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Objectives of W117 include Exploration of the optimal uses of performance information in the built environment, Create a worldwide resource or "centre" of knowledge of proven methods for implementing and sustaining performance metrics in an organization and industry, Create and catalogue performance measurements for many countries by engaging researchers and practitioners worldwide, to be a forum for innovative, pro-active, and progressive clients, industry practitioners, and academics to drive forward the knowledge and use of performance information and value in construction and related services and as a portal to learn from each other. The group strives to be a bringer of change, based upon 14 years of testing in construction performance, to push the industry away from commoditization and low performance and into an environment of measurement and value, to identify and compile a list of experts, documents, case studies, and research on the use of performance information in the delivery of construction in each major country or area of the world, to highlight the use and impact of performance measurement in each country in both a CIB commissioned and sponsored journal and a CIB "living document" to allow clients, professionals, contractors, and researchers to quickly identify experts and their work with performance information around the world and to document, create, and implement performance information to minimize construction risk.
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Measuring and Improving U.S. Construction Productivity

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Abstract

Although the construction industry is a major component of the U.S. economy, it has experienced a prolonged period of decline in productivity. Due to the critical lack of measurement methods, however, the magnitude of the productivity problem in the U.S. construction industry is largely unknown. To address these deficiencies, efforts are underway that focus on the measurement of construction productivity at three levels: task, project, and industry. We discuss how such measures can be developed, how they are related to the use of information and automation technologies and construction processes over the life of the project, and how to build on several ongoing collaborative efforts aimed at improving the efficiency, competitiveness, and innovation of the U.S. construction industry. We identify and prioritize activities that have the greatest potential for improving the productivity of the U.S. construction industry over the next 20 years. These activities include, but are not limited to, interoperable technology applications via building information modelling (BIM) and effective performance measurement to drive efficiency and support innovation. The paper concludes with a vision for the future built around a suite of standards for measuring task and project-level productivity, a database of task and project-level metrics, guidelines for efficient use of BIM and modularization techniques, and industry-level metrics. Leaders in the U.S. construction industry are aware of the successes and benefits that have accrued from the investments in measuring and monitoring construction safety and can envision the potential for similar improvements in construction productivity.

Keywords: building economics, construction, economic analysis, information technology, labor productivity, metrics, performance measurement, productivity
1. Construction: an engine for economic growth

Construction is an engine of growth for the U.S. economy. Investment in plant and facilities, in the form of construction activity, provides the basis for the production of products and the delivery of services. Investment in infrastructure promotes the smooth flow of goods and services and the movement of individuals. Investment in housing accommodates new households and allows existing households to expand or improve their housing. It is clear that construction activities affect nearly every aspect of the U.S. economy and that the industry is vital to the continued growth of the U.S. economy.

In 2008, the construction industry’s contribution to gross domestic product (GDP) was $582 billion, or 4.1% of GDP (Bureau of Economic Analysis (BEA), 2009). In 2008, the value of construction put in place was $1072 billion (Census Bureau, 2009). Construction also has a major impact on U.S. employment. In 2008, 11.0 million persons were employed in the construction industry (Bureau of Labor Statistics (BLS), 2009). This translates into 7.6% of the total U.S. workforce. The composition of the construction workforce differs from much of the U.S. workforce due to the large number of self-employed workers (sole proprietorships and partnerships). Within the construction industry, there are 1.8 million self-employed workers. The large number of self-employed workers both reduces the size of the average firm and increases fragmentation within the construction industry, where 79% of construction establishments with employees have fewer than 10 employees (Census Bureau, 2002a and 2002b). Both factors complicate the adoption of new technologies and practices. Construction employment is affected by both the weather and the business cycle. Thus, year-to-year changes in employment can be substantial, resulting in layoffs and hiring surges. The cyclical nature of construction employment produces shortages in many highly-skilled trades. These shortages adversely impact productivity in the construction industry. Finally, declining construction productivity is exacerbated by the influx of unskilled labor from abroad, many of whom find their first employment opportunity in the construction industry.

2. Productivity and competitiveness

Given the large impact of construction on the U.S. macroeconomic objectives, effective construction research becomes critical to the economy. Key drivers for change in construction research are sustainability and environmental security; competition due to globalization and offshoring; infrastructure renewal; and information technology. The problem is that the U.S. construction industry invests little in research relative to its significant GDP contribution to the economy. A landmark study co-sponsored by the Civil Engineering Research Foundation (CERF) and the National Science Foundation (NSF) involved a nationwide survey of civil engineering-related research and development (R&D). The study, later published by CERF (1994), is especially noteworthy because it includes R&D associated with each of the key construction industry stakeholders. The CERF study reported that all key construction industry stakeholders combined invested in R&D at a rate that corresponds to only 0.5% of the value of construction put in place. This translates into approximately $5.4 billion in 2008. A recently published NSF study covering companies performing industrial R&D provides a useful contrast (NSF, 2009). Private sector R&D investments in manufacturing totaled...
nearly $167 billion in 2007. Underinvesting reduces the potential for research-inspired innovations that contribute to substantial national benefits—namely constructed facilities that are more user and environmentally friendly, affordable, productive, and that are easier, faster, and more life-cycle cost effective to build, operate, and maintain. Given the impact of construction spending on the U.S. economy’s health, construction research becomes a critical variable in generating economic growth.

