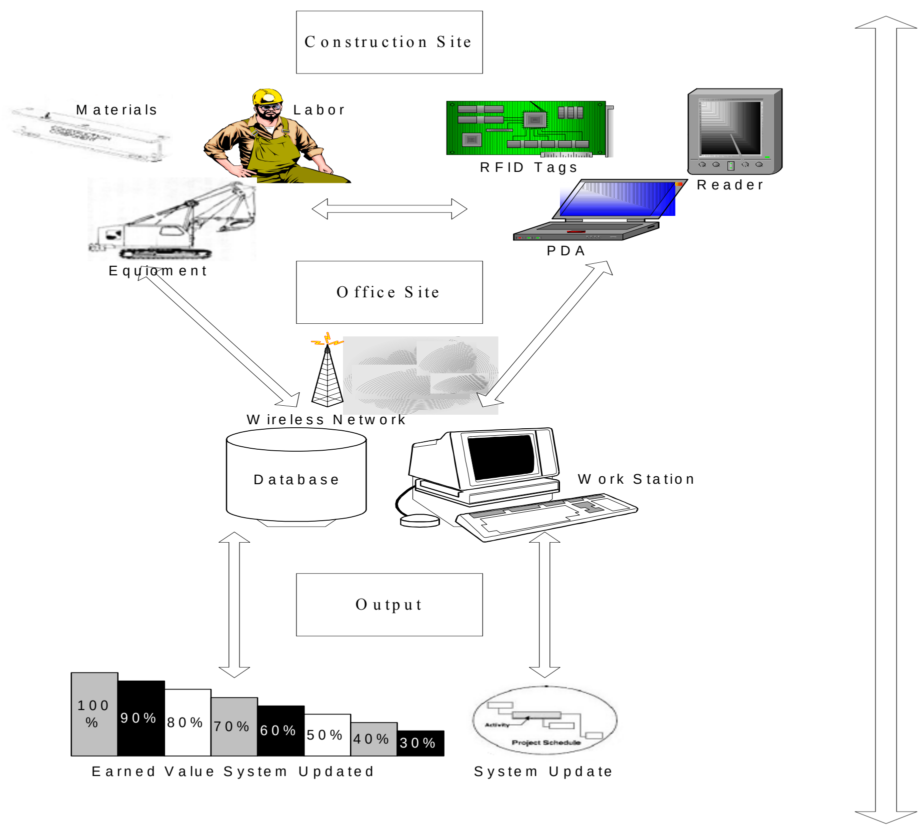

Figure 2: System Configuration

3.2 Model Applied on a Pre-Engineered Construction Site

The following example is a simplified case study to illustrate the earned value calculation using data obtained from our model in a Pre-engineered building construction. Figure 3 represents different parts of a Pre-Engineered building. At the manufacturer level, the company is responsible to attach RFID tags to the steel parts.

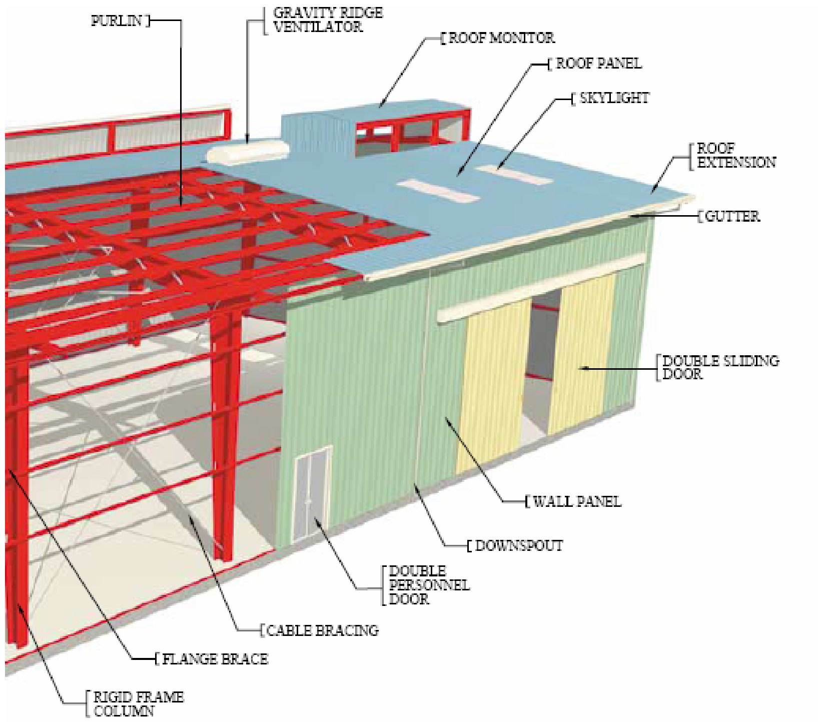

Figure 3: Pre-engineered Building Model (Zamil Steel 1999)

The steel building consists of 8 bays (16 columns) spaced at 19.5 feet, with width of the building equal to 39.5 feet, and an eave height equals to 13 feet. In this example, only installation of steel columns is taken into consideration Based on a normal crew size, it takes one hour to install one column. The cost of one column is \$150 and the cost of its installation is \$300 per hour.

As soon as the materials arrive to the construction site, the tags on the steel parts are scanned. The scanned information is sent wirelessly to the data base system.

BCWS = (150*16) + (300*16) = \$7,200

When the installation of columns starts, materials being used are scanned and information is sent to the database system: Start of installation (activity A: column installation). Monitoring of activity A is so simple, every time a column is installed; tags are scanned prior and after installation. Start and end time of installation is sent to the database. Using software, earned value of activity A is calculated.

At the end of day 1, based on information sent to the database system, only six columns were installed instead of eight columns (only 37.5% of the scheduled work was done instead of 50%). So BCWP = (\$150*6) + (300*8) = \$3,300, ACWP = \$4,800

Once BCWP and ACWP are calculated, variances and indices can be calculated and the status of the construction project is reported.

4. EVALUATION METHODS OVERVIEW

There are at least 30 currently available IT benefits evaluation methodologies (Andresen, 1999a). Two main categories arises from these methodologies; those seeking to quantify inputs and outputs in order to attach values to them-objective methods, and those relying on the attitudes and opinions of users and system builders-subjective methods.

The difficulty in evaluation centers on the fact that both costs and benefits are difficult to quantify. In addition, there are often hidden costs and benefits. Overly notes that technology based programmes often result in benefits and costs which were not identified or acknowledged in the planning and resource allocation process (Overly 1973).

4.1 The Value of the technology in Construction

The potential for technological improvements to benefit the construction project are many and are highest during the construction phase (O'Connor and Tucker 1986). In construction, value is generally viewed as tangible and direct, and is often defined in terms of changes in the following three metrics: Cost (or budget); Time (or schedule); Quality. Other measures such as safety, rework, and productivity are also widely used, however, these are intrinsically related to the above three metrics. Thus, if rework is required on a project, the budget and/or the schedule may grow. Similarly, when productivity, safety, or other measures of project performance are affected, the budget, schedule, and quality are the ultimate measures of the effects. Construction companies usually expend considerable effort through their project control function to ensure that the project adheres to the planned budget and schedule, and that it meets the specified quality standards.

4.2 Technology Evaluation Methods

4.2.1 Life Cycle Cost

The term Life-Cycle Costing is quite broad and encompasses all those techniques that take into account both initial and future costs and benefits (savings) of an investment over some period of time. The following model can be used to estimate the life cycle cost of the model presented in this paper:

$$LCC = INC + HDC + CA + INSC + TC + DISC + CS$$

Where LCC is life cycle cost; INC is introduction cost; HDC is hardware cost which includes the cost of RFID system, the cost of handheld computers, and the cost of wireless network; CA is software acquisition cost, and the cost of internet database system; INSC is installation cost; DISC is disposal cost = [(unit cost of the disposal)*(-0.1)]*(inflation) / (discounting); CS is system support cost = [2.5*(direct labor cost per man-month)*$\sum MMSi$]* (1 + F) + additional support costs.

With $\sum MMSi$ as the required man-months for support in month i, and F is overhead factor.

The components of the life cycle cost can be categorized into two major groups: recurring costs and non recurring costs. The recurring costs are training cost and system support cost. The non recurring costs are introduction cost, hardware cost, installation cost, and disposal cost

4.2.2 Utility Function

Engineers like to discuss goal seeking in a mathematical terminology. A good way to identify potential benefits of applying a new technology in construction is by using Utility Functions.

Utility, as the word used here, is an abstract variable, indicating goal-attainment or want-satisfaction.

The performance of the model will be scaled based on five criteria:

1) Material management (control waste)
2) Tools Management (control losses)
3) Equipment management (increase productivity)
4) Labor productivity (increase productivity)
5) SPI and CPI indices (taking decision for critical activities)

So the utility functions will have the following shape:

U = f (material management, tools management, equipment management, labor productivity, SPI & CPI indices)

5. ASSESSING AN IT INVESTMENT IN THE CONSTRUCTION INDUSTRY

5.1 Identify the Need

The first step in analyzing the feasibility of any investment is to realize that there is a need to be fulfilled. This realization can come about by necessity or opportunity.

There may be inefficiencies in work processes recognized or simply an opportunity to exploit that will give the analyst's organization an edge over their competitors, or both.

Unlike the structured environment and highly repetitive processes in manufacturing, construction poses many barriers to the implementation of advanced technologies. Characteristic fragmentation, diversity, and fierce competition of the construction industry combine to make Research and Development (R&D) difficult (Tucker 1988). In a fiercely competitive environment with thin profit margins, individual firms, especially the smaller ones, simply can't afford to conduct R&D or pay added regulatory costs of introducing new technologies. For this reason, the construction industry has a high resistance to adopt new technologies and change traditional processes, and most instances to date have been part of either university funded research or pilot project through consortia such as FIATECH, CONSIAT Construction Integration & Automation Technology), and COMIT. This shows that at the present the need for adoption of new technologies in the construction industry should largely be for competitive advantage, not necessity. Many of the inefficiencies that exist in construction can potentially be eliminated with the implementation of IT investments.

5.2 Determine the Objective

Once the need for investment has been identified, the goals and objectives of the study should be determined. This step should layout what the outcome of a successful solution would provide, and who the stakeholders of the solution are.

5.3 Identify the Alternatives

The first alternative to consider is the "do-nothing" scenario and is the base by which all other alternatives will be analyzed. Some form of functional analysis should be performed to understand how the current business process functions. Process flowcharts can be developed to assist in this task.

Identifying the other alternatives involves researching what type of products on the market can provide the successful solution previously determined. When selecting specific product alternatives, an initial comparison should be made to ensure that an overpriced product is not being selected.

5.4 Perform an LCC analysis

The next step is to set the study period in which the financial analysis will cover.
It is typical for IT investments to be considered over a maximum of three years due to the rapid change in technology that is currently taking place. If the investment is being considered for a single project, then the study period should be the length of the project or three years, which ever is the minimum. It would be beneficial at this point to determine what time interval cash flows will be represented at, i.e. monthly, quarterly, annually. If a multiple year study period is being considered, then representing cash flows annually is the typical practice.

Once the study period is set the cost should be assessed over that period of time and assigned to the time interval in which they will occur. Any costs that result as a change in the "do-nothing" scenario should be considered. The obvious costs are the direct initial costs that go into purchasing the necessary products such as hardware, software, and wireless communications equipment. Other direct initial costs are planning and feasibility studies, initial wireless consultant fees, training of users, wireless provider activation fees, software development, IT systems integration, implementation costs, etc.

Direct ongoing cost to be considered include maintenance, upgrades, replacements, ongoing training, wireless subscription fees, salaries of in-house technical support or periodic wireless consultant fees, etc. Finally, any indirect costs should be identified, such as staff time spent in training, downtime due to device failure, and any initial drop in productivity.

The ultimate goal of an LCC analysis is to determine the present value of all costs incurred over the study period; however, if the analyst plans to account for the effects of income tax, then the cost should not be discounted at this point. This is due to the fact that income tax will be levied on current dollars, not constant discounted dollars.

5.5 Identify and Quantify the Benefits

This step involves documenting the changes that will occur in the current business processes as a result of the implementation of the investment. These changes are what will ultimately produce the benefits of the investment. Benefits can be classified as tangible and intangible. Tangible benefits will be any benefit that a dollar value can be assigned to. These include reduced travel time, reduced staff, work process elimination, worker productivity gains, reduced paper, reduced material wastage, reduced rework, etc. Intangible benefits are those in which a dollar value can't be directly assigned. Some intangible benefits can be broken down into sub-benefits, which are tangible. For instance, improved information quality is intangible; however, this benefit results in worker productivity gains, reduced rework, and reduced material wastage which can be assigned a dollar value.

6. EXPECTED OUTCOME

The authors believe that applying the following model at construction sites will bring some tangible benefit to the project. It will offer a lot of information at the construction site. It eliminates gaps in time and space and gets rid of duplicate work. It will integrate previously stand alone islands of work, depending on the job description of each individual. Moreover, it will greatly increase productivity and efficiency, reduce labor hours and time required for project tracking, and give more accurate results in estimation.

7. CONCLUSION AND RECOMMENDATIONS

There are many ways that the construction industry might benefit from incorporating this model. It will permit information to flow in a faster, more timely manner between all related parties. All the technologies presented in the model are already applied in construction industry, but combining these technologies together is the prominent feature of this model. Tracking project progress with less work done, fewer assumptions made, and a better method used is the dream of every project manager. Undeniably, new systems come with uncertainties, risks, costs, problems and application resistance. Companies interested in implementing this model within their organization must recognize the nature of the new technologies involved, their life cycle, and most importantly how to integrate their work processes with these technologies.

A detailed model should be presented, which includes the description of each component of the system proposed and how they interact with each other. A case study should be used to validate the hypothesis made: Implementing this model on the construction site will increase productivity and efficiency, decrease materials waste, and build a more reliable construction activities progress system.

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USING INTELLIGENT WIRELESS COMPUTING TO SUPPORT COLLABORATIVE WORKING

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ABSTRACT.

Construction work require the collaborative and creative activities that demands a seamless interaction between the site and the office staff. Achieving the goal of such seamless interaction poses some peculiar requirements to be met by an ICT solution supporting nomadic workers. The existing approaches to support nomadic workers involves information delivery, which is mainly static and is not able to take into account the mobile worker changing context and the dynamic project conditions. This results in a mismatch between the static information being delivered and the changing information requirements of workers. This paper presents the work done as part of the WiSECON project, which involved development of a conceptual framework and a prototype application to enable context capture, context-reasoning and discovery, and the integration of resources based on the captured context. Two case-studies are presented that relate to actual deployments on a construction site and in a transportation environment. The deployment process and findings from each of the case studies are summarised and illustrates the tremendous potential of intelligent wireless web services to improve working practices by providing intelligent context-specific support to them. Conclusions are drawn about the possible future impact of context-aware applications in AEC/FM.

Keywords: Intelligent wireless services, context-awareness, collaborative working

1. INTRODUCTION

Due to the unpredictable nature of the construction projects, different activities are often difficult to anticipate, and construction project plans, drawings, schedules, project plans, budgets, etc have to be updated periodically. Thus to support site workers and to make construction processes better integrated and more efficient, construction enterprises increasingly wish to use powerful wireless devices coupled with the availability of improved bandwidth, to tap into different back-end systems. Wireless communication devices with network access to central servers, can be used for tasks such as real time progress monitoring of on-site works, remote expert support, on-site collection of qualitative and quantitative measurements, collaborative review of technical drawings, on-site supplier and subcontractor evaluation, on-site evaluation of equipment usage measurements, keeping track of the physical equipment position anytime and anywhere, answering audit checklists and filing audit reports during site audits (Meissner et al., 2001). The potential of mobile Information Technology (IT) applications to support the information needs of mobile AEC/FM workers has long been understood. To exploit the potential of emerging mobile communication technologies, many recent research projects have focused on the application of these technologies in the AEC/FM sector. Also, mobile communication technologies are already rapidly penetrating various types of construction fieldwork in applications such as safety management, structural inspections, final finish work inspections, project status monitoring and a wide range of other data management operations. However, the current state of the art in mobile IT deployments in the construction industry has some underlined limitations, which include:

- From a methodological viewpoint, remote collaboration support for mobile workers is currently seen as a "simple" delivery of the relevant information. Information delivery is mainly static and is not able to take into account the mobile worker changing context. Need for dynamic synthesis of contents and context sensitive information provision for mobile workers is not adequately addressed. Commercially available mobile applications for the construction industry are designed primarily for internal off-line use, centring around batch oriented cradle synchronisation. The needs of the mobile workers to have real time access to multiple information resources is not adequately addressed. Even though in those projects in which real time connectivity needs of mobile workers are being addressed (using wireless technologies such as 3G, GPRS, WiFi), the focus is on delivering static information to users such as project plans and documents or access to project extranets. Similarly, most of the commercially available mobile applications for the construction industry are designed primarily to deliver pre-programmed functionality without any consideration of the user context. This often leads to a contrast between what an application can deliver and the actual data and information requirements of a mobile worker. In contrast to the existing static information delivery approaches, work in the AEC/FM sector, by its very nature, is dynamic. For instance, due to the unpredictable nature of the activities on construction projects, construction project plans, drawings, schedules, project plans, budgets, etc often have to be amended. Also, the context of the mobile workers operating on site is constantly changing (such as location, task they are currently involved in, construction site situations and resulting hazards, etc) and so do, their information requirements. Thus, mobile workers require that supporting systems rely on intelligent methods of human-computer interaction and deliver the right information at the right time on an as-needed basis. Such a capability is possible by a better understanding of the user-context.

- From an architectural viewpoint, state of the art mobile communication applications lack cohesion with the existing desktop based ICT infrastructure. In recent years, this issue is addressed through the use of proprietary or open standard APIs (Application Programming Interfaces), resulting in tightly coupled and inflexible systems (Anumba & Aziz, 2006).

- From a technological point of view, there has been little work to integrate emerging technologies such as the Semantic Web, Web services, location and context based technologies, etc in the construction work environment.

- Application of mobile communications in the construction sector is done in a piecemeal fashion. Very often, mobile applications are designed to support a specific high end client e.g. project management, quality assurance, health and safety etc. The selective application of mobile communication technologies often results in a mixed handling of data, where a set of manual and semi-automated processes work together. Very often this mixed handling has a negative impact on the process workflows.

All aforementioned factors affect the value proposition of mobile communications in the construction sector. This paper presents the results of the WiSECON (2005) project which addressed some of the aforementioned limitations to improve cohesiveness and information flow between the construction teams. Section 2 introduces the concept of context-aware computing and reviews the state of the art. Section 3 presents the WiSECON service delivery architecture which facilitates context capture, context brokerage and integration with back-end systems using a Web Services model. The deployment process and findings from each of these case studies are summarised in the paper and the benefits highlighted. Section 4 presents case-studies related to the deployment of context-aware applications. Conclusions are drawn about the possible future impact of context-aware service delivery technologies in the AEC/FM sector.

2. CONTEXT-AWARE COMPUTING – STATE OF THE ART

Context-aware computing is defined by Burrell et al (2001) as the use of environmental characteristics such as the user's location, time, identity, profile and activity to inform the computing device so that it may provide information to the user that is relevant to the current context. Context-aware computing enables a mobile application to leverage knowledge about various context parameters such as who the user is, what the user is doing, where the user is and what mobile device the user is using. Pashtan (2005) described four key partitions of context parameters, including user's static context (includes user profile, user interests, user preferences), user's dynamic context (includes user location, user's current task, vicinity to other people or objects), network connectivity (includes network characteristics, mobile terminal capabilities, available bandwidth and quality of service) and environmental context (include time of day, noise, weather, etc.).

Context-aware computing is an established area of research within computer science. The application of context-awareness for mobile users has been demonstrated in a large number of applications, including fieldwork (Kortuem et al, 1999), museums (Fleck et al, 2002), route planning (Marmasse et al, 2002), libraries (Aittola et al, 2003) , meeting rooms (Chen et al, 2004), smart-houses (Coen, 1999) and tourism (Laukkanen et al, 2002).

Location is a key context parameter and other projects that have specifically focused on location-based data delivery included Mobile Shadow Project (MSP) (Fischmeister et al, 2002) and the GUIDE project (Davies et al, 1999). The MSP approach was based on the use of agents to map the physical context to the virtual context while the GUIDE project focused on location-aware information provision to tourists. Lonsdale et al (2003) implemented a prototype to facilitate mobile learning. In the implementation, mobile devices pass contextual information obtained from sensors, user input, and user profile to the context subsystem. The context sub-system then compared this metadata to the content metadata provided by the delivery sub-system and returned a set of content recommendations. In the Active Campus project (Griswold et al, 2002), a prototype was developed, to demonstrate the potential of context-aware information delivery technology to support staff and students in an educational setting. In a similar piece of work (Arnstein et al, 2002), location-aware technologies were used in a laboratory environment to first collect and organise data where and when created and then make this information available where it is needed. Proximity to a particular object or location was sensed either via Radio Frequency Identification (RFID) badges or direct contact with a touch screen. Each researcher in the laboratory was given a RFID badge that uniquely identified him. This unique identifier provided authentication for access to laboratory applications as well as triggering the migration of the user interface from one display to another closer to the position of the researcher. Context-aware applications are also being investigated by other fields of research in computer science, including mobile, ubiquitous and wearable computing, augmented reality and human-computer interaction. However, the application of context-aware technology in the construction industry remains limited.

The awareness of user context can enhance mobile computing applications in the AEC/FM sector by providing a mechanism to determine information relevant to a particular context. In recent years, the emergence of powerful wireless Web technologies, coupled with the availability of improved bandwidth, has enabled mobile workers to access in real time different corporate back-end systems and multiple inter-enterprise data resources to enhance construction collaboration. Context-aware information delivery adds an additional layer on top of such real time wireless connectivity offering the following benefits:

- Delivery of relevant data based on the worker's context thereby eliminating distractions related to the volume and level of information;
- Reduction in the user interaction with the system by using context as a filtering mechanism. This has the potential to increase usability by making mobile devices more responsive to user needs;
- Awareness of the mobile worker's context, through improved sensing and monitoring can also be used to improve security and health and safety practices on the construction site. At the same time, it is possible to use the knowledge of on-site activities to improve site-logistics, site-security, accountability and health and safety conditions on the site.

3. CONTEXT-AWARE SERVICE DELIVERY FRAMEWORK

Figure 1 presents WiSECON's context-aware services delivery framework that combines context-awareness and Web Services to create a pervasive, user-centred mobile work environment, which has the ability to deliver context-relevant information to the workers to support informed decision making. The framework separates the capture and inference of context from information delivery. The key features are discussed below:

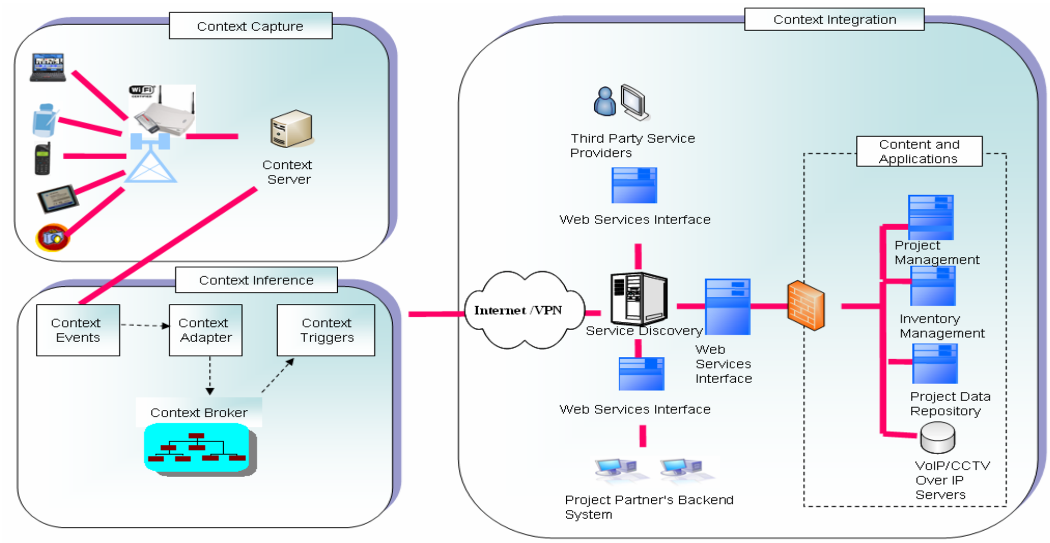

Figure 1: WiSECON Service Delivery Framework

3.1. Context-Capture

This tier helps in context capture and also provides users access to the system. Context capture includes capturing implicit contextual information (such as user's profile, location, time, etc). Five context dimensions were addressed in this research, including Location, Time, User Device, User Profile and User Activity. Such information is drawn from different sources, including:

- Current location, through a wireless local area network-based positioning system (Ekahau,2006). A client application running on a user’s mobile device or a tag sends constant position updates to the positioning engine over a WLAN link. This allows real time position determination of users and equipment. It is also possible to determine a user’s location via telecom network-based triangulation;
- User Device Type (e.g. PDA, Tablet-PC, Pocket-PC, Smart-Phone, etc.), via W3C CC/PP standards (2003). These standards allow for the description of capabilities and preferences associated with mobile devices. This ensures that data is delivered according to the worker’s device type;
- User profile (e.g. Foreman, Electrician, Site Supervisor, etc.), via the unique IP address of their mobile device. User profile is associated with user identity;
- User’s current activity (e.g. inspecting work, picking up skips, roof wiring, etc.), via integration with project management/task allocation application;
- Time via computer clock.

The use of IP-based technologies enables handover and seamless communication between different wireless communication networks such as wireless wide area networks, local area networks and personal area networks. Also, both push and pull modes of interaction are supported. Thus, information can be actively pushed to mobile workers (through user-configured triggers), or a worker can pull information through ad-hoc requests, on an as-needed basis. As application content, logic and data processing reside on the wired network, the mobile client is charged with minimal memory and processor consuming tasks.

3.2. Context Inference

This tier provides the ability to reason about the captured context using a Semantic-Web based model to describe a knowledge model for a corresponding context domain, thereby helping context description and knowledge access (by supporting information retrieval, extraction and processing) based on the inferred context. The understanding of semantics (i.e. meanings of data) enables the creation of a relationship between the context parameters and available data and services. Output from the context-inference tier is passed into AEC/FM applications to make them aware of events on the site. The context adapter converts the captured context (e.g. user id, user location, time, etc.) into semantic associations. RDF schema (RDF, 2006) is used to provide vocabulary and structure to express the gathered contextual information. Being XML-based, RDF also ensures the provision of context information in an application and platform-independent way. Also, using the RDF schema, the context broker maps the captured contextual information to available data and services. Mapping can include user profile to project data (mapping of information, based on the role of the user on site), location to project data (mapping user location to project data e.g. if electrician is on floor 3, he probably requires floor 3 drawings and services) and user task to project data (mapping information delivery to the task at hand). RDF was also used as a meta-language for annotating project resources and drawings. Such a semantic description provides a deeper understanding of the semantics of documents and an ability to flexibly discover required resources. A semantic view of construction project resources logically interconnects project resources, resulting in the better application of context information. At the same time, semantic description enables users to have different views of data, based on different criteria such as location and profile. As the user context changes (e.g. change of location, tasks), the context broker recalculates the available services to the users in real time.

3.3. Context Integration

Based on the captured context, this tier helped in service discovery and integration. Changes in the context prompt the context broker to trigger the pre-programmed events which may include pushing certain information to users or an exchange of information with other applications using Web Services, to make them aware of the events on the site. Web-services standards are used to allow applications to share context data and dynamically invoke the capabilities of other applications in a remote collaboration environment.

4. FRAMEWORK IMPLEMENTATION

This section presents two case studies which relate to the deployment of the WiSECON context-aware services delivery framework in a simulated construction site and in a transportation environment.

4.1. Construction Site Environment

This involved the deployment of the context-aware services delivery architecture to support construction site processes. As site workers arrived for work, the on-site wireless network detected the unique IP address of their mobile devices and prompted them to log-in. On a successful log-in, the site-server pushed the worker’s task list and associated method statement (as assigned by the site supervisor using an administration application) based on the worker’s profile (Fig 2 (a & b)). Completion of tasks were recorded in real-time and an audit trail was maintained. Also, application and service provisioning to site workers was linked to their context (i.e. location, profile and assigned task) e.g. based on changing location, relevant drawings and data was made available. The context broker played the key role of capturing the user context and mapping the user context to project data, at regular time intervals. Real-time location tracking of site workers and expensive equipment was also used to achieve health and safety and security objectives. Also, WLAN tags were used to store important information about a bulk delivery item. XML schema was used to describe the tag information structure. As the delivery arrives at the construction site, an on-site wireless network scans the tag attached to the bulk delivery and sends an instant message to the site manager's mobile device, prompting him/her to confirm the delivery receipt. The site manager browses through the delivery contents (Fig 2 (c)) and records any discrepancies. Once the delivery receipt is confirmed, data is synchronized with the site server, resulting in a real-time update of the inventory database.

(a) (b) (c)

Figure 2 : Profile based task allocation (a & b) and inventory logistics support (c)

The implementation was evaluated in terms of its appropriateness for the construction industry and the implementation approach. This involved expert and end-user evaluation and workshop. A total of 23 evaluators including construction industry experts and project managers participated in the process. Generally, there was a positive feedback from evaluators about the prototype's relevance to the industry's needs. The evaluation process allowed them to explore future context-aware applications, and they took a keen interest in the presented concepts. 82% of the evaluators thought that the overall system was very usable while 70% thought that construction workers will be able to learn to use the system very quickly. It was also observed that different evaluators had different expectations. Those with a high level of IT literacy expected more complex functionality (such as an ability to capture context history), whereas evaluators with basic technology literacy wanted simple functionality (such as wireless project management or ability to track items). Also, during the evaluation process, many barriers were identified (such as cost, technology-related, user-acceptability, fragmented nature of the industry, etc.). Successful deployment of such a technology in the construction industry would require the industry to move beyond its existing practices.

4.2. Transportation

A proof-of-concept deployment was undertaken on a UK train station to provide an intelligent wireless support infrastructure for the station staff. The key objective of the deployment was to provide context-aware data support to the station staff based on their information needs (location, role), device processing capabilities (device type, bandwidth) and external events (train disruptions, security alerts). Figure 4 presents the deployment architecture. Based on availability, both wireless local area and wide-area networks were used to capture real-time location.

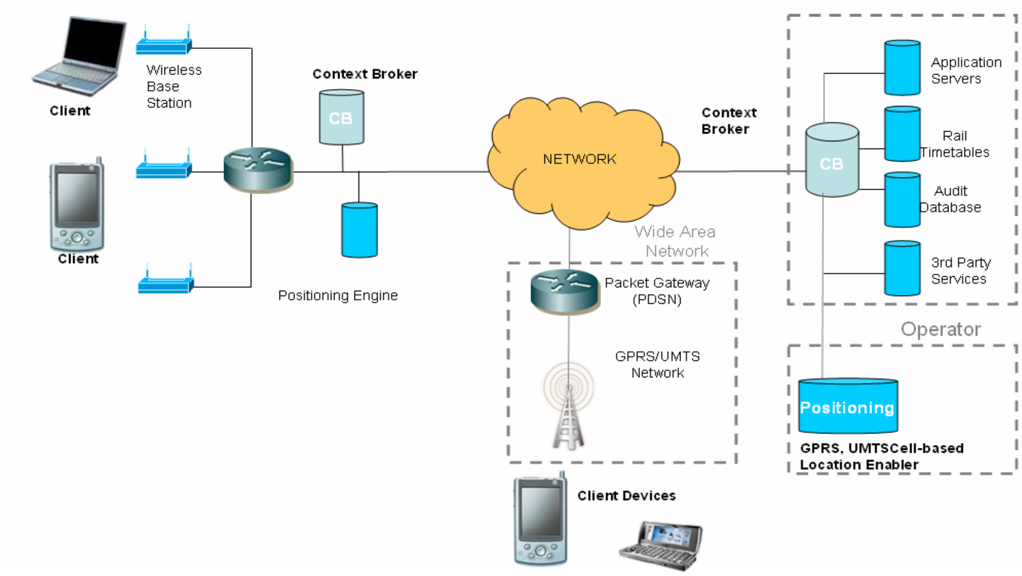

Figure 4: Deployment Architecture

On account of a large number of user profiles (which included train managers, station managers, station supervisors, train dispatch staff, maintenance engineers), the interface was personalised based on the user log-in. Station staff were pushed information about disruptions to train services via integration with a customer information system using Web Services. After a successful log-in, the content was automatically updated with current information, personalised for the user’s context. Two main applications were deployed:

- ***Real-time Train Information:*** Station staff were provided real-time access to train running information. Knowledge of the user context (e.g. station information, time of the day, date, etc.) was used to present the relevant information minimising the interaction required between the staff and the mobile device.
- ***Security Alerts:*** Using their handheld devices, station staff could generate and respond to security alerts. Also, based on their location, station staff could access video feeds of IP-based surveillance cameras. Once a security alert is generated, the closest station staff and security officer were immediately warned based on their proximity to the person or object generating the alert.

5 orange SPV5000 PDAs were used for field trials. The trials were conducted from a small office on the train platform. Feedback was collected through questionnaires and qualitative interviews. Key identified advantages of the implementation included real-time access to traffic information, better management of station activities, ability to obtain location-specific information and better management of station facilities and trains. Ergonomic and cost issues were identified as key barriers to implementation of such a system.

5. CONCLUSIONS

This paper has presented an architecture for context-aware services delivery and implementation case-studies. Awareness of the user-context has the potential to cause a paradigm shift in AEC/FM sector, by allowing mobile workers access to context-specific information and services on an as-needed basis. Current approaches of supporting AEC/FM workers often involve the complexities of using a search engine, moving between files or executing complicated downloads. In comparison, context-awareness makes human-computer interaction more intuitive, thereby reducing the need for training. Also, new application scenarios are becoming viable by the ongoing miniaturisation, developments in sensor networking, the increase in computational power, and the fact that broadband is becoming technically and financially feasible. However, the case studies have demonstrated that context-aware services delivery in the AEC/FM sector needs to satisfy the constraints introduced by technological complexity, cost, user needs and interoperability. Also there is a need for more successful industrial case studies; these will be explored as part of further field trials.