A recent article by Teicholz (2004) highlights the magnitude of the U.S. construction industry’s perceived decline in productivity. As measured by constant contract dollars of new construction work per field work hour, labor productivity in the construction industry has trended downward over the past 40 years at an average compound rate of -0.6 % per year. That is, construction projects have required significantly more field work hours per constant dollar of contract. This is particularly alarming when compared to the increasing labor productivity in all non-farm industries, which has trended upward at an average compound rate of 1.8 % per year. In other words, the construction industry seriously lags other industries in developing labor saving ideas and in finding ways to substitute equipment for labor. Teicholz reiterates the points noted earlier for their adverse impact on construction labor productivity, namely the lack of R&D spending and fragmentation within the industry. He also notes that despite the fact that there has been a significant adoption of new information technology by the construction industry over the past 35 years, these applications tend to run in a stand-alone mode that does not permit improved collaboration by the project team.

It should be noted that not everyone in the construction industry agrees with Teicholz’s assessment. For example, Young and Bernstein (2006), in their McGraw Hill SmartMarket Report, contend that the U.S. construction industry is making productivity improvements through innovation with new technologies, processes, and services. Teicholz asserts, however, that a fragmented market with very small players makes application of these innovations less frequent than desired for a healthy increase in industry productivity. Another reason Teicholz finds declining productivity is that it focuses on field work. For example, many of the improvements in construction productivity in the oil and gas industries stem from the use of offsite fabrication facilities, where component production is well-controlled and highly-automated (Construction Users Roundtable, 2007). The debate about whether construction productivity is declining, holding its own, or increasing cannot be easily resolved, because there are no industry-level measures of productivity for either the construction industry as a whole or its components (i.e., commercial, industrial, infrastructure, and residential). Such measures do exist for manufacturing, and they are routinely disseminated by the BLS.

To address these challenges, the National Institute of Standards and Technology (NIST) requested that the National Research Council (NRC) appoint a committee of experts to provide advice for advancing the competitiveness and productivity of the U.S. construction industry. The committee’s specific task was to prepare a report that identified and prioritized technologies, processes, and deployment activities that have the greatest potential to advance significantly the productivity and competitiveness of the capital facilities sector of the U.S. construction industry over the next 20 years.

To gather data for its report, the NRC committee commissioned three white papers by industry analysts and held a 2-day workshop in November 2008 to which 50 additional experts were invited. A range of activities that could improve construction productivity were identified in the three
commissioned white papers, at the November 2008 workshop, and by the committee itself. From among these, the committee identified five interrelated activities that could lead to breakthrough improvements in construction efficiency and productivity in 2 to 10 years. These activities are highlighted in the NRC report that states, “If implemented throughout the capital facilities sector, these activities could significantly advance construction efficiency and improve the quality, timeliness, cost-effectiveness, and sustainability of construction projects.” (NRC, 2009) The five activities, entitled “Opportunities for Breakthrough Improvements,” are: (1) Widespread deployment and use of interoperable technology applications, also called building information modeling (BIM); (2) Improved job-site efficiency through more effective interfacing of people, processes, materials, equipment, and information; (3) Greater use of prefabrication, preassembly, modularization, and off-site fabrication techniques and processes; (4) Innovative, widespread use of demonstration installations; and (5) Effective performance measurement to drive efficiency and support innovation (NRC, 2009). Although the focus of this paper is on effective performance measurement (activity 5), it also provides limited coverage of activities 1 through 4. Readers wishing in-depth discussions are referred to the NRC report and NIST Special Publication 1101 (Huang et al., 2009).

3. Construction productivity: task, project, industry

The nature of the construction process points to a need for measures of construction productivity at three levels: (1) task; (2) project; and (3) industry. Tasks refer to specific construction activities such as concrete placement or structural steel erection. Projects are the collection of tasks required for the construction of a new facility (e.g., the construction of a new commercial office building) or renovation (i.e., additions, alterations, and major replacements) of an existing constructed facility. Industry measures are based on the North American Industrial Classification System (NAICS) codes for the construction sector and represent the total portfolio of projects.

Producing measures of construction productivity at each level involves the development of both metrics (i.e., the definition of the appropriate measure that forms the basis for the calculation) and tools (i.e., the means through which construction industry stakeholders can perform the calculation for the selected metrics). Once produced, these metrics and tools will help construction industry stakeholders make more cost-effective investments in productivity enhancing technologies and life-cycle construction processes; they will also provide stakeholders with new measurement and evaluation capabilities (Construction Industry Institute [CII], 2003a).

Leading industry groups, such as the Construction Industry Institute (CII, 2005), Construction Users Roundtable (CURT), and FIATECH (FIATECH, 2004), have identified the critical need for fully integrating and automating life-cycle construction processes. Having metrics and tools will address that need and enable those industry groups and other stakeholders to: (1) evaluate the performance of promising automation and integration technologies and (2) measure the value of real-time monitoring and control of construction processes.
3.1 Task

Task level metrics are widely used within the construction industry. Most task level metrics are single factor measures and focus on labor productivity. For example, RSMeans has published task level metrics for many years (RSMeans, 2006). Typical task level metrics published by RSMeans estimate how much of a given output is produced by a designated crew in a normal 8-hour day. In this case, the denominator is the number of hours associated with a designated “crew day.” Thus, for a designated crew day, higher output is better. In this case, higher output equates to higher task labor productivity. The CII Benchmarking and Metrics Program uses a different metric to measure task labor productivity. CII fixes the output (e.g., volume of concrete put in place) and measures the labor hours required to produce that output (Mulva, 2008). In this case, the denominator is the fixed output and the numerator is the number of labor hours. Thus, for a given amount of output, lower labor hours is better. In this case, lower labor hours equates to higher task labor productivity.

Both the RSMeans and the CII task labor productivity metrics include explicit measures of output and labor hours in the values reported. Such metrics are easy to understand and are widely used within the industry as a basic estimating tool. To differentiate these metrics from alternative formulations, we use the term “raw metrics” to refer to these ratios of input and output. These metrics are raw in the sense that they include the units of measure and are based on unadjusted outputs and labor hours. For example, the relative prices for selected labor inputs and the given output may vary over time. There can be many reasons for such changes (e.g., expanded use of information and automation technologies, use of equipment with increased functionality, and changes in construction processes).

The CII Benchmarking and Metrics Program collects data on a project basis, where productivity is but one data element. The raw task level metrics produced by CII include not only the average productivity for that task—referred to as a baseline measure—but the full set of observed values. The observed raw task productivity values are then rank ordered into a distribution. Once this is done, the raw task productivity values can be assembled into quartiles. CII researchers can then examine the characteristics for a given task associated with projects in the best performing quartile and in the worst performing quartile. This topic is explored further in Section 5.1 of this paper.

A task productivity index is an alternative to the raw metrics discussed previously. An index is a dimensionless number, pegged to a reference data set, where the reference data set establishes the baseline value for one or more components of the index. An index can be a ratio of raw metrics. An index can also incorporate additional information, such as the value of a deflator to help control for changes in relative prices over time. Because the index is a dimensionless number, users can focus on the changes in the index value rather than the functional form of the metric underlying the index.

3.2 Project

Project level metrics are more complicated because a project is a collection of tasks. The inputs and outputs for a given task, say concrete placement, differ from those of another task, say structural steel erection. Thus, it is not possible to aggregate the individual raw task productivity metrics into a project productivity metric unless adjustments are made.
One way to make these adjustments is to use a reference data set to calculate baseline values for each task, in the same way as described in Section 3.1. Information is still needed, however, to calculate a meaningful project level productivity metric. For instance, information yielding the task weight (share that it represents to the overall project) is required.

A project level productivity index can also be used to track changes in project productivity over time. In this case, the reference data set corresponds to time zero. For each index component, the values for the task weights and the task baseline values appearing in the denominator are equal to values computed in the reference data set. The numerator in each index component then becomes the average value of the corresponding task productivity in the future data set. As noted earlier, an index can also include a deflator to adjust for changes in relative prices over time.

A variant of Teicholz’s formulation can be used to produce an alternative project level productivity index. In this case, the index is the quotient of two ratios, in each ratio the numerator is the value of construction put in place and the denominator is the number of field work hours. A reference data set can be used to fix a baseline value for the ratio of value put in place to field work hours. The baseline value for the ratio is then used as the denominator in the index calculation. How an individual project compares to the baseline is determined by inserting its ratio of value put in place to field work hours in the numerator of the index. Alternatively, this project level productivity index can be used to track changes in productivity over time by following the process described in the previous paragraph.

3.3 Industry

At the industry level, productivity—the amount (or value) of output produced per unit of input—provides a measure of industrial efficiency. BLS publishes two common measures of productivity: (single factor) labor productivity and multifactor productivity (BLS, 1997). BLS measures labor productivity as the ratio of the value of output produced for sale to labor hours worked. Because the value of output is influenced by other forces exogenous to labor, such as changes in technology, multifactor productivity measures provide a useful indicator of industrial productivity. BLS measures multifactor productivity using output, labor, capital, and intermediate purchases input. While multifactor productivity may be viewed as a better measure of productivity (compared to a single factor, labor productivity measure), it is obviously more costly in terms of data required.

The BLS does not collect nor report productivity measures for the construction industry. This appears to be due to the lack of suitable data (Allmon et al., 2000). Some have argued that measuring construction industry productivity is challenging due to the large number of small firms operating on a minimal profit margin, and to the industry fragmentation (Bernstein, 2003). However, the BLS maintains productivity measures for other industries with seemingly similar attributes (e.g., full-service restaurants [NAICS code: 7221]; drinking places [NAICS code: 7224]; automotive repair and maintenance [NAICS code: 8111]). The BLS Current Employment Statistics (CES) survey provides statistics on annual labor hours by industrial classification.

One key element in productivity measurement is output deflators. The BLS has recently produced several producer price indices in the nonresidential sector, and this effort has enhanced the estimates
of investments in BEA’s National Income and Product Account tables. BEA and BLS may collaborate further to develop other nonresidential building construction indexes, such as price indexes for highways, hospitals, retail, communication, power, and lodging structures (Lally, 2009). Efforts such as these improve the quality of existing statistics and have spillover benefits for productivity measurement.