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APPLICATION OF VISUALISATION TOOLS IN PROJECT MANAGEMENT IN CONSTRUCTION INDUSTRY: INNOVATION AND CHALLENGES

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ABSTRACT

The advancement of information technology has resulted in the development of new visualization and planning tools that offer major improvements when compared to the use of traditional planning tools such as Gantt charts and Critical Path Method. Despite their limited capability for planning and monitoring projects, these tools are still almost universally used by the construction industry. Two case studies managed using traditional techniques, one construction of an apartment block and other installation of a new high technology production facility in the Precast Concrete Industry have been reviewed in the paper from a viewpoint of how the application of new 4D (3D+time) and visual planning/simulation techniques would have improved the management and control of the projects. Widespread use of visualization and simulation techniques in the Aerospace and Car Industries is compared with the limited use in the Construction Industry. The paper examines the barriers to the introduction of the technology based on the experience gained from the presentation and demonstration of the visualization technology to six major construction companies operating in the UK construction industry and the means of breaking down the barriers to the implementation of the new IT innovation are discussed.

Key words: Innovation, IT Tools, Project Management, Visualization

1. INTRODUCTION

The advancement of information technology has resulted in the development of new visualisation and planning tools that offer major improvements. The outputs of traditional planning techniques are very difficult to communicate and validate as the complexity of the project increases. Despite their limited capability, these tools are still almost universally used by the construction industry. These tools don't show the three dimensions of space and the fourth dimension of time, making it difficult to analyse and visualise construction sequences (Sheppard, 2004). The knowledge, skills and awareness of project planning is the key competency of planners which is difficult to communicate and pass on to the other stakeholders and as the project progresses significant gaps begin to occur in the understanding and comprehension of all planning issues by the other stakeholders(Gardiner and Ritchie, 1999). Furthermore, the planning and scheduling process is a multi-disciplinary team process. Being able to communicate the plan, at any stage of the project, is essential to ensure that a reliable and workable plan can be used by the project team and visual planning and simulation techniques such as 4D (3D product model in CAD or Virtual Reality (VR) + time i.e. schedule) offer an easy means of communication. VR provides users with a medium to walkthrough the model and visualise or experiment with the model. If schedule information is linked, it allows the users to see the time phased status of the project in terms of the execution of the project thereby enabling the users to identify existing or potential problems before actual execution begins. 4D models have been expanded by increasing their functionalities by researchers such as Wang et al (2004) and several prototype and commercial developments have been reported in the literature (Fischer; Construction.com; Heesom and Mahdjoubi, 2004). In this paper, the aim is to explore the benefits of using the visualisation technologies and identify challenges for its adoption by the industry.

Two case studies managed using traditional techniques, one construction of an apartment block and other installation of a new high technology production facility in the Precast Concrete Industry have been reviewed in the paper from a viewpoint of how the application of new 4D and visual planning/simulation techniques would have improved the management and control of the project. The collaborative culture of involving all the project partners in the planning process including the client embedded in the 4D concept is considered alongside the performance improvement that would have been accrued by the use of the new technology. Despite the many advantages offered by using advanced planning techniques such as 4D, as developed from the case studies and cases evaluated by other researchers, new visualisation technology is not widely used by the construction industry.

The paper examines the barriers to the introduction of the technology based on the experience gained from the presentation and the demonstrating of the visualisation technology to six major companies operating in the UK construction industry. The widespread use of visualisation and simulation techniques in the Aerospace and Car Industries is compared with the limited use in the Construction Industry. Recent research activity carried out by the authors into the Key Performance Indicators improved by the use of visualisation and spatial optimisation is outlined as a means of breaking down the barriers to the implementation of the new IT innovation in project management.

2. 4D AS A VISUAL PLANNING TECHNIQUE

4D combines 3D CAD model and schedule information and produces visual animations of the construction sequences. This plays a key role in identifying scheduling conflicts, safety issues and space utilisation at any time during the construction process. Space plays a critical role in situations where the construction area is confined or is limited depending upon the location of the site, construction technology, access routes etc. Details of 4D research and application, discussed by Martin Fischer, can be found in Stanford University web pages. Sheppard (2004) highlights some case studies of different 4D technologies in construction projects and how its benefits were realised. Figure 1 shows a methodology of a 4D software developed in Centre for Construction Innovation and Research (CCIR), University of Teesside that visualises construction product and processes in CAD and VR environment linking 3D CAD and project schedule through a central database and the 4D model is organised using standard classification systems such as Uniclass (Crawford et al 1997).

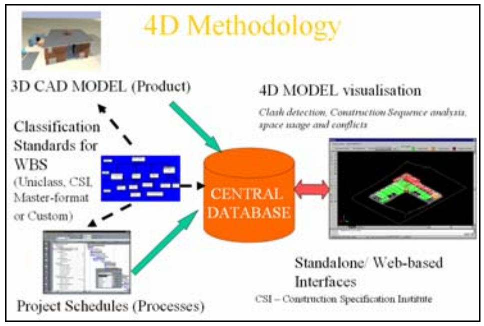


Figure 1 Overview of 4D Methodology

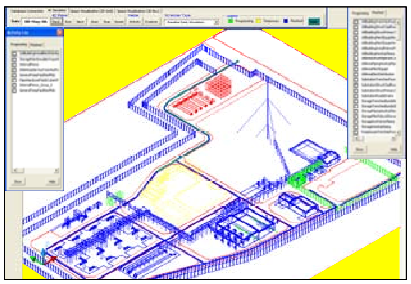


Figure 2 4D Visualization with activity progress

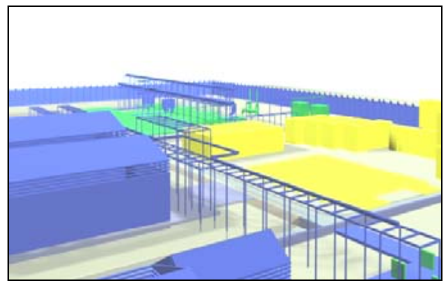


Figure 3 Photorealistic image of a Gas Receiving Facility

Figure 2 shows how planned and actual process information can be visualised and figure 3 shows an example of photorealistic image of a gas receiving facility modelled using 4D technology. Most of the 4D software either available commercially as of-the-self package or on consultancy basis use similar building blocks, however, may differ in terms of modelling CAD, linkages with plan or both. The initial advantage of using 4D is that for any construction project it ensures that a proper 3D CAD model and a schedule is available. Once a 4D model is developed, several what-if scenarios can be evaluated visually by the planners thereby identifying sequence conflicts or space clashes if space usage is modelled.

Visual planning techniques can realise many benefits on construction projects. Some of the benefits will be: major saving in waste, improved site productivity, avoidance of cost overruns, accurate planning decisions through rehearsing the construction process, identification of resource conflicts and assessment of safety issues, communication of project processes to all project parties (in particular senior managers) including accurate workface instructions – to reduce execution errors and utilization of advanced technologies and algorithms in making decisions.

3. CULTURE OF CONSTRUCTION VS. AUTOMOTIVE AND AEROSPACE INDUSTRIES

The Construction Industry lags behind the car and aerospace industries in the uptake of information technology including implementation of visualization and simulation to improve their business processes. A report by Green et al [8], discussing the managerial practices in the construction and aerospace industry, highlights that construction firms frequently compete on cost efficiency rather than the innovation and technical expertise. There is no doubt that the case study projects would have benefited from the seamless integration of photo realistic and 3D modelling using a combination of 3D AutoCAD and Virtual Reality Modelling language (VRML) coupled with critical space analysis and optimization software. Gould (1998) outlined the extent of visualisation in the Car Industry ranging from concept, design, engineering to scientific visualisation of data for crash analysis and cited the comment of a senior designer at the Chrysler Technical Centre as "Visualization is an intricate part of our day- to- day process because our data goes through various stages of scrutinization". This comment embodies the attitudes prevailing in the car and aerospace industries where it is now fundamental part of the culture associated with these industries. Karl Mecklenburg (2001) outlined the benefits of seamless integration between plant layout and discrete event simulation (DES) in order to enable the virtual factory concept to be realized. One application in car manufacturing is the application of 4D Navigator of Dassault Systemes by BMW as described by Grandl (2001) in experimental vehicle build to verify both product and process eliminating many tasks during the preparation phase. Examples of the problems identified in this experiment were: collision with floor assembly, access with screwdriver critical, torque information missing, assembly concept not verified, hole missing etc. The analysis of the problems encountered in two case studies are presented below which will highlight the differences.

4. CASE STUDY 1: PRECAST CONCRETE PRODUCTION OPERATIONS

Introduction

The project involved the transition of Wet Cast Paving manufacturing from a manual partially mechanised operation into a fully automated flexible production system. The manual processes involved are illustrated in Figure 4. The project included the building a new factory extension and equipping the factory with high tech production processes in a lean and flexible manner utilising vision enabled robot technology, Asi- safe, SCADA and Device networks automated pallet shrink wrapping and strapping equipment linked with the conveyor system and paving mould carrier cassettes, project cost was £2.6m. Flexible automation utilising linear motion devices was initiated using encapsulated read/write Radio Frequency Identification (RFID) Tags.

The project involved the use of technology developed for the car and aerospace industries including the cultural concepts of single minute exchange of dies developed originally by Shigeo Shingo (1995) for the Toyota car plant. The single minute changeover concept was enhanced in this application to four seconds. Elimination of Non Value Adding Waste (NWAW) as outlined by Mather (1988) was embodied as a main lean feature in the design concepts used to develop the final specification detail for the contract. Vision enabled robots are used in the aerospace industry for the precision fitting of components by robots. Car and Aerospace industry concepts were embodied operational techniques to be employed in the design of the project but not in the execution of the project where traditional project management tools including MS Project and an Excel based cost control system were used by the project manager. The client produced a detailed specification for the equipment installation and the building and the project was organised as shown in the organisation chart shown in Figure 5.

Hand Stripping of Paving Units

Lifting up to 40 KGS on to Conveyor

Lifting Empty Moulds

Filling Empty Moulds

Figure 4 Manual Processes to be replaced

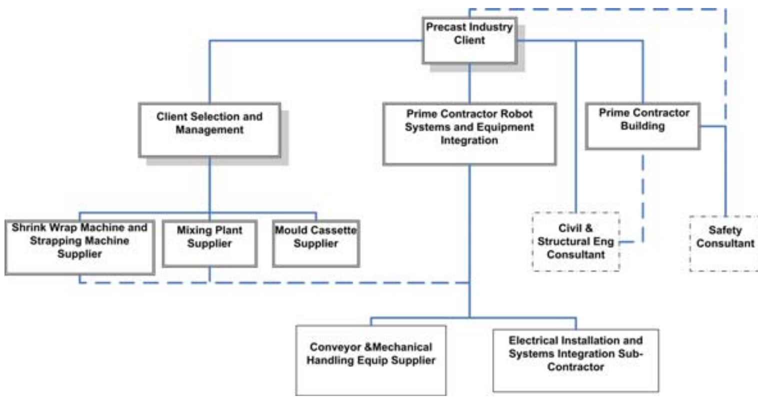
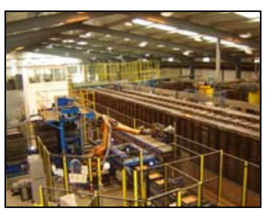


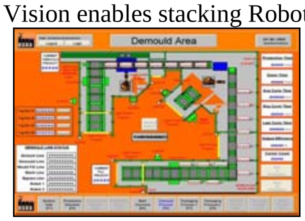
Figure 5 Precast Transition Project-Organisation



De-Moulding Robot

Vision enables stacking Robot

Automatic Shrinkwrap Machine



SCADA control

Figure 6 Some examples of the automation introduced

The client used MS Project and managed all elements of the project with the exception of responsibilities allocated to the ‘prime contractor’ for the robot systems, systems integration, mechanical handling and the electrical installation. A car industry robot supplier was chosen to be the prime contractor and a fixed price contract was negotiated including the prime contractor taking control of the project management responsibilities. The pictures presented in Figure 6 illustrate the nature of the transition that was accomplished by the completion of the project.

Post Project Review findings

The **cost overrun** on the whole project was 3.8% which was well within the performance guidelines set by the clients' parent company, of ±5% of original capital submission cost. The project was planned to be completed to commissioning stage in 12 months unfortunately the **project overrun** was three months. This was caused by the lack of information transparency by the prime contractor and the incapability of the electrical installation and systems integration sub-contractor to apply sufficient resources to recover from an underestimation of the work content. The prime contractor had failed to manage the sub-contractor and had not appreciated the level of work content involved. Extensive client involvement brought the project back on course and prime contractor was forced to employ additional internal resources since the sub-contractor became virtually insolvent.

Since all of the drawings were in two dimensional format a **key dimensional error** relating to the height of mould carrier on a conveyor relative the concrete filling chute from the mixer was not noted until the final installation of the equipment. With two separate contractors involved the client was forced to modify the mixer support structure to overcome the problem, this contributed to the cost overrun. Despite regular meetings and corrective action requirement the **key performance indicator information** was not available in time for effective corrective action. For example planned activity hit rate was at times a month late and a lack of transparency was evident.

The accuracy of **workface information** was suspect at times and there was evidence of re-work and changes/modifications necessary because of incorrect and out of date information being given to the workface installation trades especially relevant to the electrical system development where it was apparent that a significant amount of systems design took place during the installation or execution phase. This should have been completed ahead of the execution process, however the project included much new innovation, which accounted for some of the modifications and it won a major industry award for innovation from the British Precast Concrete Federation, UK.

Improvements that would have been achieved using visualization tools

The illustrations in figures 1, 2 and 3 give a brief overview of a 4D (3D+Time) advanced visual planning/simulation systems that could have been used to control the project. Through the use of 4D visualisation model, the following problems would have been avoided:

- The dimensional clash issue relating to height of mould carrier relative to the concrete filling chute and the associated cost and time associated with the modification would have been avoided.
- The limitation in capacity of electrical subcontractor to progress with the electrical installation and system would have been obvious either during the

rehearsal phase or at an early stage during the execution phase to enable corrective action.

- The availability of real time KPI information via the web in-turn enables remote project meetings using photorealistic images of progress with embedded activity completion lists would have been very beneficial in the case study project and it would have resulted in any corrective action required during the meeting review process to be taken in a timely manner.
- Transparency of information is inherent in the 4D visualisation process and the project teams must accept this for the benefits to be accrued.
- Without an overall project database with internet access meant excessive client time was needed to ensure that the target delivery dates were achieved. With the aggregate feed and mixing plant built in Northern Ireland and the shrink wrapping/strapping equipment from Italy, internet based remote project meetings would have been very useful.
- The cost overrun was approximately £100k and most of this cost overrun could have been avoided through the use of 4D visual planning. A project management cost budget of £30k was included already in the overall project budget. It is estimated that an additional £30k would have been required to fund the additional planning activities involved in the application of 4D technology, however, when viewed in simple financial terms this would have represented a payback in less than four months. In addition to the cost overrun the project was three months late which represented a three months loss in the savings scheduled to be accrued from the project which were planned to be £850k per year. The loss of savings amounted to £283k, when viewed in these terms the payback reduces to less than one month.

5. CASE STUDY 2: CONSTRUCTION OF A 30 FLAT APARTMENT

Introduction

This project (Figure 7) considered the construction of an apartment block with thirty units on three levels and two sets of communal stairs servicing fifteen units each. The building was built utilizing traditional construction methods (suspended beam and block) with precast flooring members and precast stairs. The initial contract was to build the shell of the apartment block. Unfortunately, after building the shell had commenced, the construction company were awarded the contract for fitting out and the external works contract including the car park and drainage. The project completion was delayed by two months. The management team argued that the project would have been completed on time if all elements of the contract had been awarded at the outset so that effective planning could be undertaken.

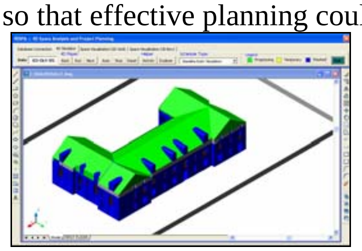


Figure 7: Case study 2 project with 4D Visualization

There was only one access to the site. With roads at either end of the site and a brick wall and fencing to each side, the site was enclosed to avoid off-loading issues with local residents and road safety problems. Vehicles were effectively forced to enter the site with only one entrance for off-loading.

Problems Encountered

Statutory services became an issue because gas and water connections were only available in on major road nearby parallel to the site and electricity required connection from the opposite end of the site. The result was that a trench running the whole length of the site was necessary. The end result was that co-ordination of deliveries became extremely difficult and the original intention of using fork lift trucks for off loading vehicles had to be abandoned because of access issues. A crane had to be leased and mounted on a concrete pad for stability purposes. The crane serviced all erection and offloading on the site. Critical space analysis embodied in 4D would have assisted significantly here.

Redesign of flooring units: The need to utilise a crane required the redesign of flooring units instead the planned use of 1200cm units it was necessary to use 600cm units because of weight restrictions. Fortunately, the supplier was able to supply the units required in time. The contract for the external works was only awarded after the building activity had commenced and it was necessary to **redesign the drainage system** to avoid the roots of the three large trees. The **crane** required banksman for slinging and a crane operator. The crane costs and productivity issues were partially offset by reduced a fork lift truck costs.

Two dimensional drawings and the lack of adequate quality checks by the GRP Dormer window supplier meant that two different pitch roof structures had not been noticed by the supplier. Hence the GRP dormer windows were supplied for one Pitch only. The **wrong dormer units** had to be returned and new units manufactured, which extended the scheduled watertight time.

Improvements that would have been achieved using visualization tools

The architectural errors, problems with the statutory services, redesign of flooring units would simply have been detected using the 4D visualization tools. The high level of visual information from 3D model or photorealistic images would have prevented the problem with dormer windows and the inherent transparency of information and rehearsal involved in a client walkthrough would have prevented the sequence issues and improved the management of problems indicated above.

6. CHALLENGES TO THE INTRODUCTION OF THE TECHNOLOGY IN CONSTRUCTION

The 4D model developed at Teesside University [Figures 1, 2, 3] was demonstrated to six major AEC companies in UK and these demonstrations generated high interest among the contractors and appealed to the planners the most. Due to the lack of appreciation by the senior managers, many companies did not take up the project. The challenges, as highlighted in the discussion, are:

- **Adversarial relationships in the procurement and execution processes.** In 4D model use, client could be involved from the start and collaborative approach is seen as essential.

- **ICT Skills Shortage** –There are 3D skill shortages in the construction industry. Hence, traditional way of developing 2D drawings is continued by the industry.
- **Time available to tender-** The time between the release of tender documents to submission is relatively short and construction companies do not have sufficient time to develop 4D models since the process can take a few weeks.
- **Fear of transparency of information** – There is a key concern among construction companies that the client could use the information provided against the construction company since delays and errors would be visible to the client. The other kind of fear is the use of explicit information about the technical aspects of the operations which companies may not wish to share with others to protect their opportunities for obtaining future contracts.
- **Fragmented industry-** The industry is fragmented with many small sub-contractors. In the UK 80% of the subcontractors have less than 20 personnel.
- **Resistance to change-** There is a reluctance to change working styles with a belief that the traditional approach still satisfies the job requirement.

7. INITIATIVES REQUIRED TO ENCOURAGE THE ADOPTION OF VISUAL PLANNING TECHNIQUES

The lack of adoption of the visual planning techniques such as 4D is evident in the construction industry. In order to enhance adoption and realize the benefits by the industry, initiatives from the government, professional bodies and main construction firms are required. Some examples are:

- **Identification of clear benefits of the application of visualization techniques:** There is a lack of industrial applications that have clearly justified and encouraged the application of 4D techniques. Currently the authors are conducting research, funded by a company developing and utilising 4D in construction projects on a consulting basis, to quantify the benefits of using 4D on construction projects. An analysis of case studies of three main construction projects in London and the results of 10 semi-structured interviews with the planners and managers involved in the execution of the projects use of 4D planning revealed that the factors that can be influenced or improved by the use of 4D planning include: time (85%), communication (73%), planning efficiency (70%), safety (68%), client satisfaction (63%), rework efficiency (63%), cost (50%), team performance (50%) and productivity (15%). The results show the percentage of respondents that ranked the factor as most important.
- **Push from the clients**: Large clients should include visual planning techniques as part of the project contract so that clients and construction companies will be in a “Win-Win” situation by minimising wastes during the construction process.
- **Training on the application of 3D** – Use of 3D models in the development initial brief is growing. Software like SketchUp^{TM} (www.sketchup.com), Revit^{TM} (AutoDesk, Inc) etc are helping Architects and Designers to start developing models in 3D and generating 2D drawings directly from the CAD applications as used in the aerospace and manufacturing sectors.
- **Issues with compatibility** – There are significant problems with the compatibility across the CAD software used in the construction industry. Initiatives like industry foundation classes (IFC’s) should be encouraged so that

CAD models can be exchanged easily without losing accuracy and reliability of CAD models during the conversion processes.

- **Cost of the technology-** The current cost of 4D techniques are high compared with other project management software. However, the commercial development of 4D software application is growing and there is a need to develop best practice examples.

8. CONCLUSION

The adoption of visual planning tools for project management is very slow despite the fact that such techniques facilitate planners and stakeholders to visualise the project execution process and identify problems that may occur before construction takes place. Advancements in 4D CAD and virtual reality are capable of handling complex models and can change the culture of the construction industry. Initiatives are required to encourage the use of visualisation techniques are seen as essential and researchers, developers and industry must work together to deliver affordable solutions for the construction industry and lessons must be learned from the benefits gained by automotive and aerospace industry.

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"ARE WE GETTING THE BEST OUT OF OUR INTRANET SYSTEM ?" A PRACTICAL CASE STUDY

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ABSTRACT

The construction industry as other industries is exposed to considerable advancement in information technology. Construction companies are no longer judged exclusively by the level of their past performance but also how they can sell their expertise and services by employing the latest technology. Investment in new hardware and software technologies is necessary to gain a competitive edge but this investment needs to be justified particularly by demonstrating that companies are actually benefiting from the investment It is also vitally important that the knowledge gained on construction projects is captured and shared for continuous improvement to avoid 're-inventing the wheel' and to prevent repetition of previous mistakes. This is particularly useful for construction companies that undertake PFI (Private Finance Initiative) projects where they are responsible for maintenance of the building for a long period of time. By using a practical case study, this paper examines how one of the largest privately owned European companies provides information & knowledge to their employees, what their employees feel about the system and if the company is getting maximum return for their investment.

Keywords Case study, Information Technology, Information Management Intranet Systems, PFI projects.

1. INTRODUCTION

The information and knowledge provided by the sponsoring company and other external sources through their Intranet system are often lost in pages of text, and is difficult to access in a user friendly and rational manner. The user normally requires training and long periods of time to search through the database to find any relevant information that could be of use. Often due to the volume of work that the staff has to deal with and because of the time it takes to retrieve the information they need from the system they simply give up. At best this may lead to making unqualified decisions that may not provide the best solution and at worst may lead to making entirely the wrong decision potentially costing the company a great deal of time and money to rectify.

Within the research work presented in this paper, the author has conducted a number of interviews focussing on the use of IT within the sponsoring company. The literature survey(see section 5- Literature Review) And the authors' extensive experience in the construction industry suggest that it is unusual to come across any contractor that can present knowledge gained from previous contracts and useful information in a comprehensible, structured and user friendly manner not only as a record that can be accessed in future but also as a bench mark to be used in forthcoming projects.

Despite 21st century technology, a great deal of time is wasted trying to find information, because of the various systems and techniques. The user has to be highly trained and/or spend a lot of time to stand any chance of finding the expected results. Jim Carty (2005) observes "A major overlooked cause of many IT project issues is that the technology tool set is not the correct one for that particular project. However, many IT professionals valiantly try to make it work since management likes the economics of using what you already have. Yet, ultimate success often depends on knowing when it's time to stop and re-evaluate the technology direction before its too late."

This paper continues on section 2 by stating its aims and objectives, it will then briefly explains the methodology in section 3 followed by presenting a case for the need for improvement in section 4 and literature review in section 5. It then proceed to present the Practical case study that will review the outcome of a survey carried out within the sponsoring company , the result presented in pie chart format in the appendix and short summary of the conclusion of the survey in section 6. Finally it will conclude by a summary of the findings in section 6 ,future work in section 7 and recommendation to the industry in section 8.

2. RESEARCH AIMS AND OBJECTIVES

At the time of carrying out this research Wates Construction (sponsoring company) were looking to explore the effectiveness of their information systems with the following fields of study:

- How often the information provided in their intranet is being used
- How effective it is in providing information needed by the users
- What are the strengths and weakness of the existing system
- What is the success rate in finding the information that the users need
- Which company employees are more likely to use the system
- How likely is it that the users find what they looking for on the system
- Is there a need to improve their system
- Can they develop or deploy a better system that would serve their needs better.

Taking into account all of the above, the justification for this research is the need to:

- Provide an up-to-date survey of effectiveness in dissemination of information within the company and their partners
- Give a qualified view of the effectiveness of the existing systems
- Advise in improvement of the existing system including costs and predicted benefits

3. METHODOLOGY

In the first few months of the study, the research engineer undertook a period of investigation, participation and learning in how the existing system of information retrieval , management and presentation is carried out within the company and its partners. This was achieved by:

- Adjusting into the new role as a researcher
- Learning about the company's IT system and how it is maintained and updated
- Gaining an insight into how various information is uploaded into the system
- Understanding how company employees and their partners access the system and find the information they are looking for
- Building relationships with key personnel, particularly those who expressed their interest in the research subject.
- Informing key users of the IT systems of the researcher's activities and asking for their active participation in the project
- Developing an understanding of who decides what information is archived and made available to the users and why.

4. THE NEED FOR IMPROVEMENT

The government, as the largest client of the construction industry, has led the drive to change. Its Construction Task Force challenged the industry to commit itself to change. Their report commonly referred to as the 'Egan Report', set clear targets for improvements.

"The industry must replace competitive tendering with long term relationships

based on clear measurement performance in quality and efficiency...Construction companies must prepare comparative performance data and share it with clients and each other without compromising legitimate needs for confidentiality" (Egan 1998)

There are also calls from the academic profession for change, 'Competitive pressures from within the industry as well as external political, economic and other considerations are now forcing the industry to re-examine and improve its modus operandi' (Anumba et al. 2000).

5. LITERATURE REVIEW

Jim Carty(2005) observes, that it is difficult to find the needed technical expertise. He emphasises that it is a common symptom that sometimes has as much to do with the approach as it is to do with selection of technology. He points out that if you find your staff is short on the skills needed to meet the schedule in a timely and cost-effective way, it is possible that the wrong technology may have chosen vis-à-vis the resources. He observes " One benchmark of the right technology is that you don't feel like the technology is a daily struggle and you have time to focus on critical success factors like maintaining your business partners active support and participation." He goes on to say that It is enough of a struggle just staying on top of ever changing user requirements, scope, and maintaining organisational buy-in from the sponsors and that the last thing you have time for is a struggle with the very tools you're using to implement the system.

Karl-Erik Sveiby (1996) identified two 'tracks' of knowledge management:

Management of Information –'Knowledge = Objects that can be identified and handled in information systems.'

Management of People – 'complex set of dynamic skills, know-how, etc., that is constantly changing.

Ann Macintosh (University of Edinburgh) has written a Position Paper on "Knowledge Asset Management". It identifies some specific business factors, such as:

- Marketplaces are increasingly competitive and the rate of innovation is rising.
- Reductions in staffing create a need to replace informal knowledge with formal methods.
- Competitive pressures reduce the size of the work force that holds valuable business knowledge.

Hemamalini Suresh (2002) In her paper proposes that the organisations who are driven by knowledge are the ones that will succeed. She emphasises the fact that the Combination of global reach and speed compels organisations to ask themselves, "What Do we know, who knows it, what do we not know that we should know?"

Dougherty(1999) confirms that knowledge transfer is about connection not collection, and that connection ultimately depends on choice made by individuals.

6. CASE STUDY

In this case study the emphases are on strengths and weaknesses of the existing information retrieval system. The major source for retrieving information is the company's Intranet. The information and knowledge provided by the company and other external sources are often buried in pages of text, and seldom can be accessed in a rational and user friendly manner, the user normally requires training and long periods of time to search through the database to find any relevant information that could be of use.

Following an in-depth study of the current Intranet system as the point of access for provision of knowledge and information in the sponsoring company the following findings were observed:

- There seems to be no logic in where in the intranet the user should be looking for the information they require.
- The format is not user friendly and information is more likely to be achieved by luck rather than judgement.

- Although there is a vast amount of information and knowledge stored in company's servers often the result that the search engine provides is not what the user may expect.
- The sub-sections in different folders provided within the Intranet system often don't seem to present the user with clear and concise heading. Consequently the user need to almost open every folder to find the subject matter that they maybe interested in.

A survey was carried out to test the suitability of the existing system and how and why certain information is accessed within Wates Company and its partner's Intranet systems. The survey included questionnaires on the company's Intranet, the internet and the collaboration systems. A total of 36 people from different disciplines took part. The results of the survey are presented in pie chart format .The outcome is as follows:

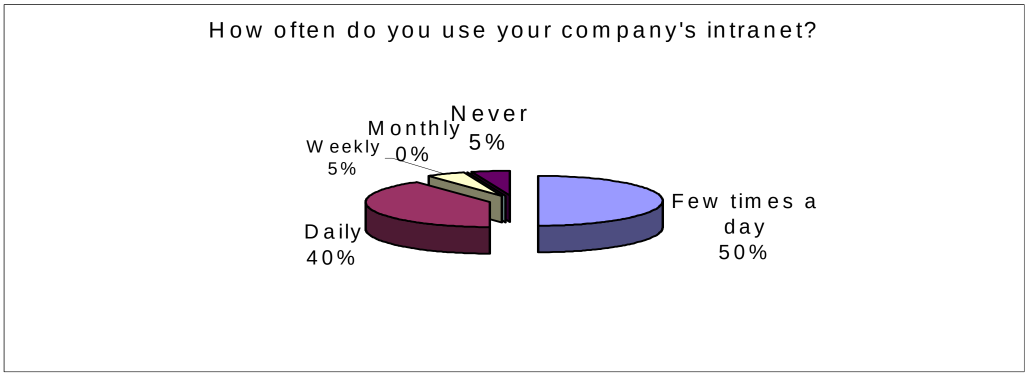

Fig.1- Over 95% of employees seem to be using the company's Intranet system on a daily bases, although about 5% of management have never used the system. A further study through one-to-one interviews was carried out with the individuals not using the system, and the results analysed and conclusion drawn in the summary section of this paper.

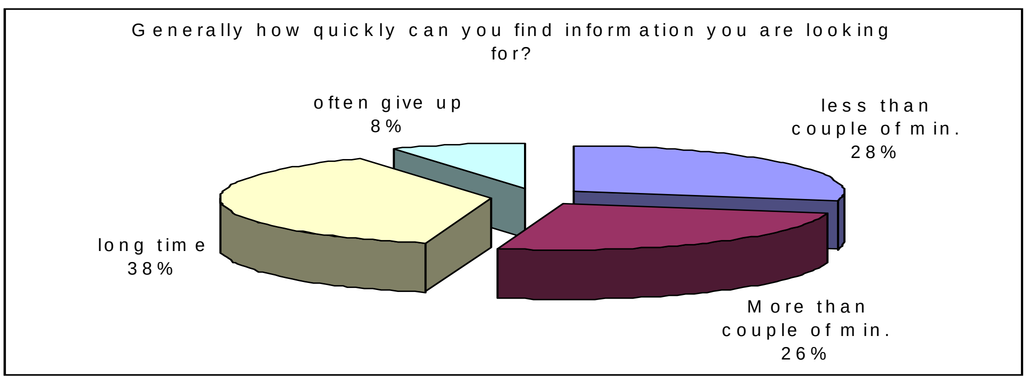

Fig.2 -The pie chart indicates the excessive amount of time it takes to look for information, this seems to discourage the users in making use of the system to the extent that 8% give up trying.

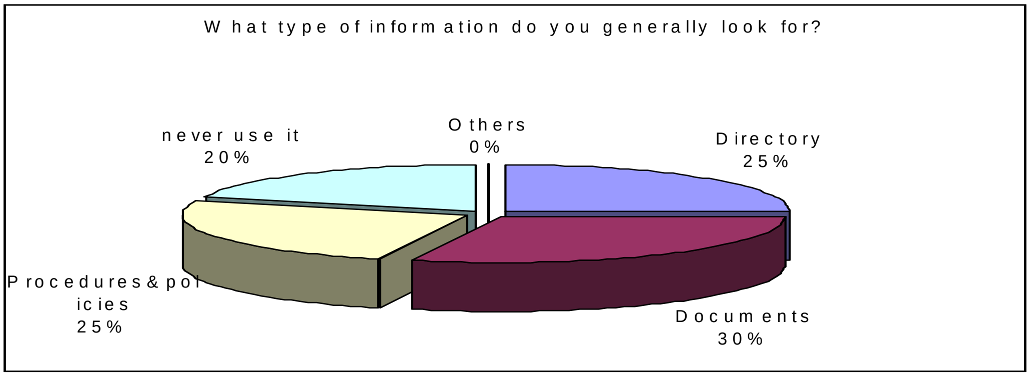

Fig.3 -It is interesting to find that 20% of users who are part of the management team do not use their company's Intranet and seem to rely on other sources in finding the information they seek. This was analysed further with one-to-one interviews to establish their reasons.

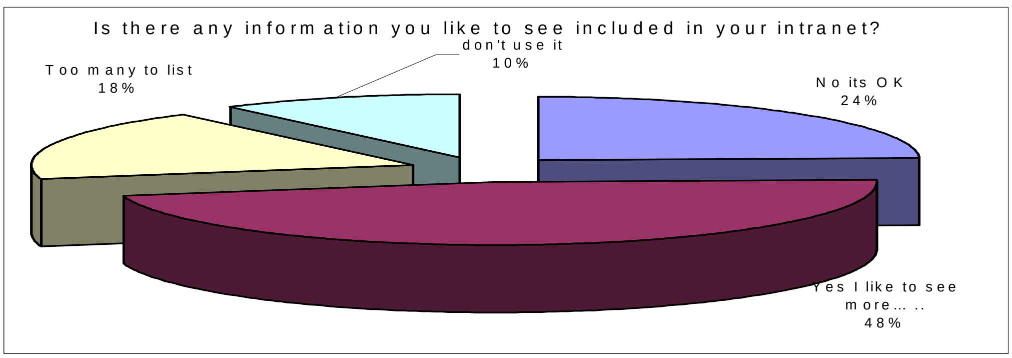

Fig.4 -In fig.4 66% of the users expressed the need to have more information on their intranet system and only 24% think that it is fine as it stands.