4. Factors affecting construction productivity

Much has been published about the factors that affect construction productivity. Although a comprehensive treatment is beyond the scope of this paper, several key factors are usually cited in the literature. These factors are concerned with: (1) life-cycle construction processes; (2) technology utilization; (3) skilled labor availability; and (4) offsite fabrication and modularization.

4.1 Life-cycle construction processes

Management practices affect productivity over the life cycle of a construction project in a number of ways, including planning, resource supply and control, and supply of information and feedback. Management practices that are inflexible or applied inappropriately can introduce inefficiencies that reduce productivity. To address these problems, organizations such as CII have developed a suite of best practices aimed at improving the project execution process. These practices are directed at all phases of the project life cycle, from design, through procurement, fabrication, construction, commissioning, and operations and maintenance (CII, 1999). In-depth analyses of the value of best practices on cost and schedule control, as well a field rework have been performed (CII, 2003).

4.2 Technology utilization

Technology utilization impacts construction productivity in a number of ways. Historical changes in construction equipment have resulted in sustained improvements in task level productivity. Goodrum and Haas (2002) have shown that these improvements stem from better control, amplification of human energy, increased functionality, better ergonomics, and better information processing and feedback. Goodrum et al. (2009) came to a similar conclusion regarding material characteristics that lead to reductions in unit weight and installation flexibility. Analyses of CII Benchmarking data covering information and automation technologies revealed significant task level productivity improvements (CII, 2008).

4.3 Skilled labor availability

One of the greatest challenges facing the U.S. construction industry is the ability to attract and retain qualified workers. This is underscored by the fact that shortages of skilled workers continue to plague the construction industry (CII, 2003b). Employers have attempted to identify the root causes and to develop strategies to overcome these shortages. CII and others have funded research on the problem and generated potential solutions (CII, 2003b). Despite this research and efforts to stem the problem, the construction industry’s skilled worker pool continues to shrink. The decreasing number of young people entering the work force and the failure to recruit from non-traditional labor pools exacerbate
this trend. Over the past 30 years, real wages of construction workers have declined relative to those of other workers. Poor industry image, tough working conditions, and the industry’s perceived poor safety record also have contributed to the decline in the number of people willing to enter and remain in the industry.

4.4 Offsite fabrication and modularization

Prefabrication, preassembly, modularization, and offsite fabrication (PPMOF) offer potential benefits in the increasingly competitive global marketplace. Owners want better facilities faster, at the lowest possible cost, and with increased safety. Both owners and contractors view PPMOF as a means to meet challenges of demanding schedules, adverse site conditions, and limited availability of skilled labor. However, CII research shows that using these methods requires careful consideration of their implications for engineering, transportation, coordination, and project organization (CII, 2002). Recent advances in design and information technologies, combined with increasing emphasis within the industry to address cost, schedule, and labor issues, have proven the use of PPMOF to be more viable than ever. In a recent CURT publication, CII Director Wayne Crew noted that “the use of PPMOF has increased in the last 10 years, especially with new technologies such as building information modeling and internet design capabilities (CURT, 2007).” Future workforce shortages will likely encourage the use of PPMOF. PPMOF benefits such as reduced construction time, decreased costs, and increased safety have all contributed to its popularity, and while many companies in the oil and gas industries have used it for decades, others are realizing its full set of benefits.

5. Efforts aimed at improving construction productivity

Concerns over the perceived decline in construction productivity have stimulated interest in ways to use technology and management practices to address this challenge. Current industry efforts aimed at the seamless flow of information in an interoperable design and construction environment seek to promote labor productivity both by enabling the project team to respond quickly and effectively to new requirements, changes in scope, site conditions, and delivery delays and by promoting the use of value adding processes and technologies. The CII Strategic Plan (CII, 2005), the FIATECH Capital Projects Technology Roadmap (FIATECH, 2004), and CURT’s efforts to address owner issues associated with productivity improvement and cost reduction are several noteworthy examples.

5.1 Correlating task and project productivity with best practice use

Proponents of construction productivity metrics tend to focus on the measurement of task labor productivity. Although the value of producing task-level metrics is widely accepted, the current methodology for producing these metrics has not focused on identifying improvement opportunities. To address this issue, NIST launched a “data mining” effort in collaboration with CII to analyze how best practices and automation and integration technologies affect construction productivity at the task and project levels. The study published as NIST GCR 09-925 develops statistical relationships that correlate increased use of best practices and integration and automation technologies with construction productivity. Additional analyses were conducted to correlate the combined use of best practices and integration and automation technologies on reductions in cycle time, reductions in
construction cost, and reductions in field rework, which also affect construction productivity. Major findings were that technologies can facilitate the implementation of specific best practices, such as Front End Planning, Alignment, and Project Risk Assessment. Technologies and specific best practices, when used synergistically, can improve productivity of capital projects and may also decrease the amount of rework. These findings help key industry stakeholders understand how increased use of best practices and integration and automation technologies impacts the bottom line.

5.2 Leveraging technology to improve construction productivity

CII in collaboration with FIATECH established a research team on leveraging technology to improve construction productivity (CII, 2008). Since many factors impact construction productivity, the research team adopted a three-pronged approach to better control for any external factors. First, it examined how historical changes in construction equipment, materials, and information technologies influenced improvements in construction productivity. Second, a field test of materials tracking and locating technologies was conducted to measure how using such technologies can improve productivity on prototypical CII construction projects. Previous CII research identified materials tracking and locating technologies as significant factors impacting construction productivity. The use of radio-frequency identification (RFID) tags and a Global Positioning Satellite (GPS) system were coupled to track materials in lay down areas in two CII member projects (CII, 2008). Improved materials tracking was shown to increase productivity at the workface because material retrieval became more efficient. Third, a predictive model that estimates the potential for a technology to have a positive impact on construction productivity was developed and tested. The predictive model addresses a technology’s costs, its feasibility, its usage history, and its impact characteristics. One of the major results of the predictive model is that as a particular technology matures, it will yield higher performance scores. Technologies with high performance scores may no longer be cutting edge, but they provide a low-risk and potentially high-reward alternative to an unproven technology. However, not all companies will limit their technology search to mature, proven technologies. The predictive model is especially valuable in identifying key characteristics of emerging technologies that provide attractive risk-reward tradeoffs. Therefore, using the predictive model to choose among alternative technology investments is the first step in leveraging technology to improve construction productivity.

BIM is one technology that can enhance productivity of an entire project, from the planning phase to the decommissioning phase. Eastman et al. (2008) describe BIM as “a new approach to design, construction, and facility management in which a digital representation of the building process is used to facilitate the exchange and interoperability of information in digital format.” A previous NIST study on interoperability estimated the cost of inadequate interoperability in the U.S. capital facilities industry to be $15.6 billion per year (Gallaher et al., 2004), and therefore enhanced interoperability has a great potential in efficiency gains.

5.3 Vision for the future

A vision for the future is to develop the enabling measurement science for achieving breakthrough improvements in construction productivity that takes into account the complexity and variability of construction and leads to well-controlled, repeatable processes. This vision includes the creation of:
(1) Standard practices for measuring task-level and project-level productivity; (2) Database of task-level and project-level productivity measures for capital facilities; (3) Guidelines for efficient use of BIM and PPMOF techniques; and (4) Industry-level productivity metrics. Achieving the vision is more likely now because the enabling technologies are sufficiently mature to be applied to construction processes, the cost of computing is no longer a barrier, and the industry is demanding new capabilities for assessing and improving construction productivity. Leaders in the U.S. construction industry are aware of the successes and benefits that have accrued from the investments in measuring and monitoring construction safety (CII, 2007) and can envision the potential for similar improvements in construction productivity. These leaders recognize that meeting the challenges of managing increasingly complex, collaborative projects with changing mixes of stakeholders and increased global competition requires the application of new measurement techniques to achieve breakthrough productivity improvements.

6. Summary

This paper identifies and prioritizes technologies, processes, measurement science, and deployment activities that have the greatest potential to significantly advance the productivity and competitiveness of the U.S. construction industry over the next 20 years. Much is currently being done to address the underlying causes of the perceived decline in construction productivity. However, key stakeholders often have a myopic view of how to best address the underlying causes and remove barriers to change within the industry. The November 2008 NRC workshop provided an opportunity to bring together construction industry stakeholders to identify common problems, generate consensus on ways to address some of these problems, and set priorities for attacking challenges to the industry that will require a long-term effort to address. By providing a common forum for discussion and planning, the NRC workshop was a first step in enabling the U.S. construction industry to achieve higher levels of efficiency and competitive advantage in the global marketplace. This paper provides a vision for the future for developing the enabling measurement science for achieving breakthrough improvements in construction productivity, including the development of construction productivity metrics at the task, project, and industry levels.

References


Stars and Stragglers in Construction Industry

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Abstract

Why is productivity in construction so dispersed? Economic textbook theory suggests that in well-functioning markets in which firms compete for work, stragglers will exit, which leads to concentration of the productivity distribution. This paper addresses the cross-sectional productivity distribution over time of construction. The research reported here serves to elaborate on firm-level productivity performance in civil engineering firms. How much dispersion in productivity is observed? Is dispersion persistent so that we may identify stars and stragglers? In this paper, we use a nonparametric production function approach, viz. Data Envelopment Analysis (DEA), to calculate the cross-sectional distribution of firm-level productivity for an unbalanced panel data of Dutch civil engineering firms over 1999-2007 for each year. After checking the robustness of the productivity measure, we identify stars and stragglers. The results indicate considerable dispersion in productivity. We plot the empirical density function with mean technical efficiency of .54 with standard deviation of .25 over 1999 – 2007. The density functions for each and every year indicate variation over years also, both in moment and dispersion. Armed with these results we then turn to the transition of firms within the distribution over years. The transition matrix indicates persistence, yet indicates substantial dynamics as well. A substantial fraction of firms move over time within the productivity distribution.