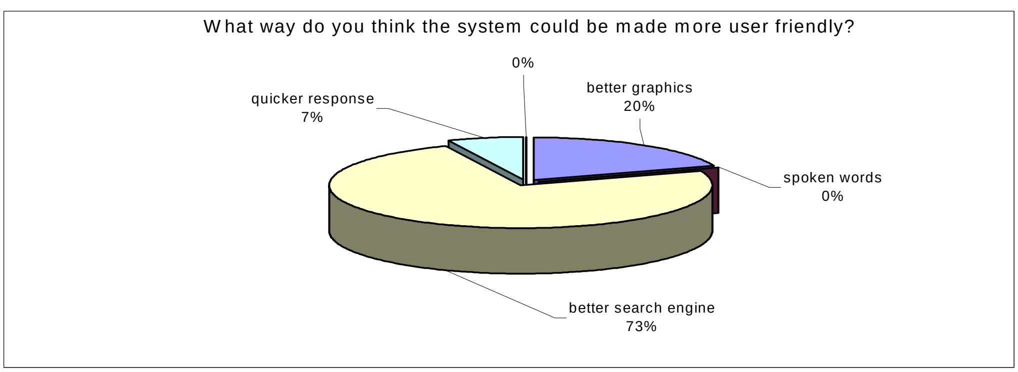

Fig.5 -Gives an idea of what end users think about how the knowledge is presented,

The overwhelming majority seems to struggle in finding information on the Intranet;

- 73% would like a better search engine . Further research indicated that the search engine provided was based on alphabetic word driven search engine and not context driven hence unless the wording in the questions are exactly as presented in the specific topic is as presented in the database the result of the search returned the wrong results .
- Better graphics seems to be the next area that could be improved.

- With improved connectivity the concerns in connection problems seem to have diminished and the 7% with this problem is seen to be an acceptable number.
- Spoken words seem to have no attraction amongst the users. This may well have to do with office environment, a further study in this section could prove beneficial.

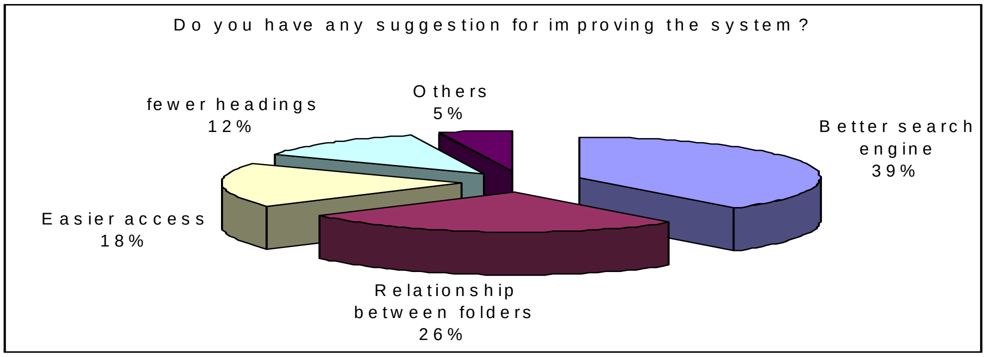

Fig.6 -This question had a blank answer section to encourage some feed back from the participants, their views on what could be lacking in the system. The following observation can be deduced from their responses:

- Better search engine (39%) Clearly information retrieval a major problem.
- Relationship between folders (26%) –On further analysis it became apparent that there were many subfolders within folders, these were subdivided into further subfolders. There seem to be no logic to the way they have been arranged. This has caused confusion as can be seen from the pie chart.
- Easier access (18%)-This again points to the confusion caused by the way the folders were put together.
- Fewer headings (12%)-Ditto

Judging by the response to the above question it is clear that the problem lies in finding the information rather than the lack of it.

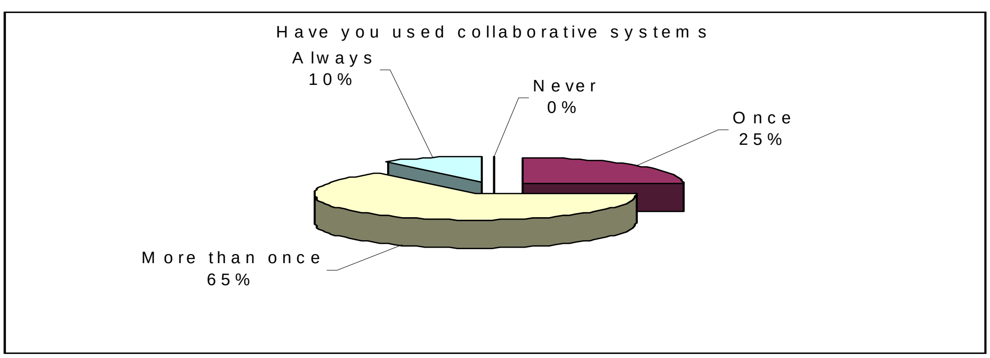

Fig.7 - The reason for posing this question was to see if there are preferences in using a particular system and if those reasons are purely to do with the information provided or the way the system is presented.

Although it should be noted that collaborative systems are not yet widely used and the users may not have been fully conversed with different elements of these systems.

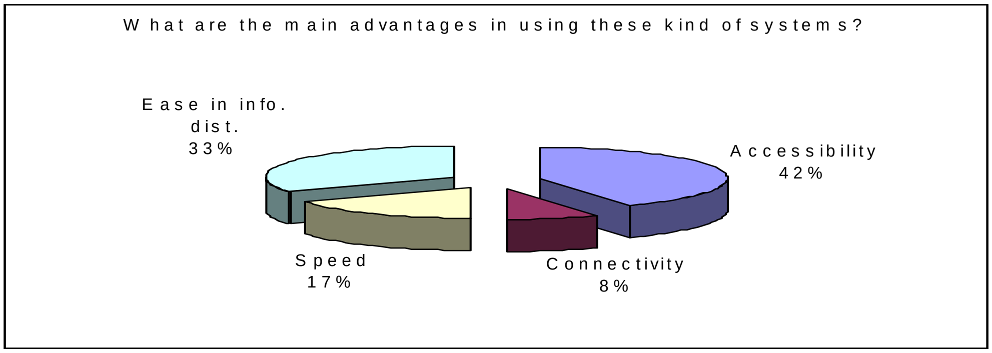

Fig 8 -Accessibility seem to play a large part in this question which is only to be expected, again speed although an issue does not seem to be of primary concern to the users and it is clear that the ease in information distribution plays a big part in using collaborative systems.

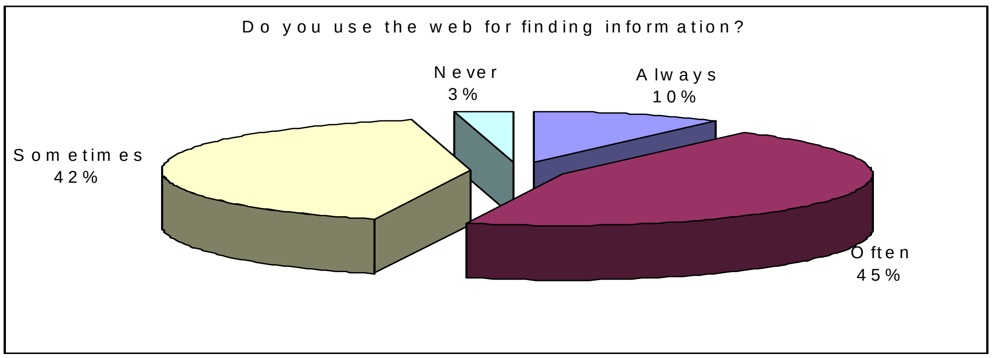

Fig.9 - This question was posed to find the users perception in inadequacy of the company's intranet, it can be argued that if the information provided was adequate there would be less need to use the web. Again the overwhelming majority seem to be using the internet to find information , products and services.

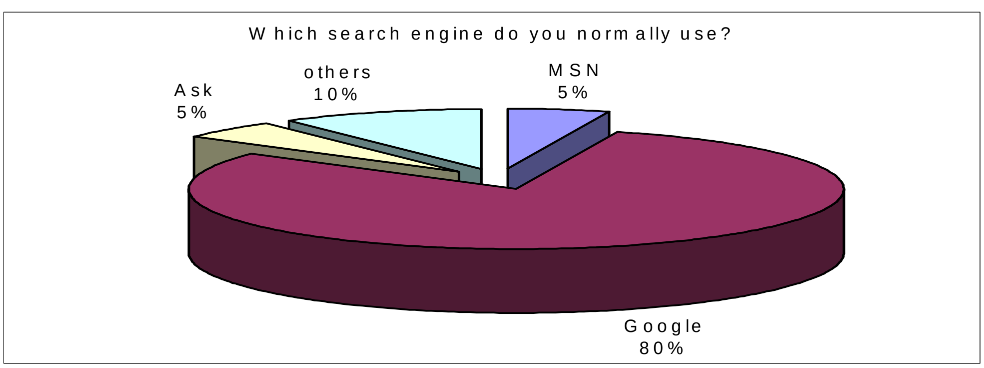

Fig.10 -This question highlights the reasons for user preference in the type of search engine they prefer and the results can be analysed to identify the factors influencing their choice.

A separate study was carried out to find if the same question given to the three search engines would give similar results. The findings reinforced the idea that layout of the search engine has a lot to do with gaining confidence of people using it. The following observations were made from the result of the study:

- Google-By far has the majority, the users seem to prefer Google search engine due to its clutter free presentation and layout
- MSN- Although gives almost the same results to the question the search engine layout is cluttered and not user friendly.
- Ask- Ditto

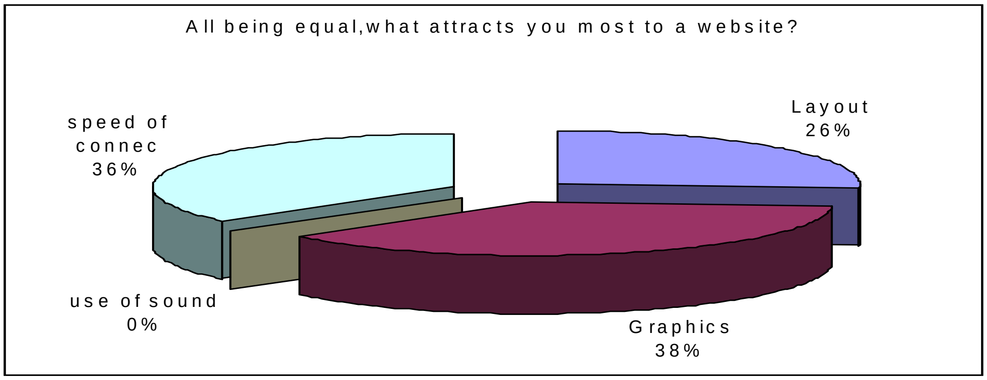

Fig.11 - Indicate the reasons behind using a particular search engine, the three areas of concern are sound, graphics and layout. Sound do not seem to have big impact; the major factors to consider are graphics & layout. Although Graphics seem to play the bigger part .

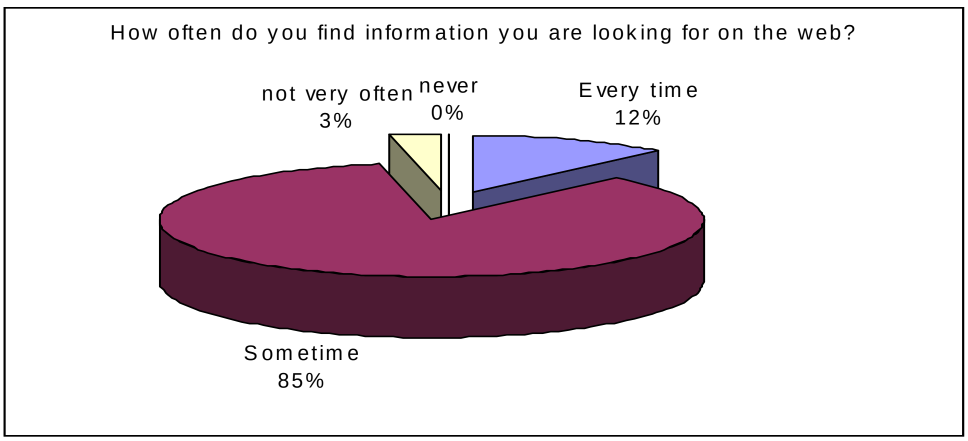

Fig. 12 –This question indicates the success that user have in finding the information they need from the Internet query systems such as Google . From the response the success rate seems to be quite high, so connecting the company's Intranet search engine to the search engines such as Google could be part of the solution.

7. CONCLUSIONS OF THE QUESTIONNAIRE

Results of the questionnaire can be highlighted by the following:

- Multiple information sources scattered across the companies database
- Existing system is not user friendly
- Many different user interfaces to different information sources
- Users seem to have more success in finding information on Internet than the Intranet

- Employers store a lot of documents on the system, but you can never seem to find the right files when they need them
- There is no standard method to capture and reuse knowledge

8. SUMMARY OF FINDINGS

The survey concludes that changes are required to the existing system if it is to succeed in not only providing the employees with information and knowledge that although present is too laborious, time consuming and in some cases inaccessible to find, but also the process of adding to the information and consequently knowledge should be made available to every one rather than the very few that currently control it. It has also explored the reasons for the system failure through conducting interviews and collating employees views via questionnaires. The finding of this paper has presented the sponsoring company with a business case to replace the existing system as soon as possible

9. FUTURE WORK

There is a clear need to develop a new system of information retrieval and knowledge management that would take account of the latest advances in information technology and delivers the goals for the company to be able to compete with its rivals. To satisfy these goals one should start by looking into how human mind/brain can absorb information with minimal effort rather like writing programmes for a computer in computer language i.e. zeros and ones. It can then explore how the information can be added to the knowledge base system without the need for rewriting the software programme and by making the individual’s contribution to the system as easy and logical as possible. This can possibly be achieved through the principals of mind mapping and software’s such as Object Orientated Design.

10. RECOMMENDATION TO THE INDUSTRY

There are two main areas where this research has impact/implication on the wider construction industry. It should be noted that this research has focused on delivering the solution for the specific needs within the sponsoring company, but its findings can and should be used to assist others that may be faced with the same problems. The two areas are:

- **Simplification-** the willingness in participation through simplification and logic in other word to contribute to the knowledge because it is possible and easy. The challenge for the industry is to ensure that the people involved in a process are informed and can draw from latest technology to willingly cruise to change, not drive change through necessity, need and competition.

- **Integration-**The current structure of organisations within the construction industry has formed barriers to sharing knowledge and information because of worries about competition and rivalry, this has resulted in alienation of the technology and progress. The continuation of fictionalisation and ‘over the wall mentality’ means that inefficiencies will remain.

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LIVE CAPTURE AND REUSE OF CONSTRUCTION PROJECT KNOWLEDGE: CAPRI.NET APPROACH

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ABSTRACT

The role and importance of knowledge as a key source of potential advantage for construction organisation has been addressed by several authors. As such, managing this knowledge is not new for the construction industry. In the course of construction project, people face problems that they cannot solve alone; their natural response is to study past experiences and re-use previously acquired knowledge, either from their own experiences or from resources within their organisation. However, there are indications that current practice does not provide an effective strategy for the capture and reuse of project knowledge. In this paper, the authors describe a web-based development (CAPRI.NET) that facilitates the live capture and reuse of project knowledge. The distinguishing feature of this research is that it emphasizes “live” capture of construction project knowledge, which is still an elusive solution in Knowledge Management (KM) undertaken. Hence knowledge live capture and reuse are key elements in project development. Following a problem definition and related work discussion, the research underpinning CAPRI.NET is discussed. This is followed by a description of the development and further works. CAPRI.NET allows project participants to document their learning during the course of a project in a Project Knowledge File (PKF) which is collectively owned by all participating firms. The knowledge captured in the PKF can be reused during or after the project. A preliminary evaluation of CAPRI.NET by AEC practitioners suggest that it proffers unique possibilities for knowledge capture and reuse in AEC projects.

Keywords: Construction, Project Management, Knowledge Management, System, Live Capture and Reuse

1. INTRODUCTION

The role and importance of knowledge as a key source of potential advantage for construction organizations has been addressed by several authors (Rezgui, 2001; Kamara *et al*., 2002 and Lima *et al*., 2003). Managing knowledge is not new for the construction industry. The project nature of the industry is abound with a frequently reconfigured set of participants, non-repetitive nature of work, pressure to complete, and lack of incentive to appraise performance or improve overall project delivery (Patel *et al.,* 2000). This means that information is not often captured for re-use in future projects (Kamara *et al.,* 2003). Furthermore, it does not allow the current project to be improved by incorporating the knowledge being captured as the project progresses. Because of these disparate repositories of knowledge, a key aspect of project Knowledge Management (KM) in construction is therefore the capture and reuse of knowledge for the 'common good' of the project at different levels and subsequent projects. In tackling some of these problems, different techniques & technologies have been proposed and developed. However, the field has been slow in formulating a generally accepted, comprehensive solution for live capture and reuse of project knowledge. At the same time, the web is now an establish medium for capturing the knowledge in organisations across the globe. This important development has been driven by the increasing use of 'Internet' at both project and individual levels. A recent survey by Andersen Consulting has shown that one of the areas in which there is increasing use of Internet is in capturing & sharing of knowledge/information among organisational personnel, and that this trend is set to grow in the near future (CIRIA, 2002).

As part of the effort to improve knowledge management in construction project, CAPRIKON (CAPRIKON Report, 2004) has been developed to capture 'live' project knowledge and reuse this knowledge in subsequent tasks. However, this paper reports on the study undertaken at University of Newcastle as part of the CAPRIKON project. The work reported here focused on the development of a prototype web-based application for capturing and reusing of 'live' project knowledge, known as CAPRI.NET. The paper first outlines the problem/requirements of projects. Next, the paper reviews previous related works in the application of project knowledge management. The framework adopted in the research is then presented, and is followed by a description of the prototype system. This includes the way the system should be navigated. Finally, the paper outlines further work that is required to enhance the functionality of the prototype, and gives some recommendations that could facilitate the adaptation of the CAPRI.NET application in the construction projects.

2. PROBLEM DEFINITION

Many practitioners and researchers in the industry have acknowledged the limitations of current approaches to managing information and knowledge related to and arising from a construction project (Fruchter *et al.*, 2000; Rezgui, 2001 and Lima *et al.*, 2002). These limitations are due to several technical, human, and business related factors. However, these outline the requirements and problems of live capture of knowledge in construction projects. A detailed outline of these problems is documented in an initial report (CAPRIKON Report, 2004). The key issues can be summarized as follows:

- Each team member develops multiple alternatives. Evolution of discipline solutions and interactions among professionals are hard to document and track;
- Most of the concepts generated in the early phases of the project as well as the rationale behind these concepts are not captured. These concepts are hard to communicate to the stakeholders of the project and re-used in future projects. Consequently, a large rework time and effort are involved in recreating these concepts and linking them to the later stages of the project, such as design, design development, and construction;
- Unsatisfactory changes prompt team members to backtrack to earlier solutions, which at many times have to be recreated;

- Different discipline solutions interact with each other. The process of identifying shared interests is ad-hoc and based on participant's imperfect memories. This error-prone and time consuming process rapidly leads to inconsistencies and conflicts;
- Memos are generated by computers but handled as paper documents, distributed to selective team members, and filed. Paper memos cannot be easily updated and are hard to retrieve;
- Project documents that are captured in heterogeneous media preclude team members and clients to have a global project memory that they can access, visualize and navigate through;
- Project documents are not linked with the information on the construction site. This precludes the design-build team to quickly assess the status of the project, identify current delays, and act in an informed fashion and;
- Much of construction knowledge still resides in the heads of individuals, or at best, exists in an informal and unstructured form that makes it difficult to comprehend and exploit.

These factors have not merely inhibited effective knowledge management; but they have inhibited the industry's ability to capture, learn and re-use project knowledge for improved performance. Improvements in project procurement using Knowledge Management (KM) can reduce the construction period and help clients save cost. Some of these improvements can be accomplished through better capture and reuse of knowledge during the project life cycle. From the above problem definition, the requirement is to use appropriate knowledge infrastructure, and improve collaborative working between members of project team. The construction industry still has a significant gap to bridge to reach best practice in KM strategies. What are required are fundamental changes to address the issues stated above. However, the research work presented in this paper, addresses how web-based application can be deployed to capture live project knowledge and reuse them in subsequent activities within the project.

3. RELATED WORK

There have been several research projects on the potential applications of knowledge management in projects. Academic and industry have led these projects. CLEVER (Kamara, *et al.,* 2002) focused on the development of a framework for the transfer of knowledge in a multi-project environment in construction. The framework developed assists construction firms in selecting an appropriate strategy for the transfer of knowledge that is appropriate to their organisational and cultural contexts. e-COGNOS (e-COGNOS, 2002) focused on specifying and developing an open model-based infrastructure and a set of tools that promote consistent knowledge management within collaborative construction environments. KLICON (Patel *et al.,* 2000) focused on the role of information technology (IT) in capturing and managing knowledge for organisational learning on construction projects. Other initiatives in the US (Stanford University) focused on the development of a project memory capture system for design evolution capture, visualisation and reuse in support of multi-disciplinary collaborative teamwork (Reiner & Fruchter, 2000); work at Dresden University of Technology in Germany on the retrieval of explicit project knowledge from heterogeneous documents (Scherer & Reul, 2000). The list of related works is not exhaustive but it demonstrates growing interest in knowledge capture and sharing in construction projects.

4. FRAMEWORK DEVELOPMENT

The work presented in this paper emphasizes modeling of the overall knowledge/learning event in a project as shown in Figure 1. The approach will enable the project knowledge to be captured 'live' (i.e. in real-time, or as soon as possible after the knowledge is created or identified) and then reused 'live' either in the subsequent stages of the same project. The development consists of seven blocks, which are designed to capture the knowledge from the various learning situations of a project.

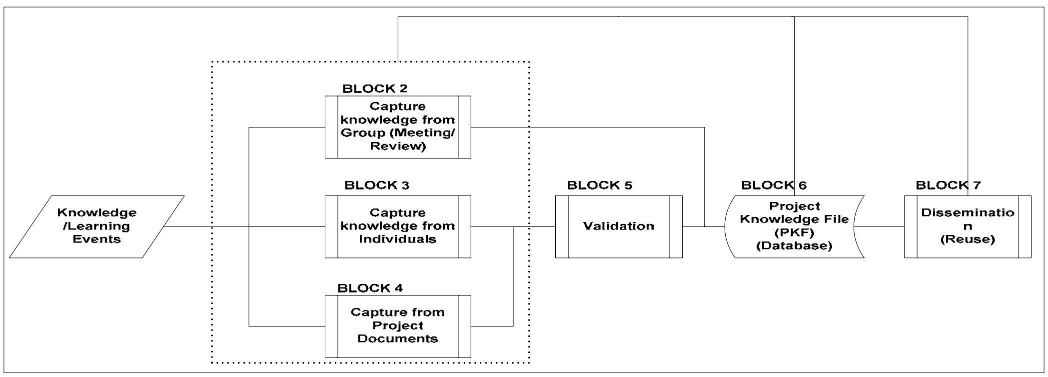

Figure 1: Project Learning Event Framework.

The Figure show that to capture knowledge/learning event in a project, three main approaches can be used: **knowledge from meeting**, **knowledge from individual** and **knowledge from project documents**. However, only the individual knowledge and document knowledge needs to be validated, before being stored in the database (as Project Knowledge Files). The reason for this is that these kinds of knowledge capture require verification before they can be reused. However, the work reported in this paper will present the prototype development, but details on the work undertaken to identify methodological issues of this framework are discussed in (CAPRIKON Report, 2004).

5. PROTOTYPE DEVELOPMENT

5.1 System Architecture

For the solution advocated to work properly, their implementation needs to be carried out on a system architecture that enables good coordination and collaboration between different entities that exist in a project environment. Given the nature of the methodology discussed in the CAPRIKON Report (2004), web-based project management system (PMS) was adopted. The system architecture is built as a platform for an electronic PMS conducted via a private network called "**CAPRI.NET**" using Internet protocols to transmit project knowledge. Only team members of the project can gain access to the system of which the team members can be located in different organisations. The system generally provides a centralised, commonly accessible, reliable means of transmitting and storing project knowledge files (PKF) (Kamara *et al.*, 2003). Project knowledge is stored on a server and a standard web browser is used as a gateway for project team members (PTM) to exchange project knowledge. Hence, the system can help the PTM transfer the knowledge captured faster and more effectively. Figure 2 depicts the system architecture and delineates the various functional activities that are carried out within the project Extranet.

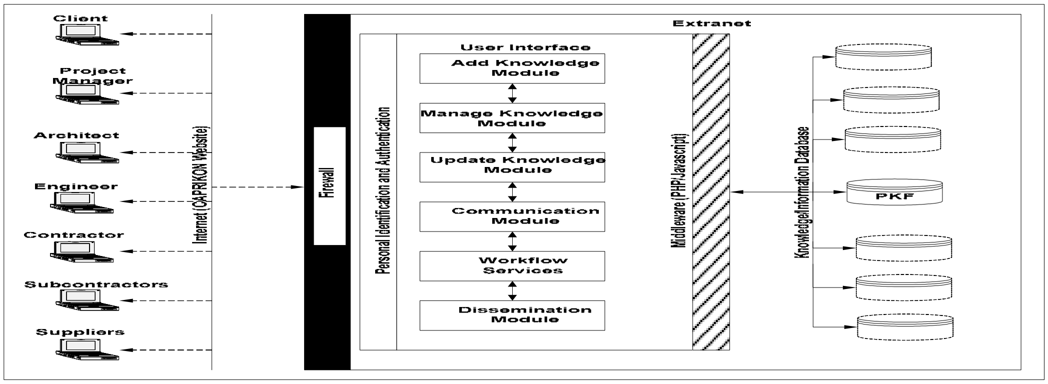

Figure 2: Architecture (Adapted from Nitthamyong and Skibniewski, 2004).

The CAPRI.NET has been implemented using multi-tier architecture; in this case the three-tier architecture composed of three logical layers (Figure 3): client side, middle layer and the server side. The Server side (that encompasses the product side implementation) scripting language PHP (Meyer, 2003) is used to generate dynamic content from the database for producing the standard web pages in the system (see Figure 3). PHP provides a simple scripting language that can be embedded in specialised tags in HTML documents. When a user request such a document, the document is parsed by the PHP interpreter prior sending it back to the web Client, and the embedded scripts can generate the dynamic portions of the document at this point. The main reasons this language was chosen will not be discussed here, but it will documented CAPRIKON report (CAPRIKON, 2004) and other relevant script language materials (Meyers, 2003).

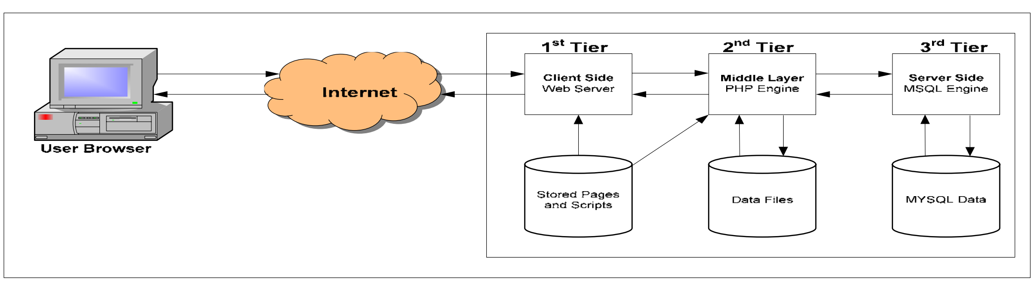

Figure 3: Basic Three-Tier Architecture Web Layout.

In the development of the system architecture in this research, the implementation was divided into two parts. The first part dealt with the development of the product issues (encompassed within the Server side); while the second part concentrated on the process issues dealing with the workflow management decision issues (Client side and middle layer). The remainder of this section will discuss and describe the development in detail.

5.2 Product - Side Development

The product-side of this development as shown in Figure 4 deals with Project Knowledge Files (PKF) and other relevant information needed for capturing knowledge. The PKF will contain information relating to the ‘project knowledge’, but will focus on knowledge that can be reused both during the execution (e.g. in subsequent phases), and after the completion of the project. The kind of knowledge to be captured and the format and contents of the PKF has been determined through detailed research into Reusable Project Knowledge (RPK) (CAPRIKON Report 2004), but the goal is to develop an ongoing ‘learning history’ for the project within a collaborative environment. The PKF will be agreed on at the onset of a project and all parties are required to contribute to its compilation. Other project information will also be present within the development (such as project detail, members’ information, other relevant documents etc.). Hence in implementing such a development require an understanding of knowledge/information flows within an organization or project undertaken for different construction project participants. A key decision in the set-up of this research is that all product data will reside on a central repository. Thus, this will facilitate the sharing of project Knowledge/information across CAPRI.NET. The vision of the research in this regard, is for system architecture to draw from a common pool of project knowledge/information, which is stored in a database. Thus enables specific knowledge/information to be retrieved and disseminated in a variety of views and levels of abstraction. The use of the shared pool of project knowledge/information in this way improves knowledge management; however, this would hinder the system/user access to a much wider range of knowledge/information that would otherwise be practical in a world wide web.

The work presented in this research on product development, looks at the construction project knowledge/information from a clear perspective of product model that needs to be abstracted, modelled and mapped into a database (see Figure 5.3). The Figure shows that knowledge/information presented in product side development has inter-relationships that are necessary for the knowledge/information to be abstracted and translated in the form of a model that will transcend into a database. In the system, all project knowledge/information is centralised in a database residing in the project server, instead of being distributed to many different locations. By utilising the latest web technology, the system works as a knowledge/information platform for all participants of project throughout the life cycle of the project. On the issue of database design, the system was designed to represent all the product details in Figure 5.3. Hence the database consists of the following: **Project Information, Reusable Project Knowledge (RPK), Contact** and **Authentication details** etc.

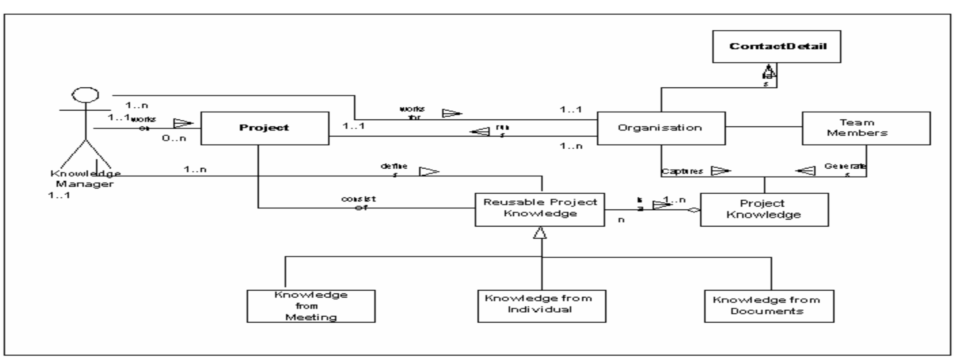

Figure 4: Knowledge manager’s View of Knowledge Capture and Reuse.

5.3 Process - Side Development

Process-side of this development deals with the Client side applications. This has been implemented as a set of common client modules for communication (prompt and email), knowledge capture Templates, and workflow management engines, as shown in Figure 2. The modules are made up of the following: **Knowledge**, **Workflow services** and **dissemination** modules. Thus, in final implementation these modules will appear as static and dynamic web pages that the Project Team Members (PTM) can interact with using a web browser to access the server side (PKF and other project information). Figure 3 above shows the interaction within the CAPRI.NET system. The figure depicts how PTM in a project can capture, store, reuse knowledge/information within the CAPRI.NET environment. Through the middle layer, the client will send a request to the server, and then the server processes the request and sends back the result through middle layer in a language the client will understand. A detailed discussion of how this will work is presented below.

6. KNOWLEDGE CAPTURE AND REUSE ENVIRONMENT

The CAPRI.NET is operated through a user interface, to which access is via the internet domain address (see Figure 3). During knowledge capture in the system, the sequences of interactions are initiated by the PTM through the web browser and this is numbered 1-6 in Figure 5. These sequences are described below:

1. When PTM first accesses the address, the first page that he/she sees is the 'login page' with the registration link page (see Figure 6).
2. Before the PTM can use the site, the PTM has to register his/her details first. Once the system receives the details of the PTM, he will send out a confirmation through email and this will activate the PTM authentication. There are two levels of authentication, the user and administration level. The reason for this is to allow only PTM to register and also the administration level gives the PKM a high level authorisation to add and update project details. The other process the system does is to upload the details of the member in the PKF (2c).
3. Equipped with the log-in details, the PTM can now log into the CAPRI.NET system. The first and main page after the 'login page' is the 'index page'. The index page is used to show and link all the knowledge that has been captured. However, at the initialisation stage the knowledge section is blank, only the add knowledge and logout links are visible. Once the PTM captures knowledge using the template, it will then appear in the table (see Figure 6).
4. The add knowledge page is a template used to capture the different types of categories and the approach used in capturing the knowledge (see Figure 4.1).Once the template has been filled in and submitted, the system stores the captured knowledge in the PKF and immediately generate a fresh index page that contains the captured knowledge. The other process at this stage is for the system to send out email to every member, informing them that knowledge has been captured (4c).
5. The view knowledge page is used by members to view various knowledge added. The distinguishing fact of the view page is that members can open various captured knowledge, but the system will not allow them to edit the capture knowledge unless it was captured by that particular member. To view knowledge the system interacts with the server to generate stored knowledge.

6. The update knowledge page is used by members to update knowledge they have added. This can only be done through the index page as shown in Figure 6. The system also prevents members from updating knowledge they have not added. Once knowledge has been updated, the system stores updated knowledge in the PKF (6b).

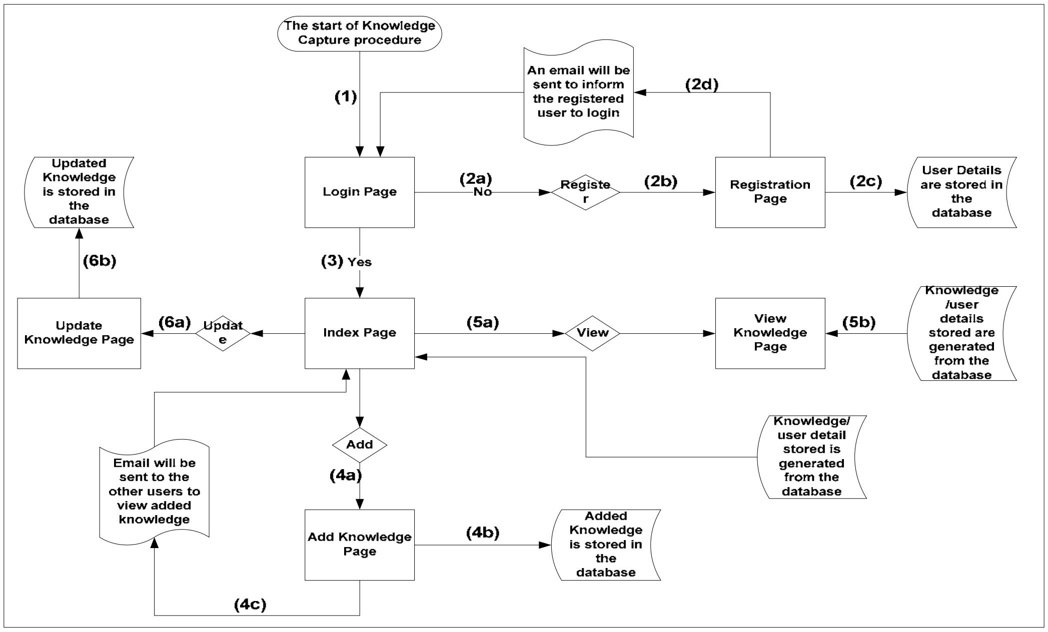

Figure 5: User View of CAPRI.NET Approach to Knowledge Capture & Reuse

The other sequence of interactions that were not illustrated within the flow chart is the search and project detail section. The search section can be used by the PTM to search for RPK that has been captured and stored in the PKF. The project detail section is the PKM only section. It is a private protected section that can only be accessed by the PKM to update or configure project details or even remove members from the system (see Figure 6).