Keywords: construction industry, civil engineering, efficiency analysis, infrastructure
1. Introduction

What has been puzzling to both academia and practitioners is why productivity in construction is so dispersed (Griffith et al. (2006)). Why is it that some firms or even business units have low productivity levels whereas others have relatively high productivity levels? Economic textbook theory suggests that in well-functioning markets in which firms compete for work, stragglers will exit, which leads to concentration of the productivity distribution. The market for construction is typically regarded as highly competitive, relating observed cross-sectional productivity dispersion to (1) measurement errors and unreliable measurement of construction productivity (Park et al. (2005); Harrison (2007)), (2) robustness of productivity measures (Van Biesebroeck (2007)), or (3) sector structure (Bartelsman and Dhrymes (1998)). The question arises as to whether cross-sectional productivity dispersion relates to measurement issues alone (Griffith et al. (2006)). The literature indicates that substantive reasons account for dispersion (Stokes (1981)). This paper addresses the cross-sectional productivity distribution over time of infrastructure firms.

The literature on productivity and productivity measurement is vast, referring for a review to Bartelsman and Doms (2000) and, more recently, Van Biesebroeck (2007). A part of this literature relates to productivity in construction industry. Most literature on productivity in construction industry considers the puzzle of declining aggregate productivity rates (Stokes (1981); Allen (1985); Harrison (2007)). These contributions are interesting; yet do not provide information on the cross-sectional productivity distribution. Dubois and Gadde (2001) consider productivity at the firm level, yet their analysis is primarily descriptive. Others, like Arditi and Mochtar (2000), use less formal approaches asking firms for perceptions on opportunities for productivity improvements. Also, Dai et al. (2007) ask for foreman’s perceptions on productivity dispersion. These studies, while interesting on their own, in actual fact do not provide answers as to what extent cross-sectional productivity dispersion exists. Empirical estimation of firm-level productivity measures in civil engineering construction is particularly thin. An exception is Albriktsen and Forsund (1990) who use a nonparametric approach to study the productivity dispersion in Norwegian building industry. They use 1986 firm-level data of main contractors in both infrastructure and property. Their results indicate considerable productivity dispersion across firms. Whether dispersion persists over time cannot be addressed on the basis of their analysis. A systematic analysis of the dynamics of productivity dispersion over time in infrastructure firms has not been considered before, to the best of our knowledge. Insight into the dynamics might contribute to our understanding of time series properties of aggregate productivity rates.

The research reported here serves to elaborate on firm-level productivity performance in civil engineering firms. Does the cross-sectional distribution of productivity of infrastructure firms show any dispersion? How does the cross-sectional distribution behave over time? Is dispersion persistent so that we may identify stars and stragglers? In this paper, we use a nonparametric production function approach to calculate the cross-sectional distribution of firm-level productivity for a panel data of Dutch infrastructure firms over 1999 – 2007 for each year. After checking the robustness of the productivity measure, we identify stars and stragglers.
The organization of this paper is as follows. Section 2 discusses the literature on productivity. Section 3 describes the survey and descriptive statistics of the sample. In section 4, we discuss the empirical model and estimation results. Conclusions and directions for future research follow in Section 5.

2. Productivity dispersion

Dispersion in productivity has been related in the literature to varying efficiency of firms. In producing output, firms transform inputs into outputs, however, not necessarily as efficient as do others. Efficient firms produce more output with given inputs, or alternatively, less inputs given outputs than inefficient firms. Firms control the inputs and outputs as to maximize output given inputs or to minimize inputs given outputs, all given production technology. The production technology defines the technical or engineering relationship between the inputs and output. The production technology is characterized by the set of feasible input-output combinations that satisfy specific regularity properties being closed, bounded, convex and being defined by a nonnegative input vector. The production frontier is the upper boundary of the production possibilities with all firms located on or beneath the production frontier. The central issue in efficiency analysis is to compare a firm’s input-output combination with the best practice represented by the production frontier.

Data Envelopment Analysis (DEA) is used to calculate the production frontier and evaluate the performance of firms. Basically, DEA involves the identification of an empirical production envelop, measuring a firm’s performance relative to the empirical frontier. DEA indicates which firms determine the frontier, with firms on the frontier being determined as efficient and those firms below the frontier as inefficient (see also Kopp (1981); Fried et al (2004)). The input-oriented variable returns to scale model starts from $B$ companies, $M$ input indicators and $N$ output indicators; for each company $b$, DEA determines the measure $TE$ as the outcome of the following algorithm:

- Denote the $M \times B$ matrix, consisting of the observed input vectors, by $X$; denote the $N \times B$ matrix, consisting of the observed output vectors, by $Y$. Denote company $b$’s input vector by $x_b$; denote company $b$’s output vector by $y_b$.

- Introduce variables $\theta_b$ and $z_b$, where $\theta_b$ represents the measure $TE$ for company $b$ and vector $z_b$ (of length $B$) is the estimator of the “ideal combination” of technically efficient companies that would make company $b$ technically efficient (in case $b$ is technically efficient itself, then $z_b$ is a zero vector except for entry $b$, which is 1).

- Minimize $\theta_b$ with respect to the following conditions:

$$\begin{align*}
X_{cb} & \leq \theta_b x_b, \\
Y z_b & \geq y_b, \\
z_b & \geq 0.
\end{align*}$$

(2.1)
Perform this minimization problem for each company $b = 1, \ldots, B$.