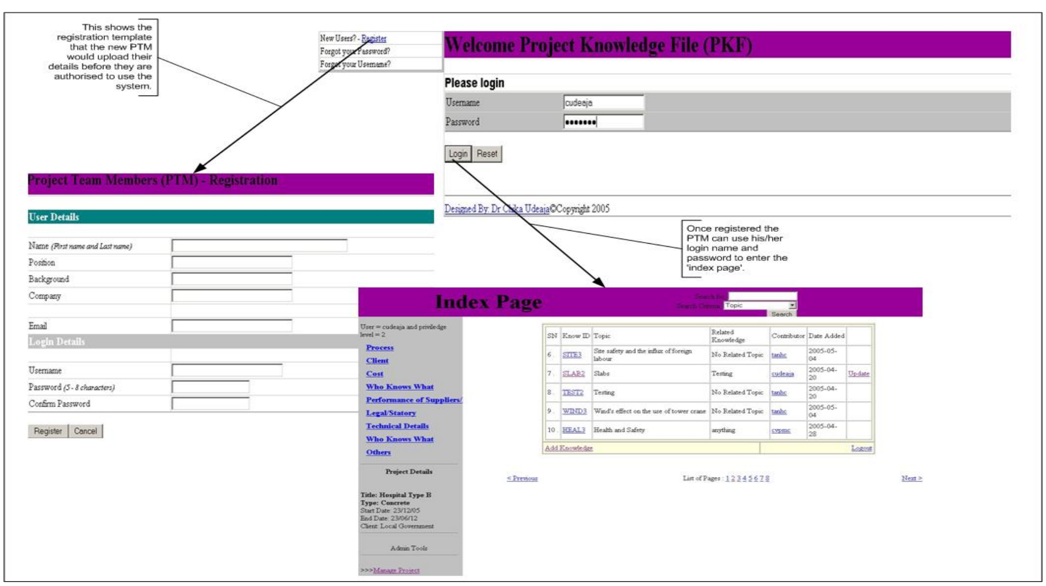

Figure 6: A Screenshot of the CAPRI.NET Environment

7. FURTHER WORKS

The research project is bound to uncover issues that need to be investigated further. This work is no exception, as a number of issues have been identified to improve the development. This section outlines the further works that could enhance the deployment of the prototype. These recommendations are based on the emerging trends and the issues raised from the test and validation exercise carried out with representatives of the industrial partners. These further works are as follows:

- Searching tools – Although the search tool implemented in this work might be appealing to many, difficulties with search are expected to worsen as the amount of RPK increases. This is mainly due to the problems of information overload and vocabulary differences. This problem can be harnessed by developing data mining approaches that support knowledge retrieval from the PKF.
- Improving web automation – The of the web automation will employ agent concepts, the approach here is that the project development is viewed as a virtual environment that employs concepts from multi-agent system field to organise and coordinate the activities of knowledge capture and reuse. This will help prevent knowledge loss due to time lapse in capturing the knowledge and also help relieve PTM of their mundane tasks (such as responding to their email request and sending confirmation to other participating agents).

Beside searching and improvement issues described, there are other issues such as the textual mining, the transfer of domain knowledge into agents, the empowerment of agents, agent-based search paradigm, agent's ability to learn from each other, the legal issues of agent roaming the web, and agent-based engineering services that deserve further investigation.

8. CONCLUSION

This paper has proposed ways in which CAPRI.NET, promote, enhance, and support live capture and reuse of knowledge. In the current dynamic environments, the potential of CAPRI.NET for enhancing a live capture and reuse can be even more important. For example, when project team member are faced with making quick decisions, the system can provide efficient and effective capabilities for capturing live knowledge. Using this knowledge, team members can easily rectify the mistakes they made in a previous task with project development. The approach corresponds to the development of high and low – level functionalities – that help a supply chain to deal with many activities within a project. However, in the early part of the paper, the general concept of project knowledge was emphasized. Comparative descriptions of existing limitations were presented and the related works were also highlighted. This chartered a course for development of a new system adopting 'live' capture approach. The CAPRI.NET has demonstrated how a web-based application can be used to partial automate the 'live' capture and reuse of project knowledge in construction. This is an important step towards the deployment of full commercial approach in the industry. It is evident that the industry stands to reap many benefits from this approach of 'live' capture and reuse of knowledge in this way, once a number of existing problems are resolved. Some of these benefits are as follows:

- Construction supply chains will benefit through the shared experiences that are captured as part of the learning on key events (e.g. problems, breakthroughs, change orders, etc.). The benefits to this group are both short- and long-term. Short-term in the sense that project teams would be enabled to manage better the subsequent phases of a project (through the capture and transfer of learning from a previous phase). Long-term because it will increase their capacities to better plan future projects and their ability to collaborate better with other organisations. Furthermore, learning from past projects can be used to train new employees and project managers.

- Other project teams can use the learning captured from previous/similar projects to deal with problems; reflection on previous learning can also trigger innovative thinking (to think about issues that might be relevant to their project).
- Client organisations will benefit from enriched knowledge about the development and construction of their assets. This will contribute to the effective management of facilities and the commissioning of other projects. In the longer term, clients will benefit from the increased certainty with which construction firms can predict project outcomes.
- Improved supply chain management, as team members would work more collaboratively and share the lessons learnt on construction projects.
- The construction industry will benefit from an enhanced knowledge base as much learning that is presently not documented can be captured and reused.
- Facilitate the reuse of the collective learning on a project by individual firms and teams involved in its delivery.
- Provide knowledge that can be utilized at the operational and maintenance stages of the asset's lifecycle.
- Involve members of the supply chain in a collaborative effort to capture learning in tandem with project implementation, irrespective of the contract type used to procure the project from the basis for both ongoing and post-project evaluation.
- Maximise the value of reusing the knowledge captured through 'live' capture and reuse. The true benefit of capturing knowledge comes only when the knowledge is being used, particularly if the knowledge is being reused 'live' after it has been captured.
- Enable the knowledge to be disseminated for reuse as soon as possible before the opportunities for reusing the knowledge diminishes. This helps prevent knowledge loss due to time lapse in capturing knowledge.

To conclude, this paper has described and discussed some ways to think about project procurement of today and the future, which can enhance the project team's activities. Ultimately, improvements in the project procurement as a result of 'live' capture and reuse approach can reduce the construction period and decrease the cost of projects.

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MANAGING CONSTRUCTION SITE INFORMATION USING MOBILE COMPUTING

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ABSTRACT

The development of Information Technology (IT) has increased the efficiency of information communication in the construction industry and brought productivity benefits to the construction process. Current IT systems have been extended to the site office, but IT support on actual work sites still need further development to benefit from advances in IT. The emergence of Mobile Computing (MC) has the potential to improve on-site information management and enhance information flow throughout the site. This paper describes an ongoing research project that is aimed at developing a framework for the use of Mobile Computing in the management of on-site construction information and communication. Research undertaken includes: (a) a pilot study; (b) a survey to investigate the information needs of on-site users and the nature of information used, (c) deployment and validation of the framework using various operational scenarios. The outcome of this research will be useful in providing guidance in the effective development and use of Mobile Computing for on-site information management.

Keywords: construction sites, information management, Mobile Computing

1. INTRODUCTION

Construction information management has greatly benefited from the advances in Information Technology (IT) in increasing the speed of information flow, enhancing the efficiency and effectiveness of information communication, and reducing the cost of information transfer. Current IT support has been extended to construction site offices. However, construction projects typically take place in the field where construction personnel have difficulty in gaining access to conventional information systems for their information requirements. The advances in affordable mobile devices, increases in wireless network transfer speeds and improvements in mobile application performance, give mobile computing technology a powerful potential to enhance on-site construction information management. However, before employing this new technology, it is necessary to identify the features of mobile computing, construction personnel, construction information and construction site, and explore the interactions that are likely to affect the implementation of mobile computing in on-site information management.

This paper presents an ongoing research which considers how mobile computing technology can be best employed in managing on-site construction information. On-site information management and the application of mobile computing in construction are described. Following a description of the research carried out to data, the findings from the survey are presented. Then the conceptual framework is introduced with detailed explanations on its nature and practical application. The paper concludes with a brief discussion on the framework and the operational scenario.

2. CONSTRUCTION SITE INFORMATION

Construction sites are information intensive environments where actual construction processes and activities are carried out. Various construction personnel in the field need large amounts of information ranging from project design drawings to personal diaries to support their ongoing works and to make decisions about the process of construction. In order to explore and develop the new effective methods of on-site information management, the starting point should be the identification and categorization of on-site construction information.

Several researchers have investigated on-site construction information from various perspectives. In de la Garza and Howitt's research (1998), on-site construction information was grouped into ten major categories from a generic construction project perspective. These ten categories include requests for information, materials management, equipment management, cost management, schedule and means and methods, jobsite record keeping, submittals, safety, QC/QA, and future trends. Each category was further divided into more detailed subcategories. For example, the group of materials management contains the following five subcategories: access to material management, material location, material order status, request materials to site and place material orders.

From a site record perspective, Scott and Assadi (1999) have summarized three types of site records, which consist of a range of information relating to finance, quality and progress. Especially, the progress records typically kept by contractors and supervisors aim to identify the works carried out during the project life-cycle and consist of site diaries, weekly progress reports, day-work sheets and joint records, photographs, as-built programmes/schedules, and minutes of progress meetings.

In an earlier research, Tenah (1986) explored the information needs from a user's perspective and stated that the information needs of each members of the project team are inextricably linked to their management responsibilities. Construction personnel are divided into five levels, each of which has different management responsibilities and information needs. For example, at the functional management level, the foreman's information needs consist of drawings, specifications, contract documents, local union activities, safety regulations labour agreements, quality control, progress and field performance reports.

Due to the complex nature of the construction process and the dynamic nature of construction sites, the management of on-site information usually inefficient and leads to low productivity. The most effective way for construction personnel to manage information on sites is to retrieve or capture information at the point where they are and at the time when they need it. However, this ideal situation has been difficult or impossible with traditional information management methods, which are normally the organization and maintenance of paper-based documents. Bowden et al (2004) indicated that the main type of information that onsite construction personnel receive and transmit is paper-based, which poses a major constraint for site information communication and exchange. Ineffective on-site information management can result in personnel overlooking important issues that require quick response and often cause on-site decisions to be deferred (Singhvi and Terk, 2003).

The development of Information Technology (IT) gives the construction industry a powerful potential to increase the efficiency and effectiveness of information exchange, but current IT support has only extended to construction site offices and they are still gaps between site offices and actual work sites. The emergence of Mobile Computing (MC) has the potential to enlarge the boundary of information systems from site offices to actual work sites and ensure real time data flow to and from the construction sites.

3. MOBILE COMPUTING AND CONSTRUCTION INFORMATION MANAGEMENT

Before the discussion of applying mobile computing in on-site construction information management, it is necessary to explain what exactly is meant by mobile computing. The concept of Mobile Computing (MC) has been considered to consist of three major components: computers, networks and mobile applications (Rebolj and Menzel, 2004). Computers which can be used indoors and outdoors by users include tablet PCs, all kinds of pocket computers, palmtops and wearable computers, but exclude conventional notebooks. Networks which can support the connection and communication of mobile computers with sufficient bandwidth include all types of wireless networks such as Wireless Wide Area Networks (WWAN), Wireless Local Area Networks (WLAN), Wireless Personal Area Networks (WPAN), and satellite networks. Mobile applications with the attributes of context-sensitivity and personalization can support mobile users' work processes and enable them to work together collaboratively and cooperatively in a mobile computing environment.

With the consideration of the characteristics of construction sites and construction processes, one major question should be carefully considered: what are the necessary requirements for mobile computing while applying it in construction information management? After interviews and discussions with construction managers, Kimoto et al (2005) identified nine necessary requirements for mobile computing, which are mobility of hardware, durability of hardware, compatibility of hardware and operating system (OS), compatibility of data between the mobile devices and PC, expressivity of display, stability of system, operability of user interface, processing speed, and continuous computing environment.

With advances in Information Technology and the decreasing price of computer hardware, current commercially available mobile devices, wireless networks and mobile applications can fulfil the above necessary requirements. The current status of Mobile IT have been discussed in the report of the COMIT project, which briefly describes the mobile devices, networks and computer applications currently in use in the construction industry (COMIT, 2003). In the three components of mobile computing concept, mobile application is the key factor that responds to specific characteristics of mobile devices and wireless networks and support users' work process by enhancing the efficiency of information communication. Based on commercially available products and related research, mobile applications can be grouped into the following three categories:

- *Mobile CAD Applications*. Construction personnel using mobile devices equipped with mobile CAD applications can view, mark-up, create, edit and collaborate on 2D/3D AutoCAD compatible designs and digital blueprints anywhere and at anytime when they are on construction work sites. Users of mobile CAD applications may contact anyone who needs the support of drawings and designs in the construction field, such as engineers, project managers, designers and drafters. Most mobile CAD applications are compatible with popular mobile devices running Windows CE, Windows Mobile or Palm Operating Systems. In order to communicate drawing files with desktop PCs, mobile CAD applications can connect and exchange data with PCs by using ActiveSync for Windows OS or HotSync for Palm OS. Example applications include PocketCAD, PowerCAD and ZipCAD.
- *Data Capture Applications*. There are three types of data capture applications used in the field, which include data capture, bar code scanning and wireless sensor network. SHERPA (Ward et al., 2003) is one of the mobile data capture systems, which enables users to utilize workforce driven mobile computers to collect real time piling work data in the field through a Wireless Local Area Network (WLAN). A bar-code-enabled PDA application, named the Mobile Construction Supply Chain Management system (M-ConSCM), has been developed to improve the effectiveness and convenience of information flow in a construction supply chain environment through integrating a PDA and bar code scanner together (Tserng and Dzeng, 2005). Wireless Sensor Network that consists of various devices capable of a cooperative sensing task is a new innovative technology similar to the concept of Ubiquitous Computing. A mass concrete curing management system (CMS) has been developed to investigate the possibility of applying Wireless Sensor Network to on-site data collection processes (Lee and Kang, 2006). This system can allow the collection, transfer, and delivery of the recorded curing temperature data automatically in real time in a Wireless Sensor Network environment.
- *Project Management Applications*. Applications in the project administration area provide users with the capabilities of project and programme management such as construction activity review, activity monitoring and updating, progress management, risk management, Microsoft Project file view and update, and material and equipment management, through their on-hand mobile computers. Available commercial applications include Primavera Mobile Management, CYtools, and OnSite FDM.

4. RESEARCH METHODOLOGY

According to current developments in mobile computing technology and the status of on-site construction information management, the potential opportunities of mobile computing are best deployed in the area of on-site information communication. In this research, a construction site is considered to comprise two components: the construction “work site” and the “site office”. The work site includes all areas outside the site office, and the site office is the headquarters for project (site) personnel. Construction personnel in this research refer to those managerial people whose work places are mainly based on construction sites. The aim of this ongoing research is to identify opportunities for applying mobile computing in construction site information management and to develop a framework that explore how mobile computing technology can be used in construction site environment to retrieve and transfer on-site information. This proposed framework will identify all major factors and their associations, which affect the design, implementation, and maintenance of mobile computing in on-site information communication. In order to validate and evaluate this framework, various operational scenarios will be developed to demonstrate how mobile computing can be used to retrieve and transfer information on particular construction site, and how mobile computing can enhance the effectiveness of the construction process for particular users.

In order to achieve the objectives of this research, an appropriately designed methodology is necessary. The research strategy contains three steps: a pilot study for the first stage, a survey that investigated the information needs of particular users and the nature of on-site information, and finally the development of a framework and the validation and evaluation by operational scenarios.

After the reviews and evaluations of previous research and published literature, a conceptual model was developed from the perspective of information management (Chen and Kamara, 2005a). This conceptual model integrates mobile computing technology with each level of information management, and explains the relationships between each of them. The three levels of this model are as follows:

- *Information retrieval and provision* is concerned with the use of mobile devices by construction personnel to retrieve and transfer on-site information from or to mobile computing systems with a view to meeting specific information requirements.
- *Mobile computing systems* that consist of three components (mobile device, wireless network and mobile application), are designed to collect, store and process construction information in a wireless communication environment. The operation of mobile computing system should combine with existing information systems in an integrated and systematic way to meet information requirements for construction organizations and individuals.
- *Construction companies* are the contexts that encounter mobile computing systems and have impact on systems design. Construction companies determine the functions and requirements that mobile computing systems and other information systems can be expected to perform.

After building up the conceptual model, a pilot study was conducted in February 2005 (Chen and Kamara, 2005b). It involved visits to three construction sites with varying project types. Findings from this pilot study included the following:

- The varieties of roles on construction sites are normally affected by project stages, types and sizes.
- The main information that construction personnel need to support their construction processes is drawings.
- IT support has been extended to construction site office and middle-level managers normally are equipped with laptops or desktops. However, construction work sites hardly have sophisticated IT support, and mobile computing is still a very new concept to construction personnel.

A web-based survey was conducted to investigate the information needs of particular users and the nature of on-site information. Data from this survey has been collected and analyzed, and findings will be discussed in the following section. The development of framework and scenarios will be introduced following the survey section.

5. THE SURVEY

This section reports on the survey that was conducted on the second research stage to find out the information needs of on-site construction personnel and the nature of information. Findings from this survey will be used as evidence to build up the final framework. The survey was conducted via the Internet, first as a pilot survey and then a final survey. The results of the pilot survey were excluded from the final analysis since it was corrected and improved for format and content problems in the structured questionnaires.

Sample frame
The survey targeted construction professionals who have work experience on construction sites. The randomly selected respondents have sound construction knowledge and are the most likely persons who need to visit construction sites for their work processes. A total of 160 companies in the construction industry were invited to participate in the survey. Of the 38 responses received, 28 were complete and are deemed suitable for the analysis.

Respondents' profiles
Among the 28 respondents surveyed, 25% are senior executives, 57% are functional management staff, 18% are work site management staff. The functional management staffs consist of quantity surveyor, quality manager and planner. Of the respondents, 29% have 1 to 10 years of construction-related working experience, 39% have 11 to 30 years of working experience and 32% have over 30 years of working experience. Based on the last project that respondents have been involved in, 45% of the respondents spent 1 to 5 hours per week on project work sites (out site offices), 36% spent 6 to 15 hours per week and 19% have more than 15 hours on work sites per week. The above findings suggest that the respondents are construction domain experts who have sufficient construction related knowledge and adequate working experience on construction sites.

Users' information needs
On-site construction information is grouped into 12 categories including drawings, material information, equipment information, contract, progress, safety information, sub-contractor information, design clarification, construction methods, specification, labour information, and quality information. From the analysis of collected data, the study showed that: (a) findings provide support for Tenah (1986) who found that information needs of construction personnel are inextricably linked to their management responsibilities; (b) senior executives including managing director, project director and project manager, need all types of information to plan, organize, and control current construction project that they are involved in; (c) different types of functional managers need specific information that relate to their functional duties to support their work; (d) drawings are the most important information on construction

sites. Nearly all respondents selected drawing as the information they need on site. This supports the findings from the pilot study; (e) construction work sites are also information intensive environment, since on-site management staffs need nearly all types of information to support their on-site construction processes.

The nature of on-site construction information

In this survey, the nature of construction information is considered to have 5 types of formats: text, graphic, form, image and verbal. On-site information grouped into 10 categories was presented to respondents who indicated the formats of each category of information they retrieved or transferred on construction sites. From the analysis of collected data, the results reveal that: (a) the major formats of drawings are graphics and images, which imply the requirement for a large amount of paper to display drawing information; (b) the major format for on-site information is text. Excluding drawings, the rest of on-site information are mostly presented and described by text; (c) forms that requires standard data input are another major information display method for on-site construction information, such as request for information, material information, equipment information and site visit record; (d) in addition to text, progress information and design clarification also need graphic to make them obvious and straight forward; (e) the information format, 'verbal', means that construction personnel have conversations with other people in order to obtain required information. Methods of conversation may include phone call, face to face and meetings. From the result, many types of information including request for information, sub-contractor information, quality and safety record, are communicated verbally, and this medium is used as a supplemental method for on-site information retrieval and transfer.

6. FRAMEWORK OF MOBILE COMPUTING IN ON-SITE CONSTRUCTION INFORMATION MANAGEMENT

The third stage of this research was to establish the framework that explores how mobile computing can be used on construction sites to manage on-site information. This framework, firstly, identifies the key factors of mobile computing, construction personnel, and construction information and construction site; secondly it describes the relationships and interactions among these factors. The intention is to use the framework to provide guidance in the effective development and use of Mobile Computing for on-site information management. Evidences that are used to build up the framework consist of the findings from the second stage survey, case studies from published paper, and other secondary sources of information.

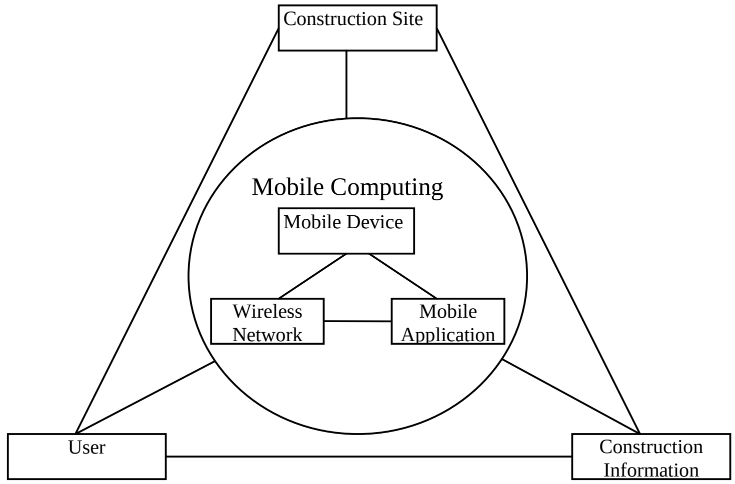

Figure 1: The Framework of Using Mobile Computing in On-site Information Management

This framework, shown in Figure 1, consists of three internal factors and three external factors. The three internal factors, which are mobile computer, wireless network and mobile application, are the fundamental components of the concept of mobile computing. The three external factors, - users, construction information and construction site, - are the elements that have relationships with each internal factor, which determines the use of mobile computing in a particular circumstance. In order to explore the links among internal and external factors, each factor has been further divided into sub-factors. For example, the internal factor of mobile device contains the following sub-factors: operating system, processor speed, storage capability, input method, output method, physical feature, battery time, and network connectivity. One of the external factors, construction information, can be divided into six sub-factors: information type, information format, file size, on-site information flow, on-site information processing, and related user.

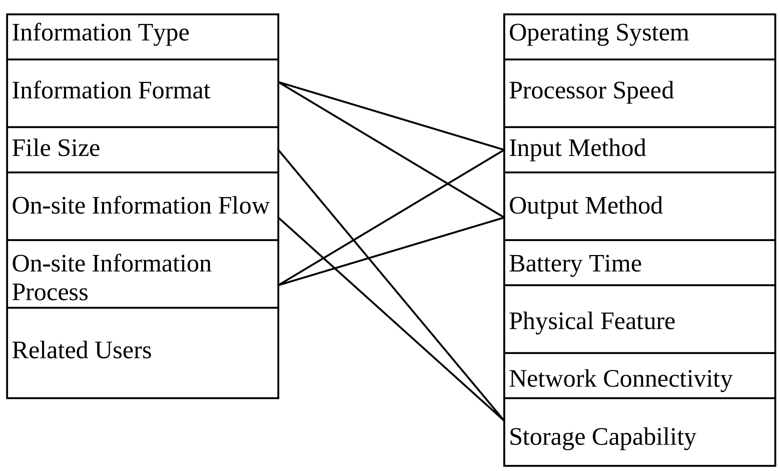

Figure 2: The Sub-framework of Construction Information and Mobile Device

Because each major factor in this framework can be divided into detailed sub-factors, the whole framework can be broken up into different sub-frameworks, each of which presents the particular relationships between two major factors. Figure 2 is one such sub-framework, which explores the relationships between construction information and mobile device. It is illustrated in this sub-framework that the information format has an impact on the output method of the mobile device; similarly the output mechanism of the mobile device can restrict the output format of construction information. For example, when a user needs the mobile device to display construction drawings, the screen size of mobile computer limits the expressional scope of drawings. The requirement of displaying large size drawings can be fulfilled from the hardware aspect by choosing a mobile device with larger size screen and the software aspect through the design of drawing viewer software with the functions of zoom out, zoom in, scrolling, moving, and layout. In addition, the input methods of the mobile device including keyboard, touch-screen input and microphone, determine what types of information format can be inputted and how efficiently this can be done. Moreover, the storage capability of the mobile device should be able to store the necessary information files; on the other hand, the file size for mobile application software should be smaller and only keep necessary software functions in order to fit in the limited storage capability.

From the discussion above, the framework will explore all relationships between internal and external factors. Major factors are divided into sub-factors and the framework is also made up of sub-framework. Each sub-framework explores the interactions and restrictions between two major factors.

7. FUTURE WORKS

For a new framework, there is a need to validate and evaluate it in a real construction situation. An operational scenario that describes a specific construction site, on-site construction personnel and the information that support their work process, will be developed to demonstrate how mobile computing can be applied to manage on-site information in the particular situation, and how mobile computing can support user's work process by enhancing the efficiency of information flow.

8. CONCLUSIONS

The aim of this paper was to explore how mobile computing can be used on construction sites to manage on-site information. From the review of previous research, on-site information has been grouped from different perspectives with the discussion of the current status and problems of construction site information management. Mobile computing, consisting of mobile devices, wireless networks and mobile applications, should have the necessary functions for it to be used in construction. These functions include mobility and durability of hardware, compatibility of hardware and operating system (OS), and continuous computing environment. Currently available mobile applications includes mobile CAD, data capture and project management software. The ongoing research reported in this paper, involved three main stages: a pilot study, a survey, and finally the development and evaluation of a framework for the development of mobile computing for construction site information management. The survey has identified the information needs of particular users and the nature of on-site information and provided supports to the development of the framework. The concept framework has identified the key factors that determine the use of mobile computing in particular circumstance and explore the interactions and restrictions between these factors through the development of sub-frameworks. The conclusion of this research will provide valuable guidance in the use of mobile computing on construction sites, from a user perspective.

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A KNOWLEDGE MANAGEMENT SYSTEM FOR LEARNING OBJECTS IN CONSTRUCTION

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ABSTRACT

The development of e-learning tools for construction education - both in the context of academia and industry - is continuously growing. However, rapid developments in new technology provoke the need for reinventing the wheel as existing applications become out of date. Sharing knowledge and expertise through the exchange of learning objects is one way of enabling education via the use of e-learning technologies. This era is enabled by the emergence of new technologies (online and mobile) and the development of educational standards. However, the broad definition of the construction domain and the interlocking nature of subjects taught within this domain, makes the concept of sharing content most appealing. This paper describes an approach adopted to develop an online knowledge management system for sharable learning objects in construction related domains, using the Semantic Web concepts. The development of this environment entails three main stages. The first stage is developing the metadata of learning objects, the second is the development of dynamic content through relational metadata and the final stage is the delivery of objects via content packaging to learning management systems. The paper summarises the findings of each stage and demonstrates how 3D learning objects can be dynamically submitted and launched to cater for different needs, using Semantic Web concepts and educational standards.

Keywords: Knowledge Management System, Learning Objects, Learning Standards, Metadata

1. INTRODUCTION

"e-Learning can be viewed as an innovative approach for delivering well designed, learner-centered, interactive, and facilitated learning environment to anyone, anywhere, anytime by utilizing the attributes and resources of various digital technologies along with other forms of learning materials suited for open, flexible, and distributed learning environment", (Khan, 2001). The instruction methods used within construction education rely on traditional methods such as exposing students to applied science courses (Moonseo et.al, 2003). These traditional teaching methods, however, are often not fully capable of providing students with all the skills necessary to solve the real world problems encountered in construction or conveying complex engineering knowledge effectively. The curricula however, often convey knowledge in fragments in a series of courses.

Ideally, visits to construction sites or site training would constantly complement the more conventional classroom instructional tools. However, there are various complicating issues that make it impossible to rely on the construction sites. Foremost, the instructor cannot control the availability of a project at the necessary stage of completion. Also, visits of larger groups to construction sites may not be welcome, involve risk, and are unpractical. The high cost of site training is a further impediment to its extensive use for construction education.

The Joint Information System Committee (JISC) had funded a number of initiatives to look into e-learning standards to bridge content and systems. Its digital repository programme has funded number of projects related to digital resources. PERX (Pilot Engineering Repository Xsearch) project aimed to develop a pilot service which provides subject resource discovery across a series of repositories of interest to the engineering learning and research communities (PERX). StORe (Source-to-Output Repositories) project is addressing the area of interactions between output repositories of research publications and source repositories of primary research data (STORE). Their development however, is costly and time consuming and also they soon become out of date. This is mainly because of the fast changes in the technology and their incompatibility with new systems or platforms and as a result of instructional software available being locally effective, but globally fragmentary (Molyneux, 2002). Construction educators and technologists must take the lead in promoting computer literacy in their curriculum, and continue to develop new courses, delivery styles and software applications through continued research activities (Charles et. al, 2004).

On the other hand, educational software has been developed with the potential for online learning as complete packages, commercially prepared and disseminated. They however, lack cohesion as an organised collection because every software application is vertically engineered to comply within its specific domain. This makes their reusability and sharing more difficult, and can lead to maintenance and deployment difficulties. This paper develops an understanding of standardisation of e-learning which underpins the theory behind developing online knowledge management system for sharable learning objects.

2. LEARNING OBJECTS AND METADATA

Learning content is the heart of education and can be divided into small chunks of learning that are defined as learning objects. The IEEE Learning Technology Standards Committee(LTSC) defines learning objects as "any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning"(LOM, 2003). According to Mohan and Brooks (2003), a learning object is a digital learning re-source that facilitates a single learning objective and which may be labelled, reused and mixed or matched in a different context.

The aim of creating learning objects is to achieve the goal of maximum reusability, leveraging the high cost of production of quality materials without sacrificing the learning meaning. The concept of learning object emerges from the need to introduce and elaborate e-learning content with pedagogical aspects in a way that can be reused in different learning scenarios. Learning object has to be labelled in a consistent way to be discovered by various search engines. It also needs to be packaged in a standardised way to be delivered to different learning environments. Therefore, there is a need for the standardising and labelling of learning objects by using metadata and packaging standards. There are however, different types of standards exist for these purposes and can be classified into some general categories for the delivery of learning objects. IEEE Learning Object Metadata standard is one of the metadata standards and is widely adopted by various e-learning systems. Learning Object Metadata is referred as the labelling of learning objects so that they can be identified via search engines (Qin and Hernandez, 2004).

Authors have already developed an approach for defining metadata for construction learning objects (Ahmed and Pathmeswaran, 2007). Using questionnaires and surveys, they have identified relevant mandatory and optional metadata elements from UKLOM standard which is the IEEE LOM standard adapted for the context of UK education. Ahmed and Pathmeswaran (2007) also proposed the pedagogical metadata elements for construction education. They proposed Learning Outcomes and Learning Styles as the mandatory elements and Prerequisites and Learning Objectives as optional.

The study of UK LOM metadata standard, metadata for construction and the pedagogical metadata has led to the development of a generic framework for the integration of metadata for construction education as shown in Figure 1. The elements from the generic metadata framework were embedded as learning object metadata in order to facilitate automated discovery and retrieval of learning objects from various repositories. This framework will be adopted to develop the metadata for a knowledge management system that can be used for sharing and exchanging learning objects that are transparent and interoperable.

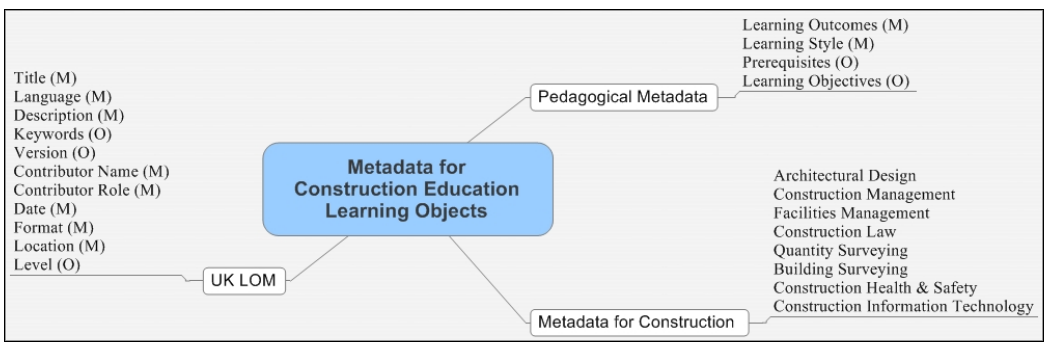

Figure 1: Generic Metadata Framework

The next section identifies the challenges in developing intelligent and dynamic learning objects taking into consideration the use of e-learning standards and also defines a conceptual framework for the development of a knowledge management system for learning objects.

3. CONCEPTUAL FRAMEWORK

The online knowledge management system which serves as a portal for learning community consists of learning objects that can be searched, retrieved and delivered to other learning management systems. The aim of the knowledge management system is to develop an environment for learning objects that are interoperable, transparent and sharable by the community of educators and learners, and to be accessible anywhere anytime. However, there are three main challenges that the learning objects face in order to develop such environment, that are, making learning objects;

- Intelligent by developing semantic metadata,
- Sharable through various learning environments via content packaging and
- Dynamic using ontologies and the Semantic Web concepts.