The input-oriented model parameter $\theta_b$ indicates to what extent company $b$’s input amounts can be reduced such that the output quantity stays the same (see Førsund and Sarafoglou (2002)). As a consequence, $\theta_b \leq 1$; $\theta_b = 1$ if company $b$ is technically efficient. The DEA scores can be computed using the assumption of constant returns to scale (CRS) – which means that the optimal production process behaves like $y = \alpha \cdot x$ irrespective of production amounts – or variable returns to scale (VRS). In the literature, variable returns to scale is assumed most commonly. In this case, by definition, DEA takes into account effects caused by changes in input or scale size effects. Since DEA returns an efficiency measure for each firm, firms can be ranked based on these scores, so stars and stragglers can be identified; in Section 4, we apply DEA for this purpose.

3. Data

The data come from the EIB Business Monitor based on 2000 – 2008 surveys among Dutch construction firms registered at the Cordares Pensions. The population includes main contractors in both real estate construction firms and in civil engineering (also called infrastructure firms). In this paper we concentrate on those infrastructure firms. We have an unbalanced panel of 693 firms, over 1999 – 2007 for 975 observations.

Table 1 gives population and sample information on the distribution of number of firms and number of employees by firm size. Firm size is categorized in three classes. Small firms have 0 – 10 employees, medium-sized firms have 11 – 50 employees, and large firms have more than 50 employees. The totals in the right column – both population and sample – are up to 2006, since the population figures of 2007 are not available yet. The figures in the table indicate that for our sample, small firms are underrepresented while large firms are overrepresented.

In the survey, firms were asked to return information on output and cost structure, and labour, other costs, and capital as inputs. Labour costs include direct- and indirect labour costs and entrepreneur costs, purchase include material- and subcontracting costs, capital include depreciation and lease costs, and other costs include general firm costs and interest charges. We consider a single-output using value added as output measure (all variables in monetary values). Table 2 gives summary statistics of cost shares.
Table 1: Population and sample number of firms by year and by size, 1999 – 2007

<table>
<thead>
<tr>
<th>Type</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>410</td>
<td>421</td>
<td>415</td>
<td>409</td>
<td>411</td>
<td>391</td>
<td>404</td>
<td>463</td>
<td>442</td>
<td>3.766</td>
</tr>
<tr>
<td></td>
<td>49</td>
<td>49</td>
<td>46</td>
<td>32</td>
<td>36</td>
<td>33</td>
<td>23</td>
<td>16</td>
<td>16</td>
<td>300</td>
</tr>
<tr>
<td>Medium</td>
<td>348</td>
<td>337</td>
<td>336</td>
<td>314</td>
<td>282</td>
<td>277</td>
<td>275</td>
<td>289</td>
<td>279</td>
<td>2.737</td>
</tr>
<tr>
<td></td>
<td>71</td>
<td>74</td>
<td>59</td>
<td>64</td>
<td>49</td>
<td>41</td>
<td>32</td>
<td>33</td>
<td>39</td>
<td>462</td>
</tr>
<tr>
<td>Large</td>
<td>143</td>
<td>128</td>
<td>124</td>
<td>120</td>
<td>116</td>
<td>110</td>
<td>97</td>
<td>94</td>
<td>81</td>
<td>1.013</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>24</td>
<td>31</td>
<td>27</td>
<td>19</td>
<td>20</td>
<td>97</td>
<td>41</td>
<td>81</td>
<td>213</td>
</tr>
<tr>
<td>Total</td>
<td>901</td>
<td>886</td>
<td>875</td>
<td>843</td>
<td>809</td>
<td>778</td>
<td>776</td>
<td>846</td>
<td>802</td>
<td>7.516</td>
</tr>
<tr>
<td></td>
<td>147</td>
<td>147</td>
<td>136</td>
<td>123</td>
<td>104</td>
<td>94</td>
<td>76</td>
<td>65</td>
<td>83</td>
<td>975</td>
</tr>
</tbody>
</table>

*bold numbers refer to the population, numbers in italics refer to the sample

Table 2: Cost shares of production inputs by size, 1999 – 2007

<table>
<thead>
<tr>
<th>Production inputs</th>
<th>Type (μ,σ)</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate inputs</td>
<td>39.2 (26.6)</td>
<td>53.3 (20.0)</td>
<td>60.4 (15.5)</td>
<td>50.5 (22.9)</td>
<td></td>
</tr>
<tr>
<td>Labour</td>
<td>41.5 (26.7)</td>
<td>31.0 (17.4)</td>
<td>25.4 (9.9)</td>
<td>33.0 (20.5)</td>
<td></td>
</tr>
<tr>
<td>Capital</td>
<td>5.6 (6.0)</td>
<td>4.9 (4.7)</td>
<td>4.7 (5.8)</td>
<td>5.1 (5.4)</td>
<td></td>
</tr>
<tr>
<td>Other inputs</td>
<td>13.7 (10.8)</td>
<td>10.8 (7.6)</td>
<td>9.5 (7.6)</td>
<td>11.4 (8.8)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

From table 3.2 one observes how a firms’ cost structure varies with the size. Small firms have below-average intermediate input use (including subcontracting) and above-average labour, capital and other inputs cost shares. Note that fixed cost items are typically in these latter two, suggesting that fixed costs are above the total average.