To meet these challenges for producing the knowledge management system, the following methodological steps are developed.
Stage 1: Developing a metadata framework which integrates the most suitable metadata as well as proposed pedagogical and construction metadata elements.
Stage 2: Applying content packaging standard that package learning objects so they can be posted to, and retrieved from various learning management systems such as Blackboard and WebCT and delivered via mobile technologies.
Stage 3: Identifying the ontology (i.e. a common vocabulary of terms and concepts) for construction education, and to develop a Semantic Web environment that will increase sharability of learning objects within the construction disciplines.

The challenges mentioned earlier together with the above stages are studied further to develop a framework which is shown in Figure 2 for the knowledge management system. The semantic aspects of learning objects are developed using metadata, pedagogy and ontology. Similarly, the delivery of learning objects is associated with the ontology, content package and Semantic Web. The structure of the learning objects mainly created using pedagogy, construction domains and content packaging standard.

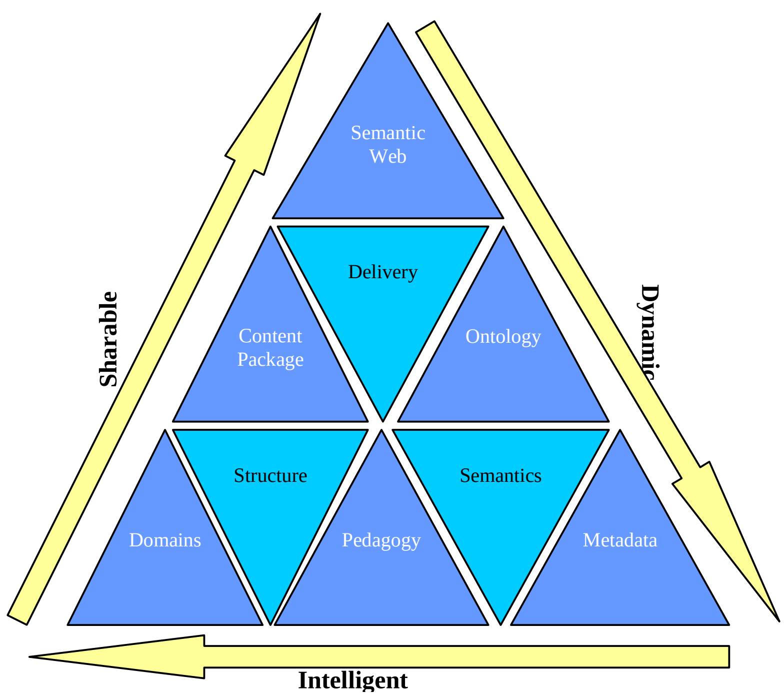

Figure 2: Conceptual Framework for Knowledge Management System

The following section demonstrates how this framework is applied for developing a knowledge management system for learning objects.

4. KNOWLEDGE MANAGEMENT SYSTEM

The following steps demonstrate how the metadata, developed as a part of the generic framework is integrated within the on-line environment, whereby end users will able to follow these steps to submit and retrieve learning objects.

Submitting 3D Objects

Figure 3 shows a 3D learning object that demonstrates 3D modelling concept which is one of the topics in the Digital Modelling module.

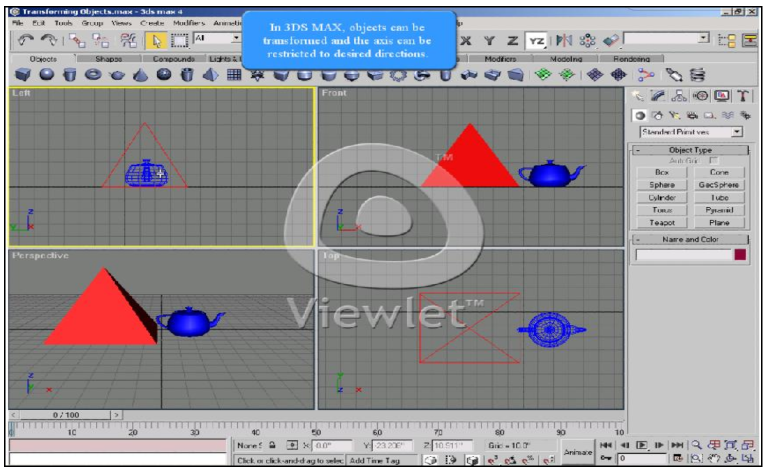

Figure 3: Sample 3D Learning Object

The metadata associated with the above 3D learning object are given in Table 1. The metadata elements are identified in the metadata framework shown in the Figure 1.

Table 1 Metadata for 3D object

Metadata elements	***Example***
Title (M)	Transforming Objects
Language (M)	English
Description (M)	Transforming objects including moving, rotating and scaling as well as creating object clones in geometric arrangements
Object Type (M)	Demonstration
Keywords (O)	Transforming Objects, Axis, Rotating, Scaling, Cloning
Version (O)	1.0
Contributor Role (M)	Educator
Creator (M)	Vian Ahmed
Date (M)	02/02/2006
Format (M)	Flash

Location (M)	http://elearning.scpm.salford.ac.uk/learningobjects/3d4a.swf
Construction Domain	Construction Information Technology

Figure 4 shows how the learning object types are integrated within the environment. It lists all the learning object types as a drop down menu so that the end users can select appropriate type of their learning object. When they make a choice, system will take them to the next step. For the 3D object shown in Figure 3, "demonstration" object type is selected.

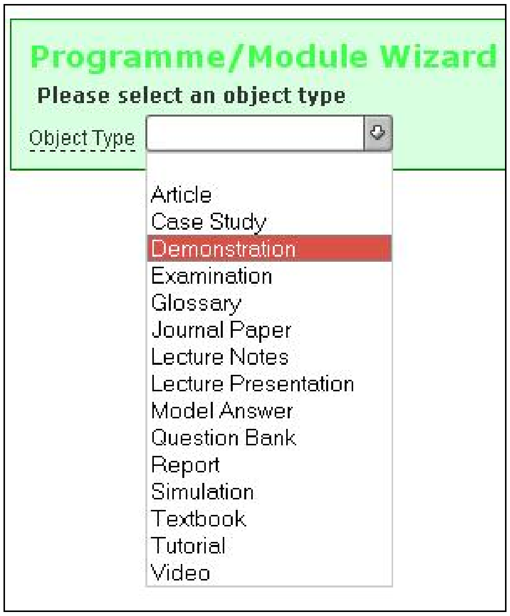

Figure 4: Choosing a Learning Object Type

Figure 5 shows how the pedagogical metadata such as 'Learning Styles' is integrated within the system. The Learning Object types are associated with Learning Styles that suit the needs of various learners. This will enable the end users to select an object that suits to their learning style; in this case it is "Imager".

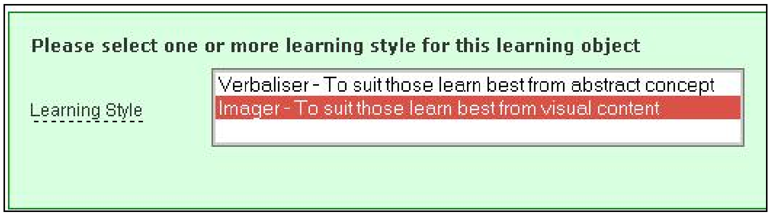

Figure 5: Choosing Learning Styles

When the learning style is selected, the system will take the user to the next step in order to select an appropriate programme, module and topic to identify the Learning Object required.

The programme structure is developed using ontology where the complex relations and concepts are modelled. It gives users freedom of choice in navigating and selecting required components by hiding the complex relations. Figure 6 shows the navigation structure of the programmes where users able to choose multiple modules and topics which are related to their learning object.

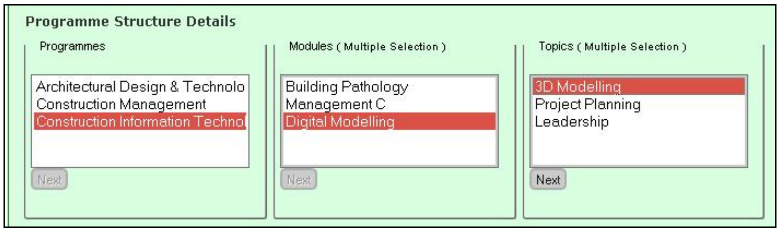

Figure 6: Programme Structure

For the example 3D object, Construction Information Technology is selected as Programme and Digital Modelling is chosen as Module. From the list of available topics, 3D Modelling is selected as appropriate one.

After choosing the pedagogical and structure details of the learning object, system will take users to the next step where learning object is labelled using the proposed metadata. Table 1 shows an example of metadata built into the 3D object to complete the metadata form shown in Figure 7.

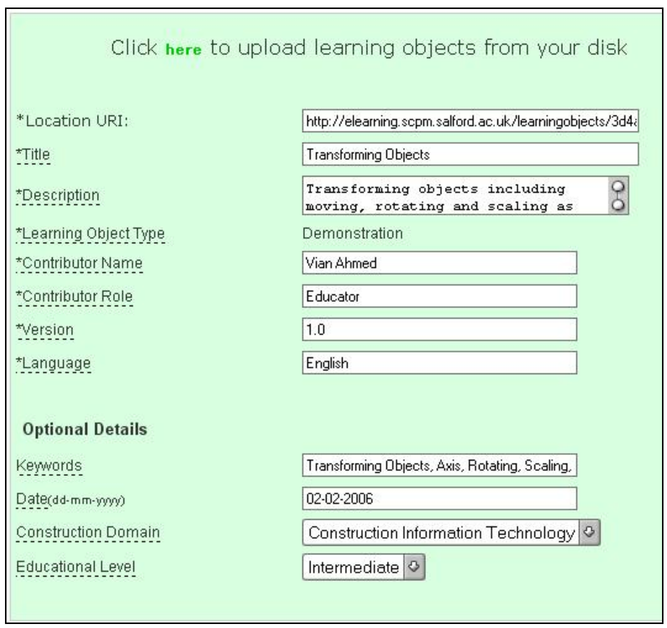

Figure 7: Metadata Input Form

The labelling of the above metadata onto a learning object is done using a form template as shown in Figure 7.

Searching and Launching 3D Object

The submitted learning object can be searched by keywords. Figure 8 shows the screenshot of the search form. The search queries the Semantic Web based database and will provide logical results.

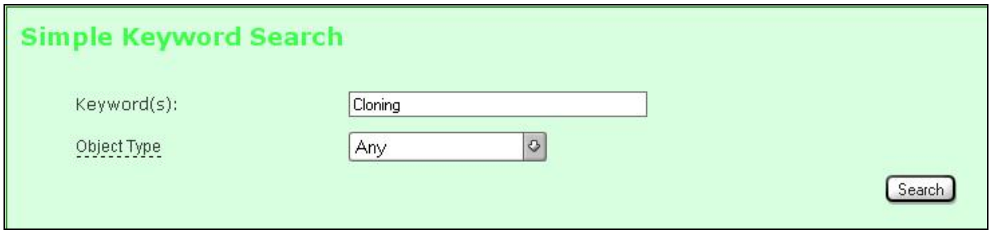

Figure 8: Keyword Search Form

Keyword "Cloning" is used to search the submitted object and is added in the metadata under "keywords" element. However search will look into all the provided metadata to look for search term.

The search result is provided in the Figure 9. Search engine returned one object based on the keyword search.

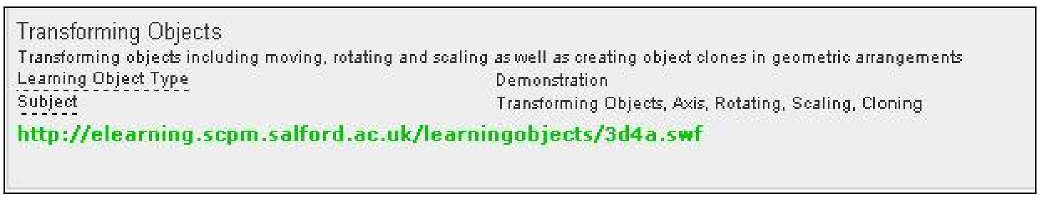

Figure 9: Search Results

From the link given in the search result, we can launch the object. Since it is a flash file, it will open in the internet browser.

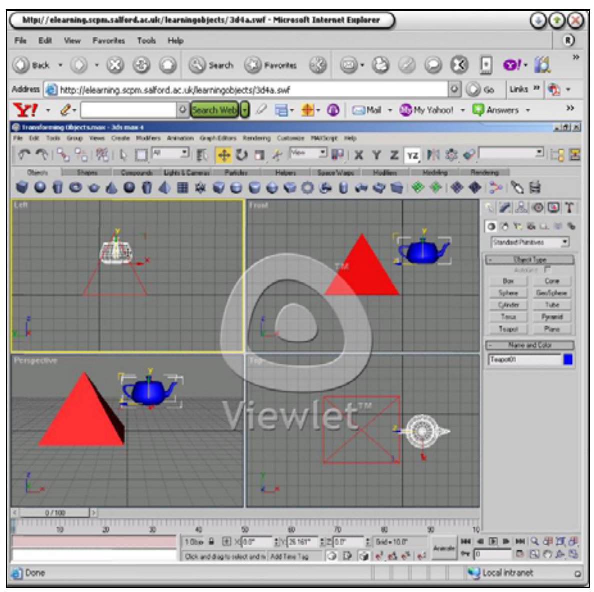

Figure 10: Launching the 3D Object

This paper covers the approach adopted to select the metadata standard for 3D learning objects. It demonstrated how the proposed metadata framework for construction education is integrated within the online environment for 3D learning objects.

5. CONCLUSION

This paper described the main concepts behind the development of standardised learning objects and the type of metadata required for the development of a knowledge management system of learning objects that can be made intelligently searched, submitted and retrieved. The proposed generic metadata framework is validated through the development of online knowledge management system of 3D learning objects. We have demonstrated how the learning objects can be tagged using appropriate metadata before submitted to the learning management system. The step by step process demonstrated how the learning objects are submitted and are retrieved using semantic searching. The conceptual framework shown in Figure 2 shows the concept and theory behind the learning management system including metadata, ontology, semantic web and content packages. They all together formed the foundation to create the intelligent, dynamic and sharable learning objects within the dynamic learning management system. Future work will focus on the technical aspects of the research which will enable the learning objects to be packaged as content that can be delivered to online learning management systems, enabling the end users to manage the learning process according to their individual needs.

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NEED FOR A STRATEGIC IT SUPPORT IN TURKISH CONSTRUCTION INDUSTRY FOR SUSTAINING CONTINUOUS IMPROVEMENT AND PERFORMANCE

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ABSTRACT

With increasing globalization and the resultant increase in competition, product development and innovation have become crucial success parameters, requiring intense research and development efforts. As the corporate sector becomes ever more international, new methods of working in cross-disciplinary and multicultural environments are finding favour. The construction sector, being a services sector, is increasingly required to adopt such new methods. However, to use these methods, engineers need high professional qualifications, but also qualifications that enable them to convert their expertise into knowledge that can be used in modern corporate contexts. In this manner of working information technology is playing a strategically crucial role.

Aim of the study is to promote a coherent and shared vision of IT support in the Turkish construction sector for agile, model-based / knowledge driven construction to create self-sustaining continuous improvement leading to high performance and better sector profitability. The paper discusses the need to address strategies of IT on sectoral and national level, and then moves to present the key concepts of IT strategy development. A survey of the Turkish construction sector is then held against the strategic dimensions of national IT strategy development.

Keywords: Turkish Construction Industry, IT Strategy, Sustainability

1. INTRODUCTION

The rapid development and expansion of information technologies over the last twenty years has ushered in the current historical period widely referred to as the “Information Age” or “Information Revolution,” comparable in economic and social magnitude to the Industrial Revolution of the early 19th century (The Harvard Policy Group on Network-Enabled Services and Government, 2001).

Since the 1970’s IT has been increasingly perceived as a driver for many of the construction business and operational processes. The 1990s have seen a technological shift in the construction sector from IT driven solutions to IT enabling ones. The industry, however, has often witnessed failed promises of IT as many companies have invested in the wrong technologies without addressing business needs. The recent development of IT systems that support business processes taking into account process, people and cultural needs is now rectifying this.

Developments in IT have the potential to affect business strategies, organizational structures, and management processes. Adopting IT within an organization's business needs to create value for the company, project and clients remains a key management task. Construction organizations need to re-shape their approach to strategic planning to keep pace with today's world. They need to focus on setting vision, providing high-level contextual strategies that can be clearly expressed and related to each other, and translating those strategies into action in the form of clear rationalization and implementation procedures. IT can be used as a support to change the construction and management processes through the introduction of new working methods and new technology (The ROADCON Consortium, 2003).

Introducing Information Technology (IT) into any organization is a strategic, business driven decision. The drivers for IT could be any or a combination of; competitive advantage, process improvement, creating an environment for growth and efficiency and creating opportunities for new products and services. The implementation of IT into an organization and its measurement of effectiveness are problematic tasks but due to the heterogeneous nature and unusual characteristics it becomes more difficult for the construction industry (Choi and Ibbs,1990; Sanvido and Mederos,1990). Buildings and infrastructure are increasing in complexity, and have to meet ever higher economic, societal, environmental and technology requirements. In this context, it is clear that in the future, IT will be the key enabler and instrument to support leading edge, innovative and powerful solutions targeting the main issues that the construction industry is facing today. Turkish construction sector has much to do to create an IT supported model-based, knowledge driven sustainable construction industry. While many of IT projects achieve high quality results, they do not overall create the right impact that will progress the industry from its current state to full adoption of proven and emerging technologies. The reasons behind a lack of impact are especially, lack of national business process model strategy, limited number of industry leaders interested in technology watch and lack of industry commitment in R&D efforts. Little emphasis is given on long-term strategies that would create the right impact in order to enhance and change practices in the industry.

As for IT research, development and implementation, the construction industry is less than the totality of the organisations contained within it. No construction organisations can reach such goals alone. The need for strategies is on sectoral and higher levels.

This study aims to add positive impact to the debate about what actions must be taken to achieve this goal in a practical way, discusses the necessity for a national IT strategy and draws up key concepts for a strategy framework from previous research.

2. NEED FOR A NATIONAL IT STRATEGY

The global economy is moving towards a digital world where the competitive standing of a nation will depend more and more on its ability to access the appropriate information and transform this information into new products and services. IT can be considered among the greatest change driving forces of this century - changing ever countless more aspects of human life such as communications, trade, manufacturing, services, culture, entertainment, education, research, national defence and global security. IT has also become the chief determinant of the progress of national communities and individuals. On the other hand for successful results, national informatics policies and strategies should be established and updated, paying special attention to the impact of the convergence of information, informatics and telecommunication technologies, focusing on the main tasks of government regarding the development and use of the new information and communication technologies.

An informatics strategy is a plan for the development and most favourable deployment of information technology, data resources and services. Most countries have sectoral IT strategies governing the implementation and operation of IT programs. The perspective within which proposals and recommendations on national informatics or IT policies are formulated differs broadly from country to country in accordance with their social, economic and political objectives. Other than developing sectoral IT strategies, creating a legal and cultural environment to encourage personal initiative and to promote private investment is also the responsibility of the public sector. Four areas that the government should focus on are given below (The Danish Government's IT Policy Action Plan 97/98):

1) Citizen's rights in the information society,
2) The existence of IT literacy on all levels,
3) Stimulating interaction between citizens and the administration to realize the vision of an open public sector,
4) Developing security solutions to encourage electronic commerce and other communications requiring top-level security.

Need for a national IT strategy can be justified based on a series of studies by Michael Porter, showing how and why certain clusters of companies in sectors in different parts of the world were outperforming others in international competition. His diamond model explains superior performance by international clusters of companies. The elements extend beyond a simple model of comparative advantage based on internal factors of production to embrace external issues of customer demands and links with associated industries (Porter, 1980).

3. KEY CONCEPTS

Key concepts for the success of an IT strategy development are illustrated in Figure 1 (Kumas, 2004). Furthermore, five areas of interest are pointed out each of which should be acted upon within the fields of research, development and implementation: Communication and the supply of knowledge, human-machine interface, product/process/computer models, classification and standards, implementation of changed working methods (Klercker, J., 2002).

Effective adoption of IT will contribute to a more integrated and innovative industry leading to increased efficiency and improved delivery of projects for clients. When used effectively, IT enables improved decision-making that contributes to higher quality and lower cost outcomes through access to relevant and timely information. It is recognized that in the dynamically changing world of IT, the sharing of ideas between industry stakeholders will lead to improvements across the construction industry as a whole (Klercker, J., 2002)**.**

4. CURRENT AND PLANNED APPROACHES FOR IT USE IN THE TURKISH CONSTRUCTION INDUSTRY

In order to obtain the approaches for the current and planned use of IT and its impact on the Turkish construction industry, a survey was conducted. The target group was 50 construction organizations where 42 of them were small and medium size engineering companies and 8 of them were large scale construction companies. The survey composed of closed ended questions –combination of multiple choice and fill in the blanks types- to be completed interactively during the face-to-face meetings with the respondents. The face to face meetings also allowed open ended questions, to explore the topic in more details when necessary. The respondents in the construction organizations were senior and middle managers, who had been involved in the IT implementations in the organization, acted as decision makers and experienced the difficulties and barriers. Senior level managers in 5 main IT suppliers providing IT solutions to the surveyed organizations were also interviewed in order to identify their perspectives regarding future technology directions. The survey questions were focusing on:

- the general IT resources of the organizations,
- the culture of IT use,
- the current adoption level of information systems,
- knowledge acquisition and sharing technologies and applications in Turkish construction sector.

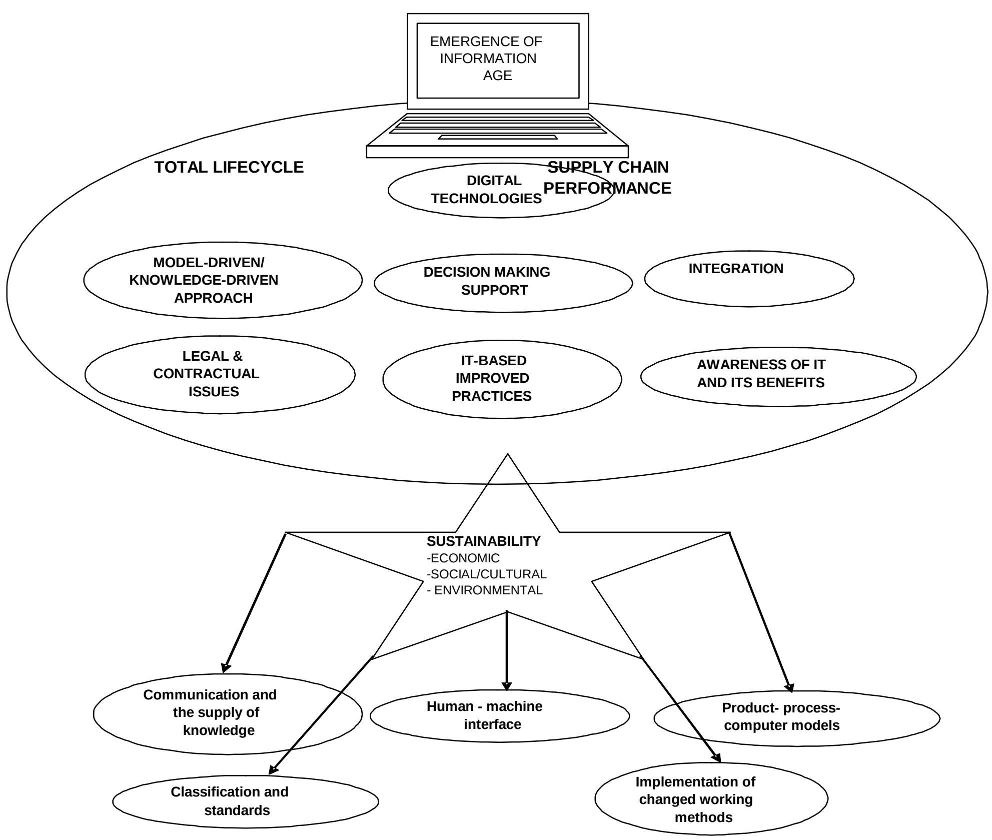

Figure 1 – Key Concepts and Areas of Interest

Survey Results

According to the survey results; the IT adoption of Turkish construction companies was in 3 different levels: 1) Automation; 2) Information management Process; and 3) Business Process Re-engineering (Table 1).

Table 1 – IT Adoption Level of Turkish construction companies

	No of Companies	%
1st Phase - Automation	32	64
2nd Phase - Information Management Process	10	20
3rd Phase - Business Process Reengineering	8	16

While some industry leaders have moved beyond automation, major percentage of the construction companies have been late adopters of IT. Some of the factors which emerged during the study may help to explain this relative slowness:

-Most firms were found to be very cautious in relation to technology risk. The risk associated with organizational change and industry profit margins were generally very tight that firms cannot afford investing in changes.

- Many firms believed that investment in IT is a one-off rather than a continuing development of a crucial business competence - having reaped the benefits of automation; they do not expect a new generation of IT-enabled change. IT-based automation has therefore become a competitive necessity for firms to remain in business but does not in itself yield them a sustainable advantage.

Each contractor identified the major problems they had experienced regarding IT adoption (hardware and software), as shown in Table 2. According to the answers, lack of training together with the cost of technology and the conservative nature of industry were the major impediments. However according to the interviews, companies who do not find security, legal and technical issues as barriers were the ones who had very little awareness and knowledge about the technologies.

Table 2 –Impediments to IT Adoption

	No of Companies	%
Training	40	80
Cost of technology	37	74
Conservative nature of industry	25	50
Security of hardware at site	12	24
Legal support for use of IT	8	16
Incompatibility / interoperability problems	8	16
Lack of technical support	5	10

Current IT Diagram

The current use of IT is very limited and not strategically implemented. There is also lack of advanced IT applications. According to the findings of the survey, a diagram showing the current situation regarding IT related problems in the Turkish construction Industry is given in Figure 2.

More to the point, a major reason for low-level use of IT in construction industry is the lack of a consistent global framework for IT implementation & deployment, including the absence of a common language and definitions agreed by all parties in the industry, as well as standardization of information structures and flows. These elements are essential preconditions for construction companies to reach a upper level of automation.

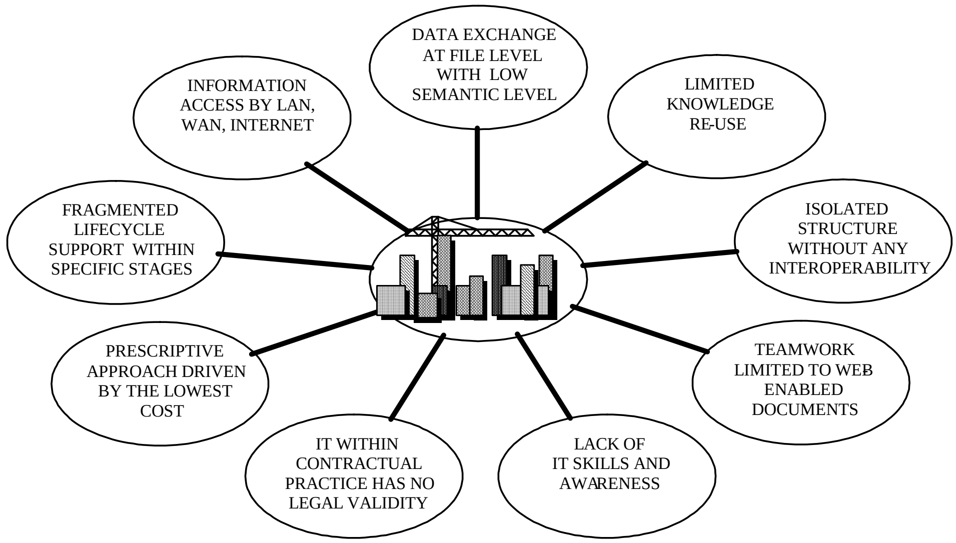

Figure 2 – Current IT Diagram

5. STRATEGY FRAMEWORK FOR IT IN TURKISH CONSTRUCTION

In order to understand and integrate the different views and expectations of many stakeholders and reach a common ground for discussions about strategic directions, a common framework is used, adapted from ROADCON and VOMAP projects, illustrated in Figure-3. The figure shows the positioning of the prime focus of the industrial stakeholders and steps of the analysis. Four main strategic goals should be identified in the form of a layered hierarchy: Industrial and societal impacts, business processes, IT applications, IT infrastructure, technologies and standards.

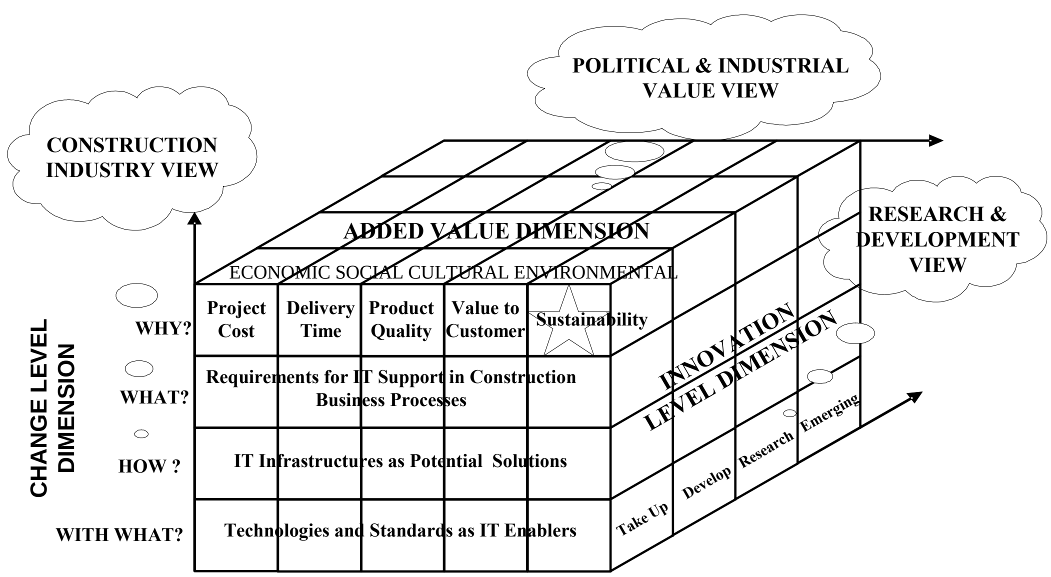

Figure 3 – Framework for IT in Construction (Sources: ROADCON Project, 2004; VOMAP Project, 2002)

Innovation capability is considered as the prerequisite of a nation in gaining competitive advantage in the world market (Turkey's Science and Technology Policy, 1999). Improving the scientific and technological ability of Turkey and creating a country that dominates information technology will strengthen Turkey's position in the world market. The whole information resource of the country should be addressed to develop a national IT strategy. This includes strategically managing basic day-to-day data, information that is used and analyzed to make decisions, and reviewing the computer systems used to deliver information. For developing an IT strategy, it is also necessary to examine how IT systems and electronic management of information relate to general business functions and plans for overall strategic development.

Change Level Dimension:

The IT strategy developed for Turkish construction industry, should answer the following questions:

- Is IT adequately supporting major construction activities? What are the requirements of Turkish construction industry for IT support? (knowledge management, ambient access, model-based engineering etc.)
- Can IT be used to create sustainable values to the industry? (model driven interoperable industry, performance based systems, intelligent buildings etc.)
- What new technologies and trends are available to address current and future construction business needs? (Virtual prototyping, web based processes, adaptive systems, collaborative engineering etc.)
- What are the offered IT opportunities enabling the industry trends? (mobile communication, positioning technologies, flexible interoperability, semantic driven processes etc.)
- What are the key concerns to be taken into account and their levels of implementation? (Sustainability, globalization, coverage, convergence of digital technologies etc.)

Added Value Dimension:

<u>The Economic Dimension</u>

The economic system lies at the heart of sustainable development. For the economic system itself, sustainable development requires stability. High growth rates and structural changes for industrialization were taken as the basic targets throughout the economic plans in Turkey since 1963. The adopted industrialization strategies, and economic policies after 1980 reflect a more profound change in the economic and industrial policies

<u>The Social Dimension</u>

Social sustainability can only be achieved by increasing social equity, solidarity and reducing poverty, worldwide. In the 1990s, this solidarity was primarily seen in relation to preservation of the natural environment and resources of Turkey. However more direct responsibility for social equity both to present and future generations should be studied for a possible and credible overall target to reduce income inequalities within Turkey and with other countries by 2030 through global contracts, more co-financing, including through widening opportunities for entrepreneurship and participation in work, together with a balanced liberalization of world trade in services and new local investment facilities. This could be part of a broader strategy for the next 30-50 years. An accelerated and determined transition to a networked knowledge society, with IT empowering entrepreneurship and trade in all communities play an important role in achieving and sustaining this goal.

The Cultural Dimension

In order to avoid a "clash of civilizations" in a multi-cultural world, cultural sustainability has to become a priority, taking into account two distinctive elements: Cultural identity and diversity; and respect for fundamental human rights. Culture is crucially important to overall sustainability because of the need to find a shared base of beliefs and goals for a global governance system with the power to conceive, implement and enforce sustainability policies on a global scale.

Organizational culture is another aspect to be taken into account. The processes, habits and techniques of organizations, as well as all those indefinable features of group life that give an organization its identity comprise its culture.

The way to achieve envisioned IT-based future scenarios also passes from issues related to entrepreneurial and risk-taking culture of organizations. Academic institutions can act as a catalyst for research, but it comes down to individuals with good ideas, talent and lots of energy to be combined with capital at the right time and with the right advice to succeed. As an agent of organizational change, collaboration between a regional centre and industry participants can be a powerful technique.

Political Dimension

In construction industry the government plays essentially two roles: regulator and client in construction processes. Clear government leadership will raise the awareness of both industry and clients and encourage a more rapid take up of IT than would otherwise occur. As a major owner and user of constructed facilities the government has a role to play and perhaps took the lead. A fundamental requirement is that the government as a major industry client provided the leadership for industry improvement. Innovative research and development should be recognized as a critical success factor. The government is the only construction client entity to have the motivation and resources to follow these objectives and provide leadership. (Lenard, D., Abbott, C., 2001)

Environmental Dimension

A growth-based strategy for environmental sustainability can only be achieved by further stimulating technology developments and innovation. The application of IT is vital to the development of environmentally sustainable production, logistics consumption, and for the emergence of a mosaic of environmentally sustainable lifestyles. Existing environmental policies (on national, or world level) should include stronger support for de-materialization: e.g. by using new ways of organizing work and lifestyles to reduce travel, and to improve the quality of life through access to immaterial services, notably for government services and social interaction. Turkey should follow this trend and encourage the substitution of material goods consumption through the consumption of immaterial services like "innovation" or added value.

Innovation Level Dimension:

Turkey has speeded up the efforts to make Turkey an information society as it joins eEurope together with candidate countries. All information society activities needed to be coordinated in such a way as to ensure increased economic value added and social welfare and be carried out in a participatory manner. Since 2002, there is a new approach that urges public institutions to take necessary measures in order to remedy long-term problems, like financial stability, public management, social security administration, agriculture, and manufacturing. E-Transformation Turkey Project, managed by the State Planning Organization (SPO) affiliated to the Prime Ministry, aims to foster the evolution and to coordinate information society activities, which were previously carried out under different topics by different institutions. First action of the project is the determination of an "information society strategy" which encompasses every part of society and maximizes national benefits and value added. The other actions will be on legislation regarding regulatory and legal framework, and several other issues related to e-commerce (T.R. Prime Ministry, State Planning Organization, Information Society Department, 2005).

6. CONCLUSION AND FUTURE RESEARCH

This paper has presented the initial findings of an ongoing research which aims at proposing a national IT strategy for Turkish construction industry. The necessity for a national IT strategy has been discussed for Turkish construction industry based on the results of an industry survey carried out in 50 construction organizations. Turkey and Turkish construction industry have been analyzed based on a strategy framework focusing on the dimension of change value, added value and innovation level as a first step to defining a national IT strategy.

In Turkey, if the environment is turbulent enough to demand large changes on a frequent basis, leaders will not only need to be engaged in the change process, they must also work actively to build an organization conducive to change. Success will require adaptive capabilities throughout the organization-within individuals and teams as well as organizational systems and infrastructures.

Turkey should aim to establish a competitive environment that is conducive to fostering innovation and promotes cooperation between government, industry, service providers and customers to develop a national information infrastructure. All innovators must be ensured to have access to affordable information infrastructure to enable them to design, develop, trial and commercialize new information products and services for improving community well-being, and are rewarded for their efforts.

Progress is clearly being made, as for example the Turkish government is taking advantage of the web to launch an e-government service. To succeed in the long term, however, disciplined and continuing support for innovation is needed. Recommendations for making IT use in Turkish construction industry for strategic innovation can be summarized as follows;

- Adopting an externally-oriented, customer-focused strategy that thoroughly addresses social needs and cross-boundary relationships.
- Nurturing and supporting an innovations-friendly culture and workplace.
- Forming partnerships that support entrepreneurial new service delivery units.
- Organizations do not need to be on the "bleeding edge" all the time, but they do need to aggressively seek out and adopt innovative ideas once the "first mover" has proven the concept.
- Developing a flexible, standards-based IT architecture as a foundation for expansion and growth. Maintaining a balance between standardization and flexibility, first supporting experimentation, then standardization, and

ultimately the elimination of outmoded practices will lead to an innovative environment.

Innovation requires a budget. At first it will be effective to allocate 5-20 percent of IT budget for innovation, but for successful innovations to be sustainable they must eventually move to the main budget—revolving funds cannot sustain programs over the long term.

Further research will focus on developing a national IT strategy applicable to Turkish construction industry for future implementation of IT. The steps for future research will include:

1. Mapping the current situation of the IT use in Turkish construction industry via in-depth industry surveys and determining the IT requirements of the industry.
2. Developing a National IT vision for Turkish construction industry
3. Determining strategic areas based on the IT related trends and the opportunities they will create for the industry.
4. Developing National IT strategies for the implementation of IT for each strategic area.

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INTEGRAL DYNAMIC PERSPECTIVE ON FIRM COMPETENCIES AND ORGANIZATIONAL PERFORMANCE: A STUDY OF CHINA'S LARGE CONSTRUCTION SOES

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ABSTRACT

As many large China's Construction State-owned Enterprises (CCSOEs) are tormented with their shortage of long-term competitiveness and no knowledge about how to adapt to the rapidly changing environment, which results mainly from China's transition from a planned economy to a market economy, it is significant to find out the mechanism of interaction among external environment, organization's competencies, and organizational performance. Despite a large body of research on organization's competence and performance, further research is needed to reveal dynamism of the whole system in the context of CCSOEs under a radically changing environment. This research aims to explore the relations between firms' competencies and organizational performance for CCSOEs, and their dynamism under the impact of the radically changing external environment, through establishing an integrated dynamic competence-based model and doing case studies among China's large typical construction SOEs. In order to accomplish the research goals, empirical studies of CCSOEs are carried out. A case study approach by combining both cross-sectional and longitudinal research methods is adopted to investigate the co-evolutionary dynamism between organizational performance, firm competencies and changing environment. As the empirical study is at its early stage, some preliminary conclusions, mainly including some distinctive features with the CCSOEs, are presented.

Keywords: Competencies, Construction State-Owned Enterprises, Organizational Performance, Resource-based View, Strategic Management

1. INTRODUCTION

The construction industry is one of the single most important industries in any national economy (Stallworthy and Kharbanda 1985). In China, the construction industry also plays a very important role in the national economy. China's construction enterprises enjoy great benefits and opportunities brought with the rapidly growing economy at average GDP growth of 9.3% per year since 1978. At the same time, however, they have to face more challenges than ever before. In addition to competition from domestic firms, because of China's entry into WTO, China's construction state-owned enterprises (CCSOE) in particular, face even more fierce competition from international contractors (Liu *et al.* 2002). More critically, China's transition from a planned economy to a market economy, together with the rapid technological development and the trend of globalization, constitutes a radically changing environment. Meanwhile, many CCSOEs are still grappling with lack of competitiveness and poor performance. Sha and Lin (2001) asserted that SOEs are not flexible in terms of operation, weak in technical innovation, heavily in financial debt and social burdens, and have a surplus of employees. Opportunities exist together with challenges. How can construction SOEs take the challenges and make full use of the opportunities to survive and develop in the competitive and changing environment with sustained competitive advantages?

To address this issue, two mainstream models from the strategic management discipline, known as the Industrial/ Organizational (I/O) model and the Resource-Based View (RBV), have made significant contributions. However, neither of them provides ultimate explanations and satisfactory solutions by itself. More and more researchers consider the explanations as complementary, instead of viewing them as competing or even contradicting, and acknowledge that organizational capabilities (Chandler 1992) and core competencies (Prahalad and Hamel 1990) are the key sources of a firm's competitive advantage (Hafeez *et al.* 2002a). Recently, some researchers and practitioners have come to realize that core competencies should not be treated statically, and long term competitiveness of the firm largely depends upon its dynamic capabilities (Hafeez *et al.* 2002b). As a result, a dynamic perspective of competence-based theory that integrates the I/O model and the RBV model seems to be an appropriate approach to tackle the aforesaid problem. However, very few empirical studies have been undertaken to examine the contribution of competencies or capabilities to organizational performance and even fewer empirical studies to determine the mechanism of how changing external environment, especially a transitional economy, influences the dynamics of the organizational performance and internal competencies. Furthermore, management theories, inclusive of the foregoing ones, often draw on manufacturing industries to do theoretical reasoning and empirical tests, while very little research concerns the sustained competitive advantages of construction enterprises.

This research aims to explore the relations between firms' competencies and organizational performance for CCSOEs, and their dynamism under the impact of the radically changing external environment, through establishing an integrated dynamic competence-based model and doing case studies among China's large typical construction SOEs.

2. THEORIES UNDERLYING THE INTEGRATED DYNAMIC MODEL

Literature from three areas contributes to the theoretic framework of this research: Industrial/Organizational-based (I/O) theories; Resource-based Views (RBV); and Organizational Performance (OP).

Contributions from the I/O school of strategic management

The I/O model argues that firms can only reach competitive advantage through implementing strategy imposed by the characteristics of the external environment. In other words, it suggests that the environment is the key factor determining the organization's strategy and, further, its performance. On this basis, Porter (1980, 1985) creates the "five forces" model to deepen the understanding of this paradigm. Porter posits that every industry has an underlying structure, or set of economic and technical characteristics, that gives rise to competitive forces. Hence, in order to gain superior performance, a firm must assess the environment and the five forces affecting competition.

In comparison with Porter's five forces model, which focuses mainly on the industry structure analysis, literature suggests that a firm's strategy may also be affected by other environmental factors (Wit and Meyer 2005). According to the influential distance between the environment and the organization, an organization's external environment is divided into the industrial environment affecting the organization's operation very directly through resource input, product output, competition, etc., which can be analyzed with the Five Forces model, and the remote environment, normally having indirect impact on the organization's operation at a macro-level. The PEST model is popularly employed to analyze the remote environment.

Contributions from the RBV school of strategic management

In contrast to the I/O theory, the resource-based view (RBV) looks inside the firm for sources of superior performance with respect to competition. In particular, it attempts to link superior firm performance to the resources and capabilities possessed by firms (Teece 1980; Wernerfelt 1984; Barney 1991; Peteraf 1993).

All RBV theorists agree that the heterogeneity in firm's resources and capabilities is the ultimate source of the firm's superior performance. However their understanding on the definition or connotation of resource and capability seems to be fairly divergent. In a broad sense, the firm's resources may include any assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled or owned by a firm (Barney 1991). Whereas, some researchers suggest that capabilities be distinguished from resources in order to better understand their contribution to the firm's performance. In this regard, Makadok (2001) gives a clear statement, arguing that a resource is an observable (but not necessarily tangible) asset that can be valued and traded—such as a brand, a patent, a parcel of land, or a license; a capability, on the other hand, is not observable (and hence, necessarily, intangible), cannot be valued, and changes hands only as part of its entire unit.

In the last decade, researchers continued to refine the RBV with increasing scope and explicitness. In summary, resource-based theories also include capability or competence-based theory (Hamel and Prahalad 1990; Henderson & Cockburn 1994), dynamic capabilities approach (Teece *et al.* 1997; Eisenhardt and Martin 2000), knowledge-based theory (Madhok 1996; Spender 1996), etc.

Contributions from theories on performance management

Why do the people come together in an organization? The reasons are no more than enhancing their effectiveness and boosting their efficiency (Linda *et al.* 2002). Effectiveness is more likely to be a result, objective and direction, while efficiency is a means to reach the target. If organizational effectiveness is not properly defined, no matter how efficient the operation and management is, the organization would never get to where it wants to go. The word "performance" is also widely used in all fields of management. Performance can be construed in two ways: ① the process and activity for converting the input into output and outcomes; ② the outcome of organizational activities. Therefore, performance is often identified or equated with

effectiveness and efficiency (Neely *et al.* 1995; Corvellec 1994). To avoid ambiguity and confusion in using concepts, this research uses "organizational performance".
Organizational performance is a complex and multi-dimensional construct, and operationalizing such a complex concept is intrinsically difficult (Dess and Robinson 1984). Different approaches to performance studies lead to little agreement on its criteria and how it should be measured. So far, the stakeholder approach has been deemed as one of the most effective methods in this connection. According to Freeman's classical definition, a stakeholder in an organization can be construed as "any group or individual who can affect or is affected by the achievement of the organization's objective" (Freeman 1984). The stakeholder theory explains that those firms which are managed for optimal stakeholders' satisfaction, thrive better than those firms which only maximize shareholders' (understood as shorter-term profitability) interests (Scholl 2002).

3. CONCEPTUAL FRAMEWORK

For the sake of explicitness and thoroughness in understanding the main constructs, namely competence, organizational performance, and external environment, and analyzing their relationship, a conceptual framework needs to be developed. The importance of the paradigms (frameworks) is that they operate to determine not only what views are adopted, but also the approach to questioning and discovery (Fellows and Liu 2003).

Construction of Competence-based Model
Competence-based theory suggests core competencies or distinctive capabilities to be the fundamental sources of a firm's sustained superior performance. As a ramification of RBV, competence-based theory is also subject to confusions on the key concepts and definitions. To avoid vagueness and ambiguity, this research defines the key concepts as below:

Resources: this research adopts narrow-sensed definition of a resource, which simply refers to an asset or input to product (tangible or intangible) that an organization owns, controls, or has access to on a semi-permanent basis (Helfat and Peteraf 2003) and relates to the concepts of "having" or "belongingness" (Hall 1992).

Capabilities: in contrast to resources, capabilities refer to a firm's capacity to deploy resources using organizational processes to effect a desired end (Amit and Schoemaker 1993), and are related to the concept of "doing" (Hall 1992).

Competencies: As the central concept in this model, competencies are understood as a bundle of unique capabilities to integrate and coordinate the internal and external resources of the organization, which makes a significant contribution to customer perceived value, is competitively unique, and is capable of being applied to new product arenas.

Based on the model of the construct of core competencies (Hafeez *et al.* 1999b), the competence-based model used in this research is shown as Fig 1.

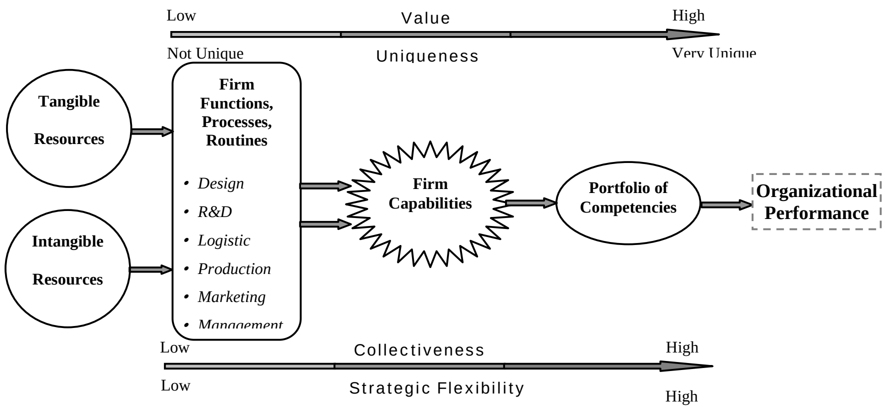

Fig 1 The Competence-based Model (Adapted from Hafeez *et*

Construction of Organizational Performance Model

This research adopts the stakeholder approach to develop key performance indicators and analyze the performance measurement systems within China's construction SOEs. The model is illustrated in figure 2.

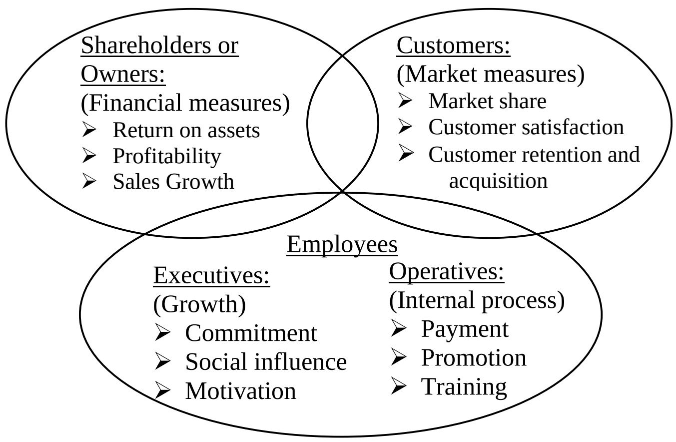

Fig 2 A Stakeholder Approach to Organizational Performance

Construction of Environment Analysis Model

Combining Porter's industry analysis model (Five Forces) and PEST model, Wit and Meyer (2005) identify eight major groups of external parties with whom the firm has to interact, and these eight external parties are further grouped into industrial factors and contextual factors, which are also referred to as operational environment and remote environment. This model is shown in Fig 3.

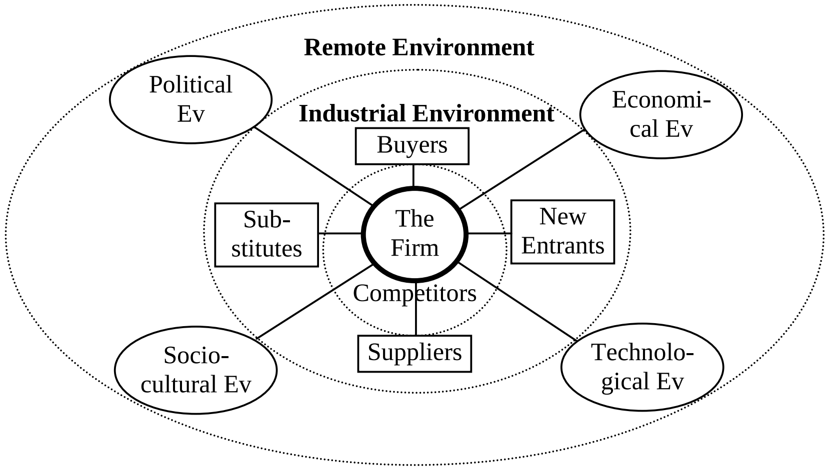

Fig 3 Environment Analysis Model
(Adapted from Wit and Meyer, 2005)

Construction of an Integral Dynamic Competence-based Model (IDCM)

Combining the aforementioned three models, an Integrated Dynamic Competence-based Model (IDCM) can be constructed, as shown in Fig 4. The model demonstrates that the external environment, as the independent construct, determines what performance the organization requires to survive and grow in that environment, and this process is moderated by the organization's perception of the external environment; the organization, according to the performance required/expected, decides what sorts of competencies and resources should be needed so that an appropriate portfolio of competencies and resources can be developed. Likewise, this process is also affected by the external environment with organization's perception being the moderator. Ultimately, the competencies and resources lead to organization's actual performance, which is compared to the expected performance to determine whether the current competencies and resources are the right portfolio. The effective operation of this whole system leads to the organization's ultimate survival and success. However, this system is not static, but dynamic and evolutionary, which can be expressed in the following formulae:

$$OP_t^a = f\left[(CP_t \bullet RS_t), EE_t\right]$$

OP_t^a - the actual organizational performance at time *t;*

EE_t - the firm's external environment at time *t;*

CP_t - the firm's competencies at the time *t*, it is a function of the competencies at the time *t-1*, external environment at time *t-1*, and the expected performance at time *t*, also considering the adjustment from comparison of the actual and expected performance at time *t-1*, as shown below:

$$CP_t = f(CP_{t-1}, EE_{t-1}, OP_t^e) \bullet \frac{OP_{t-1}^a}{OP_{t-1}^e}$$

RS_t - the firm's resources at time *t;* similar to CP_t, it is expressed as below:

$$RS_t = f(CP_{t-1}, RS_{t-1}, OP_t^e) \bullet \frac{OP_{t-1}^a}{OP_{t-1}^e}$$

This research focuses on the critical relations, i.e. the relations between firm competencies and organizational performance, and the impact of changing external environment on organizational performance and firm competencies, as shown in the Fig 4, the relation marked with number 1, 2, and 3.

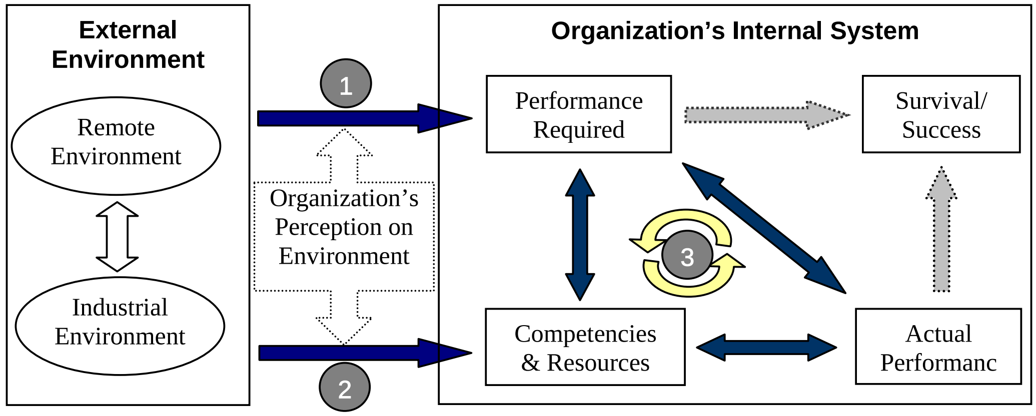

Fig 4 Integral Dynamic Competence-based Model

4. RESEARCH METHODS

As advised in the conceptual frameworks, organizational performance is the dependent variable, which is a function of both independent variable - external environment, and intermediate variable - resources and competencies. This research is a two-phase study. In the first phase, a cross-sectional study through carrying out questionnaire survey or interviews is used with two-fold purpose: 1) affirming and validating the variables and their measurement; 2) finding out what are the main determinants of firm performance. At the second stage, several typical CCSOEs are selected to do case studies involving longitudinal analysis so that the dynamism of the system can be explored and testified.

At present, the first phase has just started. Semi-structured interviews are used to collect data. The interviews were taken in February 2006 in Beijing, and each interview lasted for one to two hours. The questions were grouped into three parts, each of which corresponds to one main construct, namely organizational performance, competencies and resources, and external environment. Totally, eight persons from 4 different CCSOEs took part in the interview. They are all up-middle level managements within their firms. Content analysis is used to identify those key factors under each main construct, detailed as below:

Organizational Performance:

Table 1: Key Organizational Performance Indicators

Performance Indicators	**Appearing Frequency**	**Importance Degree***	**Stakeholder Perspective**
Turnover(Sales) and growth (Business scale)	7	4.38	Owner/ Shareholder
Profitability	8	4.13	O/S
Total Assets	6	3.63	O/S
Market Share	4	3.13	Clients
Employee Satisfaction	3	2.25	Employees

Client Satisfaction	2	1.88	Clients
Productivity	1	0.88	Employees
Assets and capital status	2	0.75	O/S and Bank
Social responsibility	4		Government/ Community

**: The importance degree is the mean of the results which ranges from "1" to "5". The greater the figure, the more important the indicator.*

It can be seen from Table 1 that economic performance dominates the organizational performance system where the most frequently mentioned indicators include profitability, turnover and growth, total assets. Beside these factors, market share (ranking), social responsibility, employee's benefit also have relatively high frequencies. The data also show that owners, clients and employees are the most important stakeholders for a CCSOE, which is in congruent with the conclusion obtained from literature. However, "client satisfaction" does not play an important role for a construction firm as it does for manufacturing firms. "Social responsibility" seems to be compulsory for a SOE, which is quite distinctive from other kinds of firms.

External Environment analysis:

Table 2: External Environment Analysis

Remote Environment		**Industrial Environment**	
Factors	Importance	Factors	Importance
Economical	4.88	Client's Bargaining Power	4.25
Political	4.38	Pressure from the current competitors	4.00
Technological	2.75	Supplier or Subcontractor's bargaining power	2.38
Socio-cultural	1.88	Threats of New Entrants	1.63
		Threats of Substitutes	1.00

As to the external environment factors that affect a firm's performance, two levels of environment are mentioned in the investigation, namely macro and remote environment. According to the results, economic and political factors at national macro level and pressure from clients' bargaining power and competitors' competition at industrial level impose extremely important influence on a firm's performance. Comparatively, others factors have no significant impact on performance.

Firm Resources and Competencies:

In addition to the external environment, elements inside a firm are also critical to its performance. In management theories, resources, understood normally as hardware of a firm, and competencies as software both lead to firm's superior performance through interacting with each other. As for resources, most frequently mentioned items are shown in Table 3:

Table 3: Critical Firm Resources and Competencies

Resources	Frequency	Competencies	Frequency
Human Resources	8	Management Process and Routine	8
Capital/financial resources	8	Project management capability	8
Physical resources (esp. equipment)	7	Strategic planning and execution	7
		Enterprise culture building	7
Qualifications	7	Government relation-building capability	7

Technology	4	External resources acquisition capability	7
		Financial management capability	6
		Human resource management capability	6
		Learning capability	5
		Knowledge management capability	4
		Marketing capability	4

When asked about their opinion on "core competencies of their firm", the respondents have a very diverse understanding of this concept. However, most of them agree that core competencies should be sustainable, unique, difficult to copy, deeply innate and integrative capabilities. According to the investigation, the most frequently mentioned core competencies and resources include: Vision, quality and solidarity of senior executives, human resources, brand (qualification, experience, reputation, etc.), technology, management process and routines, project management capability, and financing capability.

5. PRELIMINARY CONCLUSIONS

The results drawn from the initial data collection accord in the main with the elements of variables abstracted from literature. However, some distinctive features with construction SOEs are also identified. First, in terms of organizational performance, economic performance of the firm, normally measured by financial indicators, still dominates the performance evaluation system, though perspectives from clients, employees, and other stakeholders have also been observed. Furthermore, among those economic performance indicators, the scale of the firm, mainly manifested by sales and assets, seems to be more critical than other parameters, for example, profitability, for construction SOEs. In addition, as a SOE, the firm has to take social responsibilities, such as keeping stable employment in order to maintain social stability, supporting or sponsoring under-developed areas, maintaining educational, hospital facilities, and so forth. Another interesting finding is that clients appear not to have much say in assessing a firm's performance, which is supported by the fact that construction SOEs do not highlight clients or customers' satisfaction as much as the literature suggests. Second, as to the external environment, although all the factors impose impacts on firms, the influential intensity varies. For instance, it is interesting that technology and socio-culture has a very weak impact on construction SOEs, while economical and political factors affect the firms considerably; in the industry analysis, however, the buyers, i.e. the customers' bargaining power affects firms' performance most, followed by the competition from the extant contestants. Comparatively, the other three factors are not that important. The interviewees unanimously agree upon the point that economic-related policies, particularly the industrial structure policies, exert the strongest influence on the organizational performance. Third, concerning the internal drivers of superior performance, literature always suggests that only the competencies, in particular core competencies, are the source of superior performance. For a construction SOE, however, the result demonstrates that not only the competencies, but also some strategic resources lead to superior organizational performance. That is also the reason that the intermediate construct is adjusted to competencies and resources from the original "competencies" only.

There is no doubt that China's construction SOEs embody very distinctive characteristics from what is presented in the literature, and they follow a unique evolutionary process since China's reform and opening. By the time of this paper being prepared, however, the research was at its initial stage of positivistic study. As a result, the data collected through interviews served mainly as a pilot study in order to develop an effective and valid instrument for the main survey and investigation. In consideration of the relevant small sample size at this stage, the validity of the preliminary conclusions presented here will be further testified through the main study. Also, the initially-collected data cannot serve the purpose to test the presented models and the corresponding hypotheses, as are going to be realized through an extensive investigation into the big construction SOEs.

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CROSS-CULTURAL STUDY FOR THE STRESS OF ESTIMATORS IN HONG KONG AND THE UNITED KINGDOM

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ABSTRACT

Construction cost estimators generally experience a great deal of stress due to the inherent uncertainty in construction projects. Although the construction industry in Hong Kong (HK) has adopted the British system and standards, the working culture and environment obviously differ between these two countries (Eastern and Western). This paper aims to (1) identify different types of stress, and (2) compare the stress levels of estimators in HK with those in the United Kingdom (UK). A questionnaire was sent to estimators in both HK and the UK. The preliminary results show that estimators in HK and the UK bear the same levels of subjective stress. But estimators in HK suffer higher levels of objective stress than do those in the UK, although interestingly HK estimators are less likely to suffer emotional exhaustion than those in the UK. Age, demographic structure and cultural environment may be important factors in determining the stress levels of estimators. Emotional-based coping behaviours and problem-based behaviours are recommended for UK and HK estimators respectively in order to adjust their stress for obtaining the best estimation performance in the industry.

Keywords: Culture, Emotional Exhaustion, Hong Kong, Objective stress, Subjective stress, United Kingdom

1. INTRODUCTION

Construction cost estimation is often considered a stressful job. An estimator needs to estimate construction costs accurately in the tendering stage, because the estimated budget serves as a basis for establishing the job cost system and the construction schedule in the construction stage (Anonymous, 1993). In comparison with the estimated budget, actual construction costs can then be controlled item by item (Schutte and Liska, 1994). Therefore, accurate estimation is extremely important and should be achieved. As cost estimators are pressed to produce accurate cost predictions within a rigid time frame, and most construction work is inherently uncertain, error-free estimation is hardly obtainable. To carry out their job successfully, cost estimators are subjected to stress of various magnitudes.

Stress within a reasonable degree can enhance concentration and work performance (leung et al. 2005a); however, too much stress may not only cause low efficiency and estimation errors but also undermine an employee's physical health (Jex, 1998). Stress is believed to be related to various factors, such as job nature, personal characteristics, interpersonal conflict, physical condition and organizational culture. The impact of a stressor on an individual depends more on a person's perception of the stressor than on the actual stressor itself. In turn, the person's perception is largely influenced by his or her cultural values and background (Chiu, 1992). Therefore, investigating cross-cultural stress levels for construction estimators in different countries is of great significance.

Despite Hong Kong's exposure to Western business practices for many years and adoption of the British system and standards, Hong Kong people, as members of an Asian collectivist society, tend to interpret and handle work-related stress differently from Westerners. Exploring differences in stress levels of cost estimators between the United Kingdom (representing Western culture) and Hong Kong (representing Eastern culture) is therefore useful. This study seeks to (1) identify types of stress, and (2) compare the stress levels of estimators in HK with their counterparts in the UK.

2. CULTURAL DIFFERENCES

People in different cultures may experience their environment differently; they may thus experience levels of stress differently as well. Collectivism and individualism have been the most frequently studied cultural characteristics. The collectivism-individualism construct has been suggested for measuring cultural variables and attempting to explain differences in some social behaviors between Eastern and Western people (Chiu *et al*., 1995). *Eastern cultures*, like the Chinese and the Japanese, are collectivist, whereas *Western cultures* are considered to be individualist. Individualism is typically interpreted as complex behaviors based on concern for oneself and one's immediate family or primary group, as opposed to concern for other groups or for the society to which one belongs. Collectivism, on the other hand, is typically interpreted as behaviors based on concern for others and care for traditions and values. Group norms in collectivist cultures are likely to direct individual behavior. People in collectivist cultures prefer more harmony-enhancing strategies of conflict resolution, while people in individualist cultures prefer more competitive strategies (Triandis, 1989; Eric and David, 2004). That is, individualist cultures emphasize autonomy in interpersonal relations, while collectivist cultures emphasize the interrelatedness between individuals and the group (Schwartz, 1994). Chinese culture, which is rooted in Confucian philosophy, Taoism and Buddhism, differs from Western cultures in terms of "individualism", "power distance" and "long-term orientation". Chinese countries (including Hong Kong, Taiwan and Singapore) record much lower average scores on these measures compared to Western countries (Buttery and Leung, 1997).

Chinese culture, thus, tends to be collective (Chiu *et al*., 1995). The Confucian tradition emphasizes being a perfect "gentleman" and having a "humble" character, and Taoism promotes "harmony" and "unlimited happiness", while Buddhism advocates mercy, thriftiness and humility. Cause and effect are the principles that encourage people to do well and do right to receive good in return (Capra, 1991; Chen, 2000). In Chinese organizations, Confucian role definitions and relationships serve as a basis for a distinct managerial ideology consisting of paternalism and personalism (Redding and Hsiao, 1990). Paternalism includes dependence of subordinates on superiors, personalized loyalty and benevolent authoritarianism. Personalism is about emphasis on interpersonal trust, harmonious relations, avoidance of conflict and sensitivity to “face”. The action of wiping out unpleasant memories of the past may influence the self-experience of Chinese people. Within Chinese culture, it appears that a more positive self-concept is associated with more satisfactory interpersonal relationships (Chang, 1982).

The cultures of the Western countries, such as America, England and Germany, are categorized into individualism. According to Darwish and Huber (2003), “the root of individualism in the Western world can be traced back to the history of ideas (Lukes, 1973), political and economic history (MacFarlane, 1987), religious history (Capps and Fenn, 1992), and psycho-social history (Waterman, 1981).” During the formation of United States, the majority of citizens were approached by the egalitarian and fraternal ideas when they escaped from state and religious persecutions in Europe. And these are the ideas which influenced the democratic republicans of United States and making them believed that the government should seek to protect individual rights in the constitution itself. Later on, the word, “individualism” appears and was primarily used as a catchword to celebrate capitalism and liberal democracy in the United States. It implies the spontaneously cohesive society with equal individual rights, limited government, natural justice and equal opportunity, and individual freedom, and moral development and dignity (Lukes 1973). The development of individualism in the Western countries established a root of autonomic interpersonal relationships among westerners.

3. TYPES OF STRESS

In general, stress is regarded as a subjective feeling that work demands exceed the individual’s belief in his/her capacity to cope (Cox, 1983); it also represents emotional exhaustion, depersonalization and reduced personal accomplishment (Maslach, 1993). In this study, stress is classified into three types: subjective stress, objective stress and emotional exhaustion.

Subjective Stress
People in a stressful environment generally experience different subjective feelings, such as dissatisfaction, unhappiness, sadness, depression and so forth. Stress can be assessed through an individual’s reflection on his/her experience (Cox, 1983). This study applied the General Health Questionnaire (GHQ) to measure subjective stress (Goldberg, 1970). The scale, which consists of 12 items, is a self-administered questionnaire focusing on two major areas: the inability to carry out normal functions, and the appearance of distressing phenomena. The scale has been extensively used in different settings and cultures and has been proved to be reliable and valid (Politi *et al.*, 1994). Respondents were asked to express their agreement with items ranging from 1 (much less than usual) to 7 (much more than usual). Average scores were used as indicators of subjective stress.

Objective Stress
Objective stress represents the discrepancy between respondents’ expected working requirements and their actual ability. This was measured on the 10-item Rust-out and Burn-out scale (RO-BO), reflecting both the quantitative and qualitative dimensions of their workload (Gmelch, 1982). The statements asked respondents to rate their

expected and actual abilities on 10 items ranging from 1 (none) to 7 (a great deal). The average deviations between expected and actual abilities were used as indicators of objective stress.

Emotional Exhaustion

In a longitudinal study (McManus *et al.*, 2002), emotional exhaustion and stress were found to be associated with each other. Emotional exhaustion is related to low energy levels, and it induces the feeling of being drained. It is a state of feelings of depleted emotional resources and lack of energy (Lingard, 2003). The scale used to measure emotional exhaustion consists of 5 items that seek to measure the status of respondents' feelings of exhaustion, such as emotional drainage, tiredness, and so forth. Respondents were asked to rate their frequencies of exhaustion ranging from 1 (never) to 7 (every day). The average score was used to indicate the degree of emotional exhaustion.

4. RESEARCH METHOD

To understand the impact of cultural differences in HK and the UK on the stress levels of estimators in the industry, a survey was conducted in both regions with a targeted sample of quantity surveyors and estimators who were professionally qualified in the field and had direct experience of construction estimation. The sample was randomly selected from the membership records of professional institutions, including the Hong Kong Institute of Surveyors and the Royal Institute of Surveyors.

Three types of stress were involved in the survey including General Health Questionnaire for measuring subjective stress (Goldberg, 1970; also refer to Politi et al., 1994), RO-BO scale for objective stress (Gmelch, 1982; Leung et al. 2005a, 2005b) and the emotional exhaustion (Lingard, 2003). English is considered as an international major language in the study, therefore the questionnaires all are conducted in English. Since the questionnaire was distributed through the Hong Kong Institute of Surveyors and Royal Institute of Chartered Surveyors, the respondents are expected involving Western education /training for estimation /quantity surveying. The respondents are thus classified with the similar educational background in the study.

According to the data record in the HKIS (HKIS, 2006) and the RICS (RICS, 2006), the number of registered surveyors in HK is much lesser than the number in the UK. Initially, 200 questionnaires were distributed to HK organizations and 423 questionnaires were distributed to UK organizations by fax, email or in person. Eventually, 107 completed questionnaires were returned and used for the study. Among these, 72 questionnaires came from HK and 34 from the UK. Of the respondents, 36.4% were aged 21 to 30; 31.8% were aged 31 to 40; 22.4% were aged 41 to 50; and the rest, 9.3%, were above 50. Most respondents were male (83.2%). The Table 1 shows the demographic structure of the respondents.

Table 1 Age Groups of Respondents

Age groups	HK	UK	Total

	Number	Percent	Number	Percent	Number	Percent
21-30	36	49.32%	3	8.82%	39	36.4%
31-40	29	39.73%	5	14.71%	34	31.8%
41-50	8	10.96%	16	47.06%	24	22.4%
Above 50	0	0.00%	10	29.41%	10	9.3%
Total	73	100.00%	34	100.00%	107	100.0%

Note: Average age of HK estimator group -31.2 ; Average age of UK estimator group - 44.7.

5. RESULTS

Overall Comparison

The stresses of estimators in HK and the UK are analyzed in Table 2. The results reveal that estimators have similar levels of subjective stress in both HK and the UK. Differences in emotional exhaustion (t = -2.939; p < 0.01) and objective stress (t = 4.390; p < 0.01) between HK and UK estimators are statistically significant. The HK estimators' perceived objective stress is much higher than that of UK estimators, while their emotional exhaustion is much lower.

Table 2 Stresses of Estimators in HK and the UK

Stress	Mean	Standard Deviation	Mean Difference	*t*-Value (DF=105)	*p*-value
Subjective Stress					
Hong Kong	3.736	0.735			
United Kingdom	3.739	0.565			
Total	3.737	0.683	-0.003	-0.019	0.985
Emotional Exhaustion					
Hong Kong	*2.869*	0.814			
United Kingdom	*3.571*	1.277			
Total	3.092	1.032	*-0.702*	*-2.939***	0.005
Objective Stress					
Hong Kong	*0.132*	6.073			
United Kingdom	*-0.406*	5.488			
Total	-0.039	0.638	*0.538*	*4.390***	0.000

Notes: ** p < 0.01

Compared with estimators in the UK (76% of respondents in the UK being above 40), HK estimators were generally very young (nearly 89% of the respondents were aged 21 to 40). To fully explore the stress levels of estimators in HK and the UK, the data collected in these two regions were further examined based on the four different age groups of estimators (refer to Table 1).

F-values (Comparison of Stress among the Four Age Groups of Estimators)

Table 3 shows no significant differences in subjective stress (ranging from 3.619 to 3.787; F-value = 0.170) and emotional exhaustion (ranging from 2.939 to 3.800; F-value = 1.423) among the four age groups of estimators (including both HK and the UK), while significant differences are to be found in the objective stress of estimators among the four age groups (ranging from -0.390 to 0.236; F-value = 0.563; p < 0.01).

Table 3 Stresses of Estimators in HK and the UK among Four Different Age Groups

Estimator groups	Mean				Mean Difference	F-value	*t*-value	*p*-value
	Total	Subtotal	HK	UK	(HK–UK)			
Subjective Stress	3.737 (0.683)					.170		
21-30		3.716 (0.802)			-0.098		-0.655	0.517
HK			3.708 (0.835)					
UK				3.807 (0.098)				
31-40		3.787 (0.627)			0.275		0.904	0.373
HK			3.827 (0.618)					
UK				3.552 (0.700)				
41-50		3.749 (0.571)			-0.829		-1.355	0.189
HK			3.530 (0.682)					
UK				3.588 (1.183)				
Above 50		3.619 (0.694)			-		-	-
HK		-	-					
UK				3.619 (0.694)				
Emotional Exhaustion	3.091 (1.032)					.423		
21-30		2.939 (0.761)			0.089		0.192	0.849
HK			2.956(0.780)					
UK				2.867 (0.611)				
31-40		2.959 (1.067)			*-1.783*		*-4.251***	0.000
HK			*2.697 (0.856)*					
UK				*4.480 (0.934)*				
41-50		3.425 (1.075)			-0.488		-1.049	0.305
HK			3.100 (0.786)					
UK				3.588 (1.183)				
Above 50		3.300 (1.572)			-		-	-
HK			-					
UK				3.300 (1.572)				
Objective Stress	-0.039 (0.638)					*.063***		
21-30		*0.236 (0.647)*			0.400		1.051	0.300
HK			0.267 (0.647)					
UK				0.133 (0.321)				
31-40		*-0.088 (0.667)*			*0.764*		*2.555**	0.016
HK			*0.024 (0.588)*					
UK				*0.740 (-0.088)*				
41-50		*-0.271 (0.515)*			0.275		1.247	0.226
HK			-0.088(0.353)					
UK				0.363(0.568)				
Above 50		*-0.390 (0.415)*			-		-	-
HK			-					
UK				0.390 (0.415)				

Notes: ** $p < 0.01$; * $p < 0.1$.

T-values (Comparison of Stress between UK and HK Estimators in Different Age Groups)

The results also indicate that UK estimators aged 31 to 40 felt much more exhausted than their counterparts in HK (*t*-value = -4.251; $p < 0.001$), while they had much lower objective stress levels compared with HK estimators (t-value = 2.555; $p < 0.01$).

6. DISCUSSION

Three types of stress, namely subjective stress, objective stress and emotional exhaustion, were studied in the research. The results reveal that HK estimators bear almost the same level of subjective stress as UK estimators. HK estimators scored higher on objective stress than their UK counterparts, but UK estimators were more likely to be emotionally exhausted from estimation.

Detailed exploration indicates significant differences in objective stress for estimators in different age groups. Senior estimators generally consider their abilities to be higher than the actual task difficulty. For estimators in the same age group of 31-40, HK estimators suffer more objective stress than their UK counterparts, but feel less emotional exhaustion.

Although HK estimators often feel their actual abilities do not meet job expectations, they are less likely to be emotionally exhausted than their counterparts in the UK. Perhaps the *demographic age structure* partially explains this phenomenon. Since, generally, construction work is inherently uncertain in nature, experience and proficiency in cost estimation is of vital importance for successfully tendering bidding in construction projects. As UK estimators (44.7 on average) are generally older than HK estimators (31.2 on average), UK estimators are more familiar in dealing with estimation tasks than those in HK and therefore suffer less objective stress. However, UK estimators may be less energetic due to their age (44.7 on average), and thus be more likely to suffer fatigue and exhaustion.

Although the construction industry in HK has adopted the British system and standards, its *working culture and environment* differs remarkably from that in Britain. People in Western cultures that emphasize the individual tend to achieve success by themselves and not to expect others' help (Weber, 1968; Fijeman *et al.*, 1996), while Chinese people tend to help others and also expect to get support from their colleagues (Fijeman *et al.*, 1996; Hsu, 1981; Chiu *et al.*, 1995). Because cost estimation involves complicated tasks, cooperation and mutual support are essential for dealing successfully with the tasks. UK estimators, in an individualist culture, thus suffer greater emotional exhaustion from their experience in their jobs, since they lack the support of other colleagues. Hence, emotional-based coping behaviors and activities such as tea-break, outdoor activities and consultation services (Leung et al. 2006) are recommended for the UK estimators, especially for the age group between 31 and 40.

Culture has a great influence upon estimators' attitudes and emotions towards work, and it plays an important role in determining estimators' levels of work stress. In a collective environment, workers tend to be harmonious and mutually supportive, and thus can effectively reduce their emotional exhaustion. It is helpful not only for keeping workers energetic and enhancing their work efficiency, but also for maintaining their physical health. Thus, estimating managers in construction companies should consider and advocate a collective organizational culture. In order to balance the quantitative and qualitative workloads of HK estimators for optimizing their objective stress, revision of job allocation and problem-based coping behaviors (e.g., seeking senior support, instrumental support and preparatory control) are suggested, especially in the age group between 31 and 40.

7. CONCLUSION

Cost estimators suffer great stress from their work, and different cultural environments influence their stress levels differently. To understand differences in estimators' stress levels in Western and Chinese culture, a survey measuring HK and UK estimators' stress levels was conducted.

The study investigated three types of stress, namely subjective stress, objective stress and emotional exhaustion. It is interesting to note that HK estimators were less capable of carrying out actual estimating tasks than their UK counterparts, but they were less likely to feel emotionally exhausted. Perhaps the different structure in age demographics and the different cultural environments in HK and the UK are the major factors that influence the stress levels of estimators. Senior estimators normally have sufficient ability to fulfill the actual estimating task, while Chinese estimators in a collective environment manage higher objective stress with lower emotional exhaustion. Emotional-based coping behaviours and problem-based behaviours are recommended for UK and HK estimators respectively, especially in the age group between 31 and 40. Further studies focusing on different stressors such as actual estimation experience, job nature and individual personality are recommended for further study in order to fully understand the impact of stressors on the estimators in HK and UK.

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FACTORS INFLUENCING THE DEVELOPMENT OF HONG KONG'S CONSTRUCTION INDUSTRY: A QUALITATIVE STUDY

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ABSTRACT

Construction industry development has drawn attention for decades. However, there have been very few conceptual models which provide theoretical constructs to the knowledge base of construction industry development. The research on which this paper is based, aimed to validate a generic model developed by Fox (2003a) for the development of international construction by using Hong Kong's construction industry as a case study. Semi-structured interviews with key stakeholders in Hong Kong's construction industry were conducted. Stakeholders included construction clients, consultants, contractors, designers, educators/trainers, government officials, professional bodies, quasi-government officials, researchers, material and plant suppliers, construction lawyers, trades unions, and politicians. Results indicate that the factors influencing the industry are largely in line with Fox's generic model and that cultural factors are particularly important. These findings are not only relevant to the development of the construction industry in Hong Kong but also to the industry worldwide.

Keywords: construction industry, culture, development, generic model, Hong Kong

1. INTRODUCTION

Calls for improving the construction industry in both developing and developed countries have existed for decades. Two of the earliest industry reports to document the need for change are linked to studies done by the Tavistock Institute of Human Relations (Higgins & Jessop 1965). In more recent years, there have been reports by Latham (1994) and Egan (1998) in the United Kingdom, the C21 (1999) report on the Singapore construction industry, and the HKHA (2000) and the Tang (2001) reports in Hong Kong, all of which have generated a considerable number of recommendations for improving the construction industry in their respective countries. In addition to these reports, an array of research has been carried out on construction industry development, such as 'formulating long-term strategy' (Ofori, 1994a), 'role of technology transfer' (Ofori, 1994b), 'implications of globalization in the Asia construction sector' (Raftery et al, 1998), and 'moving towards a knowledge-based industry' (Ofori, 2002).

Although these reports and studies have contributed enormously to the development of the construction industry as a whole, there are still knowledge gaps and very little in the way of a theoretical foundation (Ofori, 2002). There is clearly a need for a theoretical framework of construction industry development, against which problems can be identified and remedies evaluated. This framework should not only focus on traditional or hard measures, such as economic, political, and administrative actions, but should also include cultural or soft factors, such as attitudes, practices, and values (Fox, 2002 & 2003a). Fox (2003a) developed a six-factor generic model encapsulating 62 variables of construction industry development that revealed cultural factors to be extremely important, and later carried out an initial comparison (Fox & Skitmore, 2003b) that provided evidence to suggest that it would be reasonable to apply the model to the Hong Kong construction industry. The aim of this paper is to validate Fox's model for use in the context of Hong Kong and determine the characteristics of the local construction industry. The results would be useful to government policy-makers and industry leaders as a means of helping them to focus on the key areas for developing Hong Kong's construction industry.

2. FACTOR IDENTIFICATION

According to Fox (2003a), the construction industry may be defined as the production, alteration, renovation, maintenance, facility management, demolition, and re-cycling of building and civil engineering works, including the supply of resources. It includes those who promote the industry's policies, procedures, practices, and culture, which help the industry to fulfil the tasks required of it and thus satisfy its internal and external stakeholders. Ofori (2000) defined construction industry development as 'the deliberate and managed process to improve the capacity and effectiveness of the construction industry to meet the national economic demand for building and civil engineering products, and to support sustained national economic and social development objectives.'

As the construction industry is known to be complex and multidimensional (Ofori, 2000), it is therefore not surprising that construction industry development involves multi-faceted factors that are difficult to identify. However, Ofori (1980) identified eight factors for construction industry development in developing countries, and just over a decade later Al-Omari (1992) derived six factors from a case study in Abu Dhabi.

Ofori's EIGHT Factors (1980)	*Al-Omari's SIX Factors (1992)*
Economic growth and stability	External environment
Government recognition	Indigenous environment
Planning and resources	Development planning and policies
Codes and procedures	Planning prerequisites & measurement tools
Use of local materials	Implementation strategies
Education and training	Working environment.
Appropriate technologies	
Incentives for local contractors	

In the developed world, Napier (1970) adopted a systems theory to model the Swedish construction industry and took into account the concepts of power, status, learning, boundaries, goal evaluation, innovation, and group values. Nearly twenty years later, Fox (1989) developed a causal model of 50 factors to explain the development of Hong Kong's construction industry, and seven years after that Momaya's (1996) investigation into the competitiveness of the Canadian construction industry produced a model hierarchically grouping ninety-five variables into factors, and then the factors into three facets of competitiveness: assets, processes and performance.

3. GENERIC MODEL

Rather than simply adding another set of factors to the available literature, Fox (2003a) developed a six-factor generic model using the results from his international study of construction industry development. Fox's research took a grounded theory approach, and identified 62 variables, 32 correlated variables, and ultimately six factors. It is probably the first model developed from multi-type and multi-country sources. The model, shown in Figure 1, clearly shows the traditional factors identified by Ofori (1980) and the cultural factors identified by Fox.

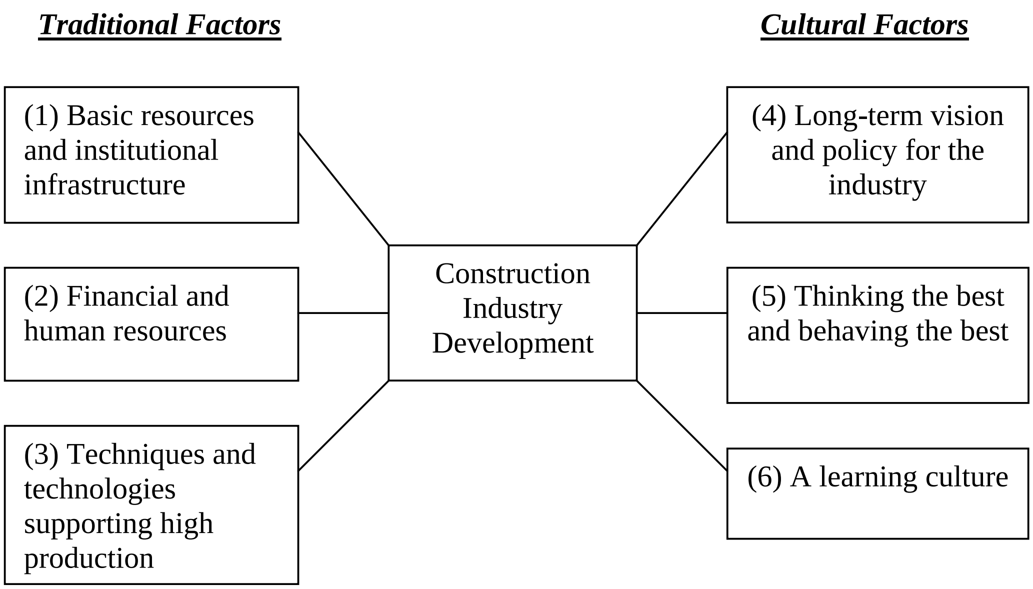

Figure 1: Generic model of the factors influencing the development of the construction industry (Fox, 2003a)

4. DATA COLLECTION AND ANALYSIS

On the basis that qualitative data has the potential for revealing complex situation, attitudes and perceptions (Miles & Huberman, 1994), a qualitative research approach was used in this study for providing sentient evidence as to whether the development of Hong Kong's construction industry can be explained by Fox's generic model.

The study encapsulates the views of thirteen stakeholders connected with Hong Kong's construction industry. These stakeholders include construction clients, consultants, contractors, designers, educators/trainers, government officials, professional bodies, quasi-government officials, researchers, material and plant suppliers, construction lawyers, trades unions, politicians, and information providers. Semi-structured interviews were the instrument for collecting the qualitative data. Interview questions were sent to the interviewees along with the request for an interview. The interviews were conducted between September 2005 and December 2005. Nearly all of the interviewees are in the top management level and have over ten years of experience in the industry. Each interview lasted for about approximately ninety minutes and was tape recorded. The transcribed interview data were coded for comparison with the list of variables in Fox's generic model, which provided a valid framework for determining whether there were any factors specific to Hong Kong.

When the variables mentioned by interviewees were compared to the 62 variables of the generic model, 38 were found to be the same (a 61% match). In addition, four variables representing the local characteristics of Hong Kong's construction industry were added to the list making a total of 42 variables that were identified from the interview data. Two of these four local variables were identified under the 'Thinking the best and behaving the best' factor, they are: (1) *Claims culture,* and (2) *Lowest bid tendering,* Only one variable (3) *Innovative project procurement strategy,* belongs to the factor **'learning culture'** and it implies that the industry needs to accumulate knowledge and learn from its mistakes when the same problems keep recurring. The final variable (4) *S*ufficient *time for construction* has been located under the traditional factor 'Basic Resources and Institutional Infrastructure' since Hong Kong is a developed city with adequate resources and physical infrastructure, but traditional social infrastructure limits the scope for innovation.

5. APPLYING THE GENERIC MODEL TO HONG KONG

By applying Fox's six-factor generic model to Hong Kong, not only is the validity of the model itself tested but also valuable insights are gained into Hong Kong's construction industry. Using the generic model as a framework, the following explains the variables identified by the interviewees in this study.

(1) Basic resources and institutional infrastructure (Traditional factor)

Availability of materials
China's rapid development to become what many see as the factory of the world has changed the way in which Hong Kong views the concept of sourcing construction material. Whereas at one time they had to be sourced from all over the world at great expense, cheap and reasonable quality material can now be obtained from just across the border.

Professional associations and trade unions
Professional associations, such as the Hong Kong Institute of Engineers (HKIE) and the Hong Kong Institute of Architects (HKIA), provide continuous professional development (CPD) and training courses to the industry to help it keep up with the latest market developments, whilst trade unions provide a check and balance for the industry, in particular by expressing views on unrealistic government requirements.

Fragmentation of organization and function

The problem of fragmentation in the construction industry is not new and has been recognized by many studies (Latham, 1994; Egan, 1998; Tang, 2001). Whilst fragmentation is still an industry norm, there is a recognised need for integration of functions in construction. Fox (2003a) contended that the way to improve efficiency and productivity is integration of construction processes, and one of the interviewees in this study suggested that the ultimate solution might be for developers do all things in-house. There is in fact evidence of a move towards integration as many contractors who at one time only undertook construction work now act as developers, and consultants who at one time only provided consultancy services now often engage in project creation activities. The industry also makes more use of project management and risk management techniques and works closer with banks and financial companies in order to better control costs.

Sufficient time for construction (New)

Developers in Hong Kong want their projects finished as quickly as possible because they pay interest on high land prices. In order to satisfy this requirement, the construction cycle is often compressed to just four days compared to twelve days in Japan. Insufficient time for construction directly affects performance in terms of safety and quality. For example, it is common to find honey-combing in concrete because not enough time has been allowed for adequate vibration. Some interviewees suggested that in order to produce buildings more quickly, there should be a better sequence of work and project coordination rather than an unrealistic compression of the programme.

(2) Financial and human resources (Traditional factor)

Training and education

The Construction Industry Training Authority (CITA) provides basic training and certificate courses for the various trades, and plays a key role in the recently introduced licensing system for tradesman. Also, some construction companies offer apprenticeship schemes although for a number of reasons including a lack of work continuity, the project-based nature of the industry, the subcontracting system, and a lack of relevant regulatory procedures, most construction companies are reluctant to invest in such schemes.

Availability of technical knowledge

Being at the forefront of high-rise building construction and the provision of sophisticated infrastructure not only is Hong Kong technologically advanced but also exports its expertise to South East Asia, China, and India.

Availability of investment

Over the past twenty years Hong Kong invested heavily in both infrastructure and building works. With the downturn of the economy in 1998 the government imposed stringent controls on its spending but as a result of a recent economic improvement the government is once again investing, this time in the area of tertiary education by providing new educational facilities and enhancing existing ones. A new government headquarters is also on the cards and there are investment opportunities in the area of the old Kai Tak airport in central Kowloon where the plot ratio has been increased from seven to twelve.

(3) Techniques and technology supporting high production performance (Traditional factor)

Attention to supply chain management

The multi-layer subcontracting system in Hong Kong has long been criticized. Among the interviewees, only the trade union representative and the information provider supported the existing subcontracting system. One reason cited by them is that subcontracting has been used in the construction industry for many years and it does appear to work. Contractors can sublet specialist work to subcontractors and do not need to retain a large pool of direct labour. They also argued that if the subcontracting system was not efficient, market forces would have made it obsolete by now.

Prefabrication and standardized production

There has been greater use of prefabrication in recent years due to the cheap labour in China that produces it and improved quality control. Although prefabrication helps to promote safety because its use requires fewer workers to work at high levels, it has adversely affected the employment of Hong Kong construction workers.

Construction IT

The biggest change would be the invention of computer graphics. It's a big change to our work. We now use AutoCAD. Measurement of quantity surveyor and architect's drawing changed with the invention of software and personal computer hardware. Everything changes with the new ages. Documentation, the way of monitoring of construction are all affected.

(4) Long-term vision and policy for the industry (Cultural factor)

Government intervention

Government intervention is considered to be an important variable that directs construction industry development. Five interviewees (client, consultant, designer, educator/trainer, and the quasi-government official) expressed support for government intervention while another five (contractor, researcher, material supplier, trade union, and information provider) expressed opposition to it. The argument for government intervention is based on the notion that the government as a major client in the construction industry should use its influence to promote and encourage best practice (Egan, 1998: 39; Tang, 2001:2). The reason against government intervention is that when there is government intervention, free market mechanism does not work and the government may not always make the right decision.

Long-term thinking of the industry

One characteristic of the Hong Kong construction industry that the interviewees identified as in need of changing is its short-sightedness; they consider that healthy development requires forward thinking and long-term planning. Before the change of sovereignty, people worried about the consequences of China's rule over Hong Kong. It appeared that there was no permanence or planning in the industry and that most developers just wanted to make money quickly and leave. The casual way in which relatively new buildings are pulled down to make way for more profitable developments without any regard for environmental or social issues suggests that this way of thinking still exists today.

Research and development

Although the Buildings Department has carried out studies on lighting, ventilation, water seepage and falling window, the interviewee representing professional bodies observed that there is no applied scientific research in the industry. For example, there has been no proper testing of external wall tiles even though falling of external wall tiles is a long-term problem; research and development has not actually been addressing the needs of the industry but has instead concentrated solely on improving productivity. Hong Kong's Research Grant Committee was also criticised for the way in which it allocates funds.

Influence of business environment

Hong Kong's construction industry is business-led and is directly affected by the performance of the property market, which is extremely volatile. After the 1997 financial turmoil, there was an economic downturn in Hong Kong, which was exacerbated by the high land price policy of the government. The interviewee representing information providers described the pre-1997 property boom period as the 'dark age' of the Hong Kong construction industry. At that time, professionalism and workmanship were neglected as the whole industry rushed to finish projects and put them on to the market before the handover of sovereignty to China.

Flexibility of government to contract conditions

Unlike the private sector, a commercial settlement of a dispute is not allowed or extremely difficult when using the government conditions of contract.

Government bureaucracy

For the sake of accountability and fairness the government has established a multitude of regulations and procedures. However, these have resulted in inefficient operation, lack of innovation, and no flexibility; it would seem that the more sophisticated the system, the less efficient it is. The problem of government bureaucracy has been worsening since the localisation of government departments in 1992. Many government officials are unwilling to make decisions, there has been an increased in the amount of paper work and form filling, disputes take twice as long to settle than they did in colonial times and contract administration generally has become more difficult..

Availability of information

Information should be released through authoritative channels so that regulations and guidelines can be assimilated by those actually involved in the construction process. For instance, the Provisional Construction Industry Coordination Board (PCICB) and Construction Industry Institute (CII) could work with professional institutions to disseminate knowledge through continuous professional development (CPD) events. The fact that this does not currently happen suggests that there is a lack of communication and cooperation amongst organisations and institutions within the industry.

(5) Thinking the best and behaving the best (Cultural factor)

Ethical behaviour

Corruption in Hong Kong's construction industry was a serious problem prior to the establishment of the Independent Commission Against Corruption (ICAC) in 1974.

Since then, ethical standards have improved to the point where some construction companies have developed their own code of ethics. However, the sub-standard piling case in 2000 revealed that there are still major ethical problems in the industry and the material supplier interviewee even expressed the view that the industry is still corrupt especially amongst small and medium size firms.

Attention to best practice
As the social status of construction workers is very low, most of them do not take pride in their work and are not interested in what they do. The norm in the industry is to finish the job as quickly as possible and get paid, even at the expense of quality and safety. The problem reveals people's mindset, which regulation and codes of practice can only change superficially. The reality is that developers are only really interested in profitability, not with safety standards; an average of four to five accidents per month on a construction project is the accepted norm.

Lowest bid tendering (New)
Egan (1998) recommended that the construction industry should end the practice of competitive tendering. The interviewees concurred with this view and suggested that the key to changing the industry is to establish a tendering system which ensures that bidding is not unrealistically high or low. Although the assessment criteria of contractors bidding for government contracts now includes performance, the issue of accountability still makes it difficult for the government to justify not accepting the lowest tender. Interviewees commented that private sector developments are generally less problematic than those developed by the government and that this may be due to private sector clients not having a lowest bid constraint when choosing contractors.

Claims culture (New)
Tied in with the lowest bid tendering practice is the claims culture. The fact that most contractors in Hong Kong make claims, has naturally given rise to a multitude of construction lawyers and claims consultants. Contentious claims are usually settled through mediation or arbitration.

(6) Learning culture (Cultural factor)

Competition between overseas contractors
Raftery et al. (1998) identified three affects of globalization on Asian construction industries: larger private sector participation in infrastructure projects; increasing vertical integration in the packaging of construction projects; and increased foreign participation in domestic construction. Unlike other Asian countries such as Japan and Korea, there are no barriers to international construction companies wishing to enter the Hong Kong construction market, although most do so by forming joint ventures with local companies. The greatest competition currently faced by local contractors is from mainland China. Although overseas contractors take away market share from local contractors, they bring in technology and expertise which is ultimately beneficial to the local construction industry.

Innovative project procurement strategy (New)
The interviewees see the need for innovative procurement strategies in order to avoid the fragmentation and adversarial nature of the traditional contract arrangement and as a way of accelerating the whole construction process.

6. CONCLUSIONS AND RECOMMENDATIONS

This study used the generic model of construction industry development (Fox, 2003a) to examine both the traditional and cultural factors that impact the development of Hong Kong's construction industry. The study validated the generic model by demonstrating that most of the variables identified by the study were to be found in the model; a few additional cultural variables were also identified. It can be concluded that construction industry development involves a multitude of inter-related factors and variables that cannot be entirely separated and that there are many problems besetting the industry as a whole. Finding solutions to these problems is an ongoing exercise, but as a result of this study a few recommendations can be made to help alleviate some of the problems in Hong Kong's construction industry, and many of these will also be relevant to construction industries in other countries.

The implications for stakeholders wanting to improve their construction industry are as follows. Government should clarify its role in the construction industry and intervene only when necessary, and the industry for its part should not rely too much on the government but instead be more pro-active in promoting itself. Fragmentation of the industry should be addressed by reviewing the fundamental approach to procurement, construction sequence, and subcontracting. Professional institutions and trade union should take the initiative to drive cultural change in the industry by promoting best practice and a more forward thinking mindset. In connection with this, training and education should be restructured to better match the needs of the industry. A concerted effort by all stakeholders in the construction industry will ensure that its development balances the needs of all parties.

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CROSS-CULTURAL ENCOUNTERS WHEN MANAGING PROJECTS IN CHINA

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ABSTRACT

With China's high economic growth, more foreign architectural, engineering and construction (AEC) firms are expected to venture into this huge and attractive market. Unfortunately, foreign AEC firms may not have experience in managing Chinese workers, contractors and subcontractors, due to differing cultural backgrounds between the Chinese and foreigners.

The aim of this paper is to identify cross cultural differences between foreign AEC practitioners and Chinese when executing projects in China. Cross cultural differences investigated include communication, working practices, attitudes and dispute management. The case study approach is adopted and data collection is via face-to-face interviews. The case studies are based on American, Japanese and Singaporean AEC firms operating in China.

The findings reveal that foreigners can work effectively with the Chinese in construction projects in China when cross cultural differences are properly managed. These include improving communication, adjusting certain working practices and accepting the habits of the indigenous. Recommendations, in the form of guidelines with which AEC practitioners from non-Chinese cultures can work more effectively with the Chinese, are made. The findings will help to foster an awareness and appreciation of cultural differences in the international arena, with specific reference to China.

Keywords: China, Communication, Cross-cultural management, Culture.

1. INTRODUCTION

With its fast growing construction industry, many foreign architectural, engineering and construction (AEC) firms are expected to export their services to China. The aim of this paper is to identify cross-cultural differences between Chinese and foreigners with specific focus on executing construction projects in China. Ways to overcome the cultural differences are also investigated.

2. RESEARCH METHOD

The research design was based on case study. Three in depth case studies of foreign AEC firms operating in China were conducted. Based on convenience sampling, firms A, J and S, with headquarters in the US, Japan and Singapore respectively, and having foreign owned subsidiaries in Shanghai, were selected for study.

Based on the literature review, a questionnaire was designed to collect data. For each case study, at least three experts from the foreign firm were interviewed in order to get a varied and wide range of perspective. Data were collected in China via face to face interviews with each of the respondents. Interviewees were chosen based on their availability as well as appropriate experience working in foreign AEC firms in China. A tape-recording of each of the interviews was done to ensure that important information would not be overlooked.

3. PROFILE OF FIRMS AND INTERVIEWEES

The three firms (S = Singapore; A = US; and J = Japanese) studied are all privately owned firms that had subsidiaries in China. The profiles of the interviewees are shown in Table 1.

Table 1 Profile of interviewees

Code	Designation	Years in industry	Years in China	Services provided in China
Singapore firm				
S-PM1	Vice President	17	2	Project Management
S-QS1	Senior Manager	18	17	Consultancy (QS)
S-QS2	QS Manager	9	5	Consultancy (QS)
S-AR1	Senior Manager	20	3	Consultancy (Architecture)
US firm				
A-PM1	Director	25	8	Project Management
A-PM2	PM	9	3	Consultancy (PM)
A-CN1	Vice President	27	19	Business Development
Japanese firm				
J-PM1	Deputy MD	16	3	Project Management
J-AR1	Vice President	24	8	Consultancy (Architecture)
J-CN1	Senior Manager	15	9	Construction

All the interviewees were in senior management positions with at least nine years experience in construction industry. The interviewees had worked in China's construction industry from two years to 19 years, with an average of about eight years.

Company S from Singapore had an average estimated turnover of US$143 million world wide and US$20 million in China alone. The company provided building and infrastructure development services such as master planning, architectural and engineering design and consultancy, project management, construction management and facilities management for building and infrastructure projects. Company A from the US specialized in planning, engineering design, program management, construction management, and operations and maintenance for all types of infrastructure and building facilities. Its average estimated turnover was US$1.4 billion world wide and US$0.3 billion in China alone. Company J from Japan was a leading architectural, engineering and general contracting firm. It offered integrated planning, design and build solutions for a broad range of construction and engineering projects. One of the top five contractors in Japan, J had more than 30 offices in cities all over the world- Europe, Africa, North America, Middle East and Asia and had a staff strength of more than 11,000. Its sales in 2005 was US$14 billion worldwide and US$0.1 billion in China.

4. RESULTS AND DISCUSSIONS

From the interviews with the respondents, the characteristics of Chinese firms and their workmen are summarized in Table 2. These are now discussed.

Table 2 Culture of Chinese firms and workmen

Characteristics	Singapore firm (S)	US firm (A)	Japanese firm (J)
Level of technical competency	High	High	High
Level of cooperation	Medium	Low	Low
Need detailed procedures	Yes	Yes	Yes
Need for micro-management	Yes	Yes	Yes
Level of initiative	Low	Low	Low
Willingness of mid-management to take additional responsibility	Low	Medium	Low
Willingness to work overtime	Low	Low	Low
Competency in English	Low	Low	Low
Level of trust for project managers	Low	Low	Low
Need for close supervision	High	High	High
Bureaucratic culture	High	High	High
Compliance with written contract	Low	Low	Low
Propensity to make claims	High	High	High
Ease of settling disputes	Easy	Difficult	Easy
Safety awareness	Low	Low	Low
Quality performance	Low	Low	Low
Prevalence of networking	High	High	High

Team-spirit

In construction projects, the presence of team spirit leads to higher collective professional effort and more effective performance (Thamhain and Wilemon, 1987). One of the difficulties faced by foreign AEC firms is developing the team's esprit de corps. A-PM1 commented that the local Chinese staff had high technical competency but they could be calculative and uncooperative. For instance, during meetings, they were encouraged to give their views and opinions. It was common for team members to have differing opinions. The usual practice for foreign firms was for the team to discuss and then come up with a general consensus. However, in some cases, after the meeting, Chinese staff might still hold on to their views and would be reluctant to implement what the team had decided. Firm A had experiences when the Chinese staff, upon leaving the meeting room, chose to totally ignore what was agreed upon in the meeting and went ahead to carry out what they wanted. This is one of the reasons why Firm A had to station expatriate staff (about 15% of total staff strength) in its China office to monitor the locals.

The foreign firms also realized that loyalty to the company was strongly linked to remuneration. The first local practice is the frequency of bonuses being paid out to staff. Initially, the foreign firms paid Chinese staff a basic salary plus a year end bonus. They found staff turnover was high. Firm S switched to basic pay plus regular monthly or quarterly bonuses. The second local cultural practice is to share project profits with staff. To keep good staff, the foreign firms had to follow this practice. The third local practice relates to the size of annual increments. By following the percentage increment set by the head office, foreign firms in China found that they were losing staff. The percentage increment for China staff had to be set higher because of their low basic salary. Foreign firms had to adopt these local practices in order not to lose competent staff because the market in China is growing very quickly and there is a shortage of trained local staff.

Micro-management

The interviewees revealed that Chinese workmen and supervisors need to be monitored closely. It is not possible to give them the master program and leave them to do the work alone. Project management on a micro level is required to monitor their progress closely, if not the deadline would not be met. A-PM2 explained that it is not enough to have weekly meetings. His firm conducted daily meetings, sometimes twice a day, once in the mornings and once in the evenings to identify the works for each day. The workers appeared to have no sense of urgency in completing the work. They have to be pushed continuously. A-CN1 stated that:

> "*You have to watch them closely if not they won't do their job. This kind of behavior has not changed in all the eighteen years that I have been in China.*"

Besides close monitoring, the foreign firms found that their Chinese staff were procedure driven. This has to do with the history of China, the old system where people lived in a very controlled environment. There were many rules, regulations and procedures that they had to obey. So the general mentality among locals is that it would be very risky to deviate slightly from rules and regulations. As the Chinese are used to complying with procedures, they do not question them. They would prefer to be given clear procedures so that they could follow, rather than being given a performance indicator to achieve. The system is very procedure driven and not result orientated. S-QS1 remarked:

> "*The (local) Chinese staff are very obedient and are mostly the 'instruction taking employees'. On the working level, staff are always expecting procedures to be given to them so the management cannot give them too much free play in the ways of working. If detailed procedures are not given, most of the staff will be lost, and cannot perform effectively*."

Initiative

Initiative is volunteering to carry out tasks that are not formally part of one's own job (Borman and Motowidlo, 1993). Individuals with initiative make suggestions regarding organizational improvements, take on extra responsibilities, volunteer for assignments, anticipate problems, take actions to prevent them, and perform extra necessary tasks without explicit orders. Initiative may be evaluated as the extent to which the individual seeks out and accepts responsibilities and takes appropriate action without waiting for directions from supervisors (Putti, 1985).

The cases showed that Chinese staff lacked initiative in solving problems. S-QS2 gave an example that in the service sector, a mid management staff would be expected to be proactive whereas in China, the local Chinese staff still expected instructions to be given by higher management on the next step to take. They were not used to taking initiative and coming up with their own working method.

Consistent with their lack of initiative, Chinese staff were found to be unwilling to work overtime. It was almost impossible to expect Chinese staff to willingly work late to meet deadlines, unless they were give overtime pay. The Japanese firm paid out large sums of money to entice local workers to work overtime.

On the point of working overtime, besides their lack of initiative, it was found that some Chinese staff had genuine difficulty in getting home later in the night. These staff stayed in the outskirts of Shanghai and traveling home by public transport would take up to 2 hours. Some of the public buses in China stopped service rather early, at around 8pm. To combat this problem, overtime pay was made and taxi fares were reimbursed.

Communication with Chinese Staff

Communication is the ability to interact effectively with others at all levels within and outside the organization (Gushgari *et al*., 1997). Effective communication enables projects to be completed faster (Walker, 1998). One of the cultural problems faced is that Chinese employees are not proficient in English and foreigners are not proficient in Mandarin. J-AR1 reported definite communication problems when working with the local Chinese. The firm overcame this by hiring more Chinese staff who spoke Japanese. As of January 2006, approximately 30% of firm J's Chinese staff were able to converse in Japanese.

S-PM1 observed that Chinese use very little English in their everyday life. Although they were taught in school, they were not comfortable speaking and reading English. On the other hand, foreigners were more proficient and comfortable speaking and reading English instead of Mandarin. One of the ways to overcome communication problem is for staff (foreign and Chinese) to be positive about the language issues and be proactive in learning whichever language they are less proficient in.

Cross cultural encounters need to be managed properly so that projects can be successfully completed. Foreign firms coming from their own home countries have the additional burden of overcoming cultural differences between their staff from home countries and people they need to work with in China (host country). One recommendation is that the foreign firm should engage either a person from the home country who has studied in the host country (China), or a person from China who had studied in the home country. Firm J said that it engaged people who had studied or worked in Japan and thus were familiar with the Japanese working systems and mentality. In engaging subcontractors, Firm J chose those who had worked with other Japanese contractors in the past and were familiar with the Japanese working culture.

Culture of Distrust

A greater degree of trust leads to greater team spirit and higher quality of information exchange among team members, and this gives rise to more effective decision-making and higher productivity (Thamhain and Wilemon, 1987). J-PM1 shared that in Japan, project managers are given full authority and responsibility all matters relating to the project. J-AR1 added, “In Japan, everything is based on mutual trust.”

This study found that in China, project managers are not fully trusted by the firms that engaged them while the head office controlled many other matters such as budget and quality. Between contractors, clients and the government, there was no culture of trust. This is attested by the need to engage a government approved supervisory brigade to check the quality of the works. The supervisory brigade is an independent quality control firm. The client has to pay them to inspect the project, and at the same time they are also accountable to the government’s quality control bureau. J-CN1 felt that is may be because the Chinese government could not trust the industry to self regulate.

Bureaucratic culture

The case studies revealed that managing projects in China involves dealing with the bureaucracy as there is government intervention in every stage of the project. One reason for the bureaucratic culture is the government’s zest in protecting the local construction industry. One example is the need to engage a supervisory brigade, as discussed earlier. J-AR1 felt that the construction industry is still very protected by the government, and that even if the central government opened up, the local government might not.

When applying for construction permits bureaucratic culture is also evident. According to A-PM1:

> *“If you knew somebody in the government, you could get it settled in a day, if not, the firm could wait for one month and it might still not be done. Construction wise, the local contractors could start work even before they obtained the construction permit. But it is especially different for foreign firms as the government likes to keep a close eye on them. Hence foreign firms have to make sure they wait for one month and receive the permit before they start construction.”*

Culture of ignoring written contracts

The cases revealed that parties that signed the contract did not always honour it. Firm A felt that is was pointless to enforce the contract through arbitration or the courts. Even if a foreign firm commenced legal proceedings, the chance of winning the case on the grounds of breach of contract was not high. To overcome this, A-PM2 revealed that it required contractors to read and stamp on every page of the contract. He did this because he found that some Chinese sign contracts without paying attention to all their legal obligations and responsibilities. Sometimes he even sat down with the contractors and went through every page of the contract documents with them, explaining to them the contents in detail. This was to ensure that there was no misunderstanding of the specifications.

One example A-CN1 gave was that of insulated glass, which consisted of two layers of glass with a vacuum/cavity in between. The local contractors quoted the price of laminated glass instead of insulated glass. A-CN1 had to explain what insulated glass was to the local Chinese contractor and asked the firm to check the pricing again. A lot of work had to be done in educating and training contractors and even clients because some clients do not understand why there was a need to insulate their walls.

Claims culture

The cases revealed a strong claims culture in China. Even though all requirements had been specified in the bid documents, A-PM2 warned that it is necessary to keep on emphasizing to the contractors what was in the contract documents. Some local contractors did not read the specifications and based on their experience, offered a price that they thought would help them win the job. Therefore firm A had to be careful in analyzing the bid prices as Chinese contractors' usual practice is to bid low and later claim for variations.

While Chinese contractors were found to be claims conscious, many were not able to adopt the correct and professional ways to claim for variations. They generally did not keep a proper record which could help them build up a good documentation. Some of them did not fully understand the clauses in the contract. A-PM2 mentioned that there was a contractor who tried to claim for additional payment on the ground that it had under priced in the beginning!

Dispute settlement

When a dispute arises, foreign contractors would look into the contract details to find out exactly how much they could claim for. Negotiating with foreign contractors means going through the whole tedious contractual process and long meetings, after which the final decision will be made by the top management.

A-PM1 felt that it is easier to resolve a dispute with Chinese contractors because they are not caught up with contractual procedures and legal requirements. He felt that it is easier to negotiate with a local Chinese contractor than a foreign contractor. Local Chinese contractors disliked scouring through thick contract documents to find clauses to support their position in the dispute. A-PM1 commented:

> *"When dealing with local Chinese contractors, the first step is to identify what their final goal is, that is how much money they really want. For example, a contractor would start his claim at RMB10 million when actually it would be satisfied with RMB2 million. The aim was to lead the negotiation towards RMB2 million. There is no need to go through the whole tiresome contractual process. We usually go through the meeting, quarrel and after that meet up with a few key people to settle it over the dining table."*

Safety culture

The cases revealed low consciousness towards safety at construction sites. The main problem is the mentality of workers towards safety issues. Firm A said that while it provided safety equipment for its workers in China, many did not bother to use such equipment. They had poor attitude towards safety. Firm A had to constantly remind construction workers to use the safety equipment provided. "It is as though they do not care about their lives", A-PM1 commented. Therefore exercising the implementation of safety practices in China is a very difficult task.

Quality culture

The cases revealed that local Chinese firms had poor quality control and quality performance. Much training had to be given to Chinese workers to educate them on what satisfactory level of quality was. Firm A had to train Chinese contractors to detect mistakes and low quality workmanship and do the necessary rework. For example they were not able to see if a wall was straight, and could not understand the fuss when the paint on the wall stained the door frame.

Firm A also tried to increase quality awareness by organizing tours for successful bidders. The project managers were brought to visit buildings where work done had met firm A's expectations. Sometimes, firm A's staff physically demonstrated what was required of contractors. They would also take photographs of satisfactory works and requested contractors to sign off after viewing the photos, to acknowledge that they had seen the requirements and would do likewise.

A-PM2 warned against leaving workers to do the work all by themselves. Firm A had to place more inspectors on site, not so much as to resolve technical issues but more as observers, keeping an eye on what workers did minute by minute. This was done so as to ensure a high level of workmanship quality.

J-PM1 said: "The clients can accept substandard work from the local (Chinese) contractors but not from us (Japanese)." There was one project where firm J did interior fitting out works for an existing factory. The original local contractors did not construct according to specifications. For example, the slab was thinner than the local specifications. They managed to get away with it, until firm J hacked off the architectural finishes to do some embedment and realized the error.

Networking culture

China's unique working culture is renowned throughout the world. Having the right 'guanxi' (relationship) with the right people is critical in ensuring the success of the firm. When two parties form *guanxi*, they establish a connection between two independent units to enable a bilateral flow of personal or social transactions from which both parties derive benefit (Yeung and Tung, 1996). S-AR1 noted: "In China, business is settled over the dining table." Firm S allocated a huge budget for entertaining clients in an effort to impress and please them, in order to foster better future working relationships.

The cases showed that there was low emphasis on meritocracy and high emphasis on networking when conducting business in China. Networking was conducted at several levels. The first level was to be invited to bid. S-PM1 felt that building an extensive network of contacts helped the firm win projects in China. Staff were trained to be proactive in identifying project opportunities and lobbying hard to win projects.

The second level of networking was after bids were submitted. The case studies showed that in China, the culture is bidders must contact clients after bids are submitted. Firm A found that to ensure a higher chance of winning a contract, it had to practice this local culture. A-PM1 noted: "The local Chinese like bidders to talk to them and pacify them after the bid is submitted."

Initially Firm A thought it was not necessary to interact with China-based foreign clients after bids were submitted. The firm found that it lost a few jobs when it did not interact actively with foreign clients in China. Its competitors won the jobs because they called and this put them in a more favourable position. The main reason is that foreign clients had engaged local Chinese to handle their operations. Firm A found that it was not because the foreign clients' culture had changed drastically, but because they had engaged Chinese staff, who had localized their operations.

5. SUMMARY AND CONCLUSION

The study revealed that foreign firms would have to deal with cultural differences when managing Chinese workers and managers. Local Chinese staff were found to prefer following detailed instructions. They were seen as less proactive because of their 'instruction taking' mindset which does not encourage initiative and responsibility taking. Some firms experienced problems with uncooperative local Chinese staff. Foreign firms found a lack of mutual trust among project team members. They also experienced Chinese firms that do not honour the contract. While they were claims conscious, it was not difficult to settle disputes. The firms generally encountered low safety and quality consciousness, and a disproportional emphasis on networking.

To succeed in China, foreign firms should localize operations and be quick to respond to cross-cultural encounters. To be successful, S-AR1 said:

> *"Because of the cultural difference, both sides (the local Chinese as well as the foreigners) have to develop a more forgiving attitude. Many of the problems are due to expectations of the foreign management staff. As time passes, they lowered their expectations and the locals picked up some of the foreigners' working styles and a balance is achieved."*

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THE IMPORTANCE OF CHINESE PROJECT MANAGERS' WORK VALUES

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ABSTRACT

This paper reports on a research project investigating the development of project managers in China. There is a growing adoption of Western project management ideas and practices in China. The demand for training Chinese project managers is high. Concerns about the relevance of Western project management ideas to China have been expressed by Chinese project managers.

The authors administered a questionnaire survey (n=60) and conducted repertory grid interviews (n=18) on Chinese project managers to triangulate and to further investigate the research problems.

From this research, the work values of project managers have been identified as an important dimension in modelling project managers' competence. A new category of Chinese project managers' work values has been developed from the literature and data gathered in this research project. The authors argue that the translation of Western project management bodies of knowledge into Chinese is just the beginning of developing the discipline of project management in China and should not be seen as a solution in itself. The authors recommend further research on a broader competence-based approach to develop project managers.

Keywords: Competence, Culture, Project management, Work values.

1. INTRODUCTION

This paper reports on a research project investigating the development of project managers in China. This paper begins with introducing key concepts of this research, such as competence, values and work values. Then the authors discuss the research problem in the context of global management research and the context of Chinese culture. The research methods, questionnaire survey and repertory grid interview survey, are presented and explained. Chinese project managers' work values have been identified. The relationship between project managers' work values and competence is discussed. As a result, the authors argue that understanding project managers' work values will benefit project managers' competence development.

Competence

A competence-based management development provides the opportunity to identify and develop people with the competencies required for performing the job. Organisations create such situations to develop the knowledge and skills of individuals, and ultimately to improve the competitiveness and productivity of the organisation itself (Gale and Brown 2003). Competence-based management development is widely accepted and advocated by major project management institutions. The International Project Management Association (IPMA) published IPMA Competence Baseline (ICB) (Caupin et al. 1999). The Project Management Institute (PMI) introduced Project Manager Competency Development Framework (PMI 2002).

Spencer and Spencer (1993) define competence as “an underlying characteristic of an individual that is causally related to criterion-referenced and/or superior performance in a job or situation”, and identify five types of competence characteristics (Figure 1):

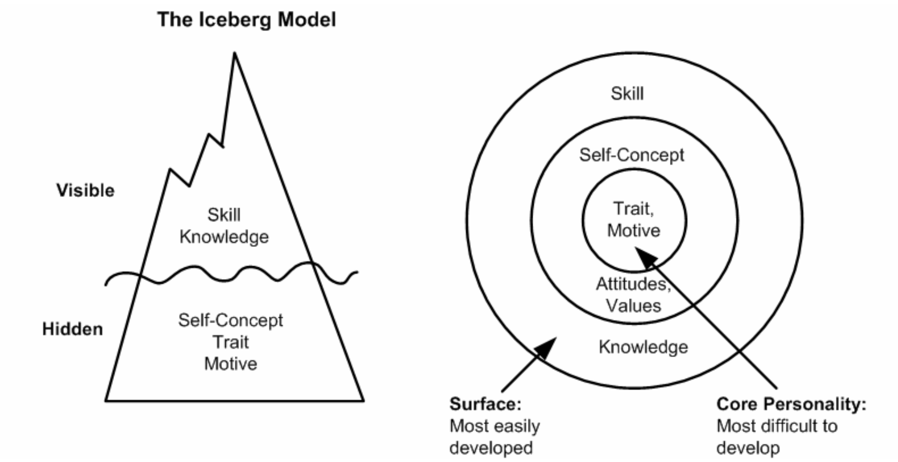

Figure 1 Central and surface competencies (Source: Spencer and Spencer 1993, p11)

1. Motives – the things a person consistently thinks about or wants that cause action. Motives “drive, direct, and select” behaviour toward certain actions or goals and away from others.
2. Traits – physical characteristics and consistent response to situations or information.
3. Self-concept – a person’s attitudes, values, or self-image.
4. Knowledge – information a person has in specific content areas.
5. Skill – the ability to perform a certain physical or mental task.

Crawford (2004) argues that neither the ICB listing of attitudes and behaviours in the ICB, nor Personal Competence in the PMI “Project Manager Competency Development Framework” (PMI 2002) have a strong foundation in research. The Personal Competencies in the PMI “Project Manager Competency Development Framework” are based on general competencies presented in the work of Spencer and Spencer (1993).

Work values

There are wide discussions on human values in the literature (Hofstede 1980; Rokeach 1973; Schwartz 1994). Rokeach (1973) defines value as “an enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposition or converse mode of conduct or end-state of existence.” A value system is “an enduring organization of beliefs concerning preferable modes of conduct or end-states of existence along a continuum of relative importance”

(Rokeach 1973). Hofstede (1980) defines value as “a broad tendency to prefer certain states of affairs over others.” Schwartz (1994) further defines value as desirable trans-situational goals, varying in importance, that serve as guiding principles in the life of a person or other social entity. Implication of this definition of values as goals is that: (1) they serve the interests of some social entity, (2) they can motivate action – giving it direction and emotional intensity, (3) they function as standards for judging and justifying action, and (4) they are acquired both through socialization to dominant group values and through the unique learning experience of individuals. The authors use this as working definition of value in this research. A work value can be defined as the importance individuals give to outcomes arising in the work context (Elizur 1984). In recent years, there has been a growing interest in analysing work values. Research on work values can be divided into three main streams: structure, correlation to other personal, social, or organisational variables, and cultural factors (Sagie, Elizur et al. 1996). A study comparing the values of managers from the U.S.A, Hong Kong and the People’s Republic of China indicates that often both culture and the business environment interact to create a unique set of managerial values in a country (Ralston et al. 1993).

Cross-cultural research

It is argued that the cultural values of the United States underlie and have fundamentally framed management research, thus imbuing organizational science with implicit and inappropriate universalism (Boyacigiller and Adler 1991). “It (culture) consists of both objective (roads, factories, etc;) and subjective (norms, values) elements. Its significance for organizational behavior is that it operates at such a deep level that people are not aware of its influences. It results in unexamined patterns of thought that seem so natural that most theorists of social behaviour fail to take them into account. As a result, many aspects of organizational theories produced in one culture may be inadequate in other cultures.”(Triandis 1983). Little is known about the effectiveness of cross-border transfer of organizational knowledge involving dissimilar cultural contexts (Bhagat et al. 2002).

Chinese project managers’ work values constructs

The authors identified a list of Chinese project managers’ work value constructs from literature. The origin of each construct is shown in Table 1. The left hand column of constructs are derived from the literature, except constructs A and B. The right hand column of constructs are added by the author.

For work value construct A, managing conflict between work and family role demands is a critical challenge for individuals and organizations, and a topic of growing importance in organizational behaviour (Frone, Yardley et al. 1997; Kossek and Ozeki 1998). The relationship between public life and private life was discussed by Confucius about 2500 years ago (Confucius 1971).

For construct B, people’s attitude to change is a key topic in Taoism. Lao Tzu lived during almost the same period as Confucius in ancient China. Guildford (1995) observes that most companies do not follow the Tao (Lao Tzu 1962) because, when they grow above a certain size, the people at the top worry about losing control and so introduce restrictive systems. These systems include a rigid line management structures, strategies, business plans, and detailed procedures for every task. At the root of the problem is the company’s loss of sensitivity to patterns of change occurring both in the company and in the company's environment. Everyone is distracted by the artificial world of procedures and strategies. The Taoist leader constantly makes many small corrections. If the changes are made early enough, they can always be small. The truly expert leader appears to do nothing.

Construct		Source
A. Public career world	Private home and self	Confucius (1971), Frone (1997), Kossek et al. (1998)
B. Keeping stable	Open to change	Lao Tzu (1962), Guildford (1995)
C. Place in the hierarchy	Able to relate to others and not status-conscious	Lockett (1988)
D. Kindness to others, willing to help others	Help others as the task dictates	Fernandez (2004)
E. Justice	Business profit orientation	Fernandez (2004)
F. Loyal to superiors	Insisting on own opinion	Chinese Culture Connection (1987)
G. Protecting face	Selflessness	Chinese Culture Connection (1987), Lockett (1988)
H. Coaching others	Personal growth	Schwartz (1985)
I. Avoid confrontation	Willing to challenge	Fan (2000)
J. Group orientation	Individual orientation	Lockett (1988)
K. Guanxi, relationships	Formal business procedures	Gold (1985), Lockett (1988), Guthrie (1998), Lovett, Simmons et al. (1999), Fan (2000), Stockman (2000)

Table 1 The origin of constructs

Four key features of Chinese culture have been identified in relation to organizations. They are respect for age and hierarchical position, group orientation, the concept of face and the importance of relationships (Lockett 1988). These features lead to constructs C, G, J and K.

Fernandez (2004) reported two values fundamental in the Confucian system: kindness and justice. These two values are illustrated in constructs D and E.

The Chinese Culture Connection is the name given to an international network of colleagues orchestrated by Michael H. Bond, Department of Psychology, Chinese University of Hong Kong. The network has identified 40 fundamental and basic values for Chinese people (The Chinese Culture Connection 1987). Constructs F and G are chosen from these 40 fundamental values. Based on Hofstede (1980) and Chinese Culture Connection's (1987) research, Hofstdede and Bond (1988) have found one uniquely Eastern dimension of cultural value - Confucian Dynamism. They believe that this dimension deals with a society's search for virtue.

Following Chinese Culture Connection's findings, Fan (2000) presented a classification of Chinese culture in which 71 core cultural values are grouped into eight categories. The origin of construct I can be found in these categories.

Schwartz (1985) found that from the familiar model of the Chinese socio-political order there emerged a highly significant orientation embodied in the Chinese motto "Zheng Jiao He Yi" (the unity of ruling and teaching). The universal king ideally was born supreme ruler and supreme teacher. The authors add coaching as a construct pole to represent this orientation in construct H.

Guanxi, is a word appearing constantly in everyday conversation among Chinese people and has draw increasing attention in academic discussions since the 1980s (Gold 1985; Lockett 1988; Guthrie 1998; Lovett, Simmons et al. 1999; Fan 2000; Stockman 2000). It is included in construct K. *Guanxi* means 'relationships' or 'connections', and can be used to refer to relationships between people and groups (social relationships, international relations) as well as between processes and ideas (Stockman 2000).

2. RESEARCH DESIGN

There are two interrelated studies in the research: a questionnaire survey and repertory grid interview survey. The findings of the two studies are synergistic.

The questionnaire survey

Four hypotheses are considered in the questionnaire survey. The first hypothesis relates to whether work values have a consistent pattern in Chinese project managers with different work experiences. The second hypothesis relates to work values and their relationship to other indicators of project manager's competence. The third hypothesis is concerned with using work values as an indicator for testing whether or not project success and project manager's personal career success are related. The fourth hypothesis using work values as an indicator to test whether project success and project manager's personal career success is different or not.

Hypothesis 1:

H_0: There is no difference between inexperienced project managers' scores on work values and experienced project managers' scores on work values.

H_1: There is a difference between inexperienced project managers' scores on work values and experienced project managers' scores on work values.

Hypothesis 2:

H_0: Project management knowledge, project manager's personal attitude and project manager work values are of the same importance.

H_1: Project management knowledge, project manager's personal attitude and project manager work values are of differing importance.

Hypothesis 3:

H_0: There is no association between project managers' scores on work values regarding personal career success and project success.

H_1: There is an association between project managers' scores on work values regarding personal career success and project success.

Hypothesis 4:

H_0 : There is no difference between project managers' scores on work values regarding personal career success and project success.

H_1 : There is a difference between project managers' scores on work values regarding personal career success and project success.

Populations and Sampling

The population of this research is Chinese project managers. It is difficult to estimate the total number of Chinese project managers. Because project managers are found in different industries and cross-sector certification for project managers has been available for only a few years. A sample of convenience method was used in this research. The benefit of this sampling method is that it is practical and relies on readily available sources of data. The risk, of course is that because the sample is opportunistic and voluntary, participants may be unlike most of the constituents in the target population (Fink 1995).

The questionnaire is web-based. When respondents complete and submit their answers online to the web server, their responses are automatically coded. The data are placed in a database for further statistical analysis. There are three different sources of respondents. First of all the authors used personal networks and sent invitation emails to the interested party with the hyperlink of the questionnaire. Secondly, five hundred invitation letters were sent by email with the questionnaire hyperlink to project managers listed on a Chinese project management website (http://www.mypm.net/). Thirdly, the questionnaire was printed out and distributed to about 40 Chinese MSc students (with Chinese industrial experience) studying project management at the University of Manchester. In total, the authors gathered 93 feedbacks. Because of missing data and errors, 61 feedbacks are valid.

Repertory grid interviews

A range of 18 interviewees from junior to senior project management positions were identified. All of them are from the construction industry, 8 from construction contractors, 3 from public sector clients, 3 from private sector clients and 4 from design institutes and consultants. All had experience in project management of at least five years. At the beginning of interview, respondents were asked a variety of open-ended questions about: career history; experiences of working with their company; their views about the company, its values and environment and their own role(s). Four elements were used to elicit constructs:

1. Self at current time.
2. Self at the start of project management career.
3. The most successful project manager you know personally.
4. The most unsuccessful project manager you know personally.

These provided a focus for interviewees to think about different project managers' behaviours and values. Then these elements were presented in varying triad combinations and interviewees were asked to characterize how two of the individuals were similar in terms of work but different from a third. The triads were presented four times in different combinations for each interviewee. These combinations were standardized so that each interview addressed the same combinations at the same stage of the interview. The constructs that the interviewees generated were written onto the grid by the interviewer. Interviewees were asked to rate each element on each construct, so that the interviewer built up a matrix of: elements × constructs. The full grid procedure allows the interviewer to exhibit not only the constructs themselves, but in detail how they are used.

3. MAIN FINDINGS

The questionnaire survey

For hypothesis 1, using the Wilcoxon-Mann-Whitney test (Siegel and Castellan 1988), regarding personal career success, for the value of *Justice – Business profit orientation*, p-value = 0.028 < α = 0.05, for the value of *Guanxi and relationship – Formal business procedures*, p-value = 0.025 < α = 0.05, the authors rejected H_0 and accepted H_1 for these two cases. For the other values regarding personal career success and project success, p-value > α = 0.05, the authors accepted H_0 and rejected H_1. Statistical results were significant for experienced and inexperienced project managers indicating that they have the same scores for work values for nine out of eleven work values. For the other two work values, namely *Justice – Business profit orientation* and *Guanxi and relationship – Formal business procedures* statistical tests indicate that both groups of project managers have the same scores on these two values in relation to project success. Project managers with less experience were inclined to believe *Business profit orientation* is slightly more important than *Justice* to personal career success. Project managers with less experience appear inclined to believe that *Guanxi and relationship* are more important than *Formal business procedures* to personal career success.

For hypothesis 2, the Friedman two-way analysis of variance by ranks was chosen (Siegel and Castellan 1988). From calculation, F_r = 2.167, when df = k–1=2, p-value = 0.338 > α = 0.05, the authors accepted H_0 and reject H_1. The test supported that project management knowledge, project manager's personal attitude and project manager working value are not different in importance to project management practice.

For hypothesis 3, Spearman's Rho correlation coefficient (ρ) was used to test this hypothesis (Siegel and Castellan 1988; Conover 1999). For a two tailed test with α=0.05, N=11, p-value= 0.958. H_1 was rejected and H_0 is accepted. That is, project managers' scores on work values regarding personal career success and project success are independent.

For hypothesis 4, the Wilcoxon Signed Ranks test was used to see if the second random variable in the pair has the same mean as the first (Siegel and Castellan 1988). From the test, there is no difference between project managers' values of *Loyal to superiors - Insisting own opinion* and *Guanxi, relationship - Formal business procedure* on personal career success and those on project success. The others are different.

The following list of Chinese project managers' constructs in project management was developed from literature.

		2	1	0	1	2	
A.	**Public career world**						Private home and self
B.	**Keeping stable**						Open to change
C.	**Place in the hierarchy**						Able to relate to others and not status-conscious
D.	Kindness to others, willing to help others						**Help others as the task dictates**
E.	Justice						**Business profit orientation**
F.	*Loyal to superiors*						*Insisting on own opinion*
G.	**Protecting face**						Selflessness
H.	**Coaching others**						Personal growth
I.	**Avoid confrontation**						Willing to challenge
J.	**Group orientation**						Individual orientation
K.	*Guanxi, relationships*						*Formal business procedures*

(The polar in bold font – project managers incline to project success,
The polar in regular font – project managers incline to personal career success,
Italic – no difference between project success and personal career success)

Table 2 A list of wok value constructs in project management

Repertory grid interviews

Based on Schwartz's (1994) five features of the conceptual definition of values, the authors preclude the constructs and themes that are not qualified as values and provide the following list of values with forty constructs in 11 themes. These values can further be grouped by Schwartz's (1994) ten motivationally distinct types of values: **power, achievement, hedonism, stimulation, self-direction, universalism, benevolence, tradition, conformity and security** (Table 3). It is not surprising that the ten types of values do not all appear in project managers' work values, since work values are not as broad as human values.

Types	***Project Managers' Work Value Constructs***	
Power	Work into details	Manage people
Achievement	Project	Personal Career
	Achievement	Profit
Stimulation	Passion for project	No passion for project
	Attach importance to communication	Attach no importance to communication
Self-direction	Willing to take responsibility	Not willing to take responsibility
	Innovative	Conservative
	Provide service	Provide product
	Develop personal relationship in work	Do not develop personal relationship in work
Universalism	Long-term orientation, wide view	Short-term orientation, narrow view
	Moral conduct	Self-interest

Table 3 Project managers' work value constructs in Schwartz's value types

4. DISCUSSIONS

An integrated category of work value constructs has been developed by combining these two constructs in table 2 and 3 (Table 4).

Types	***Project Managers' Work Value constructs***	
Power	Place in the hierarchy	Able to relate to others and not status-conscious
	Protecting face	Selflessness
	Work into details	Manage people
Achievement	Public career world	Private home and self
	Project	Personal Career
	Achievement	Profit
Stimulation	Passion for project	No passion for project
	Attach importance to communication	Attach no importance to communication
Self-direction	Willing to take responsibility	Not willing to take responsibility
	Innovative	Conservative
	Provide service	Provide product
	Develop personal relationship in work	Do not develop personal relationship in work
Universalism	Justice	Business profit orientation
	Long-term orientation, wide view	Short-term orientation, narrow view
	Moral conduct	Self-interest
Benevolence	Kindness to others, willing to help others	Help others as the task dictates
	Coaching others	Personal growth
	Group orientation	Individual orientation
Tradition	Guanxi, relationships	Formal business procedures
Conformity	Avoid confrontation	Willing to challenge
	Loyal to superiors	Insisting on own opinion
Security	Keeping stable	Open to change
Total = 9	Total = 22	

Table 4 Project managers' work value constructs in types

It seems that work values are quite consistent in project managers from hypothesis 1. Regarding the relative importance of work values, knowledge and personal attitude, hypothesis 3 suggests that there is no evidence support that they have different importance. The IPMA Competence Baseline (1999) defines:

Competence = Knowledge + Experience + Personal Attitude.

The authors recommended work values to be considered to model project managers' competence and be included in competence-based management development programmes (Figure 2).

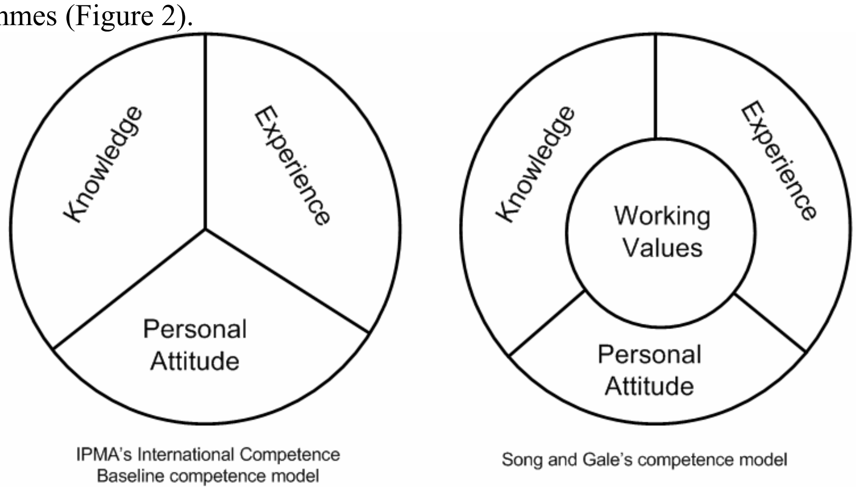

Figure 2 Song and Gale's competence model (Source: Caupin, G. et al, 1999)

5. CONCLUSIONS

From a practical viewpoint, the understanding of project managers' work values has a potential application in professional development, such as selecting staff for training and appointing project managers. In markets that are increasingly more global and complex, professionally demanding, constantly changing and oriented towards quality and customer satisfaction, business leaders would be expected to make a strategic choice of developing the personal and professional potential of each member of the organization. Management by values has been argued as a strategic leadership tool (Dolan and Garcia 2002). Organisations also have values. "To be effective in an organisation, a person's values must be compatible with the organisation's values. They do not need to be the same, but they must be close enough to coexist otherwise, the person will not only be frustrated but also will not produce results" (Drucker 1999).

In projects environments, where performance standards and behaviour-reward contingency are not clearly defined, work values may bridge the gap and have a greater impact on behaviour. Shapira and Griffith (1990) find that the work values of managers and engineers were strongly related to their performance rating, and more weakly and inversely related to their tardiness levels. When business situations are uncertain and difficult to quantify, managers tend to rely heavily on their value systems to make decisions (Davis and Rasool 1988).

Although work values of Chinese project managers have been identified in this research, these values cannot be assumed to be features of national character. In contrast to personality traits, which reflect actual differences in the ways in which people think, feel, and behave, stereotypes about national character seem to be social constructions designed to serve a specific social purpose (Robins 2005). Two papers in *Science* suggest that people are capable of providing reliable and valid assessments of a particular individual personality, but they are unable to judge accurately the aggregate, or national, character of the people around them (Robins 2005; Terracciano, Abdel-Khalek et al. 2005). A deeper understanding of the links between personality, culture, and management behaviour is particularly critical at this time of globalisation, as people and countries experience the "clash of civilisations" (Huntington 1993). Work values provide a dimension and an instrument to facilitate investigation into individual project manager's competence. The authors recommend that work values be considered in project management professional development. To explore the concept of work values across nations, it is proposed that similar research administered to comparable samples in different countries be undertaken. Since there are universal aspects of human values (Schwartz 1994), it is possible to have similar constructs of work values in general, while a few variations may exist in different countries.

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