4. Empirics

4.1 Cross-sectional distribution of productivity

The DEA model calculates a nonparametric efficiency measure for each and every firm, providing information on the dispersion of productivity. The empirical density function (pdf) of efficiency, with associated cumulative distribution, is given in Figure 1.
Figure 1: Empirical probability distribution (left) and cumulative distribution of efficiency, 1999 – 2007

From Figure 1 one observes considerable dispersion in productive performance. Mean technical efficiency is .54 with standard deviation being .25. Figure 2 gives the probability density function by year.

Figure 2: Empirical probability distribution of efficiency by year, 1999 – 2007

Again the natural question arise as to why is productivity so dispersed? Does this relate to the robustness of DEA total factor productivity (TFP) productivity measure? We tested the robustness of DEA by comparing it with another method called “Index Numbers” (IN). This comparison led to the conclusion that both methods generally agree rather well and only differ, more or less, for individual cases. This conclusion was confirmed by comparing the DEA and IN rankings using the Kendall-Tau measure. So in this respect, DEA is a robust method for ranking firms.
4.2 Stars and stragglers

To consider the dynamics we first identify stars and stragglers in the sample. For this, we ranked firms on the basis of DEA results for each and every year. We then calculated the transition rates to determine the dynamics. The transition rates are given in Table 3.

Table 3: Transition matrix, 1999 – 2007

<table>
<thead>
<tr>
<th>Efficiency in (t) (in %)</th>
<th>Efficiency in (t + 1)</th>
<th>&lt; 50%</th>
<th>50 – 80%</th>
<th>&gt;80%</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 50%</td>
<td>49</td>
<td>28</td>
<td>23</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>50 – 80%</td>
<td>42</td>
<td>41</td>
<td>17</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>&gt;80%</td>
<td>26</td>
<td>35</td>
<td>39</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>N=258</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From Table 3 one observes that the diagonal elements are largest suggesting persistence in the ranking of firms (with multiple observations) in the cross-sectional distribution of productivity. Yet, the transition rates indicate substantial dynamics as well. The results indicate that firms at the highest efficiency levels at time t may find themselves at the lower end at time (t + 1). The implications are far-reaching. Low aggregate productivity growth rates over time are at least in part associated with downward transitions within the productivity distribution. It remains to be seen what determines these transitions within the cross-sectional distribution over time. Understanding why firms move up and down the productivity ladder is an important issue for future research.

5. Conclusions

Why is productivity in construction so dispersed? In this paper we determine the cross-sectional productivity distribution of infrastructure firms over time. For this, we use a nonparametric production function approach to calculate the cross-sectional distribution of firm-level productivity for a panel data of Dutch infrastructure firms. The data come from the EIB Business Monitor based on 1999 – 2007 surveys among Dutch construction firms. We have an unbalanced panel of 693 firms, over 1999 – 2007 for 975 observations.

Data Envelopment Analysis (DEA) is used to calculate the production frontier and evaluate the performance of firms. Basically, DEA involves the nonparametric identification of an empirical production envelop, measuring a firm’s performance relative to the empirical frontier. DEA indicates which firms determine the frontier, with firms on the frontier being determined as efficient and those
firms below the frontier as inefficient. This gives the cross-sectional distribution of firm-level productivity for infrastructure firms.

The DEA results indicate considerable dispersion in productivity across firms. The results indicate considerable dispersion in productivity. We plot the empirical density function with mean technical efficiency of .54 with standard deviation of .25 over 1999 – 2007. The density functions for each and every year indicate variation over years also, both in moment and dispersion. Comparing DEA productivity measures to Index numbers indicate that DEA is robust for ranking firms. Armed with these results we then turn to the transition of firms within the distribution over years. The transition matrix indicates persistence yet indicates substantial dynamics as well. It remains to be seen what determines these transitions within the cross-sectional distribution over time. This is left for future research.

References


Minimizing inputs for a given volume of output is consistent with cost minimizing principles, whereas maximizing output given inputs relates to revenue maximizing objectives.
Industry-Specific Performance Benchmarking: Pharmaceutical Construction Projects

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Abstract

The study was driven by a recognition that the pharmaceutical sector had recently experienced fundamental changes and that an approach to comprehensive project benchmarking had not been widely adopted to date. Competitive benchmarking requires industry-specific metrics in absolute terms. This study developed a framework for evaluating pharmaceutical capital facility projects using metrics tailored to the specific characteristics of these unique projects. This framework made a flexible data collection and reporting system possible. Preliminary findings from an initial sample of 40 pharmaceutical projects confirm that meaningful industry-specific metrics can be produced. These metrics allow the industry to measure project performance more accurately, get meaningful project performance comparisons, and ultimately establish credible norms.

Keywords: performance measurement, performance benchmarking, pharmaceutical projects, project management, construction industry
1. Introduction

The increasingly competitive global economy requires organizations to adopt business strategies that increase the value of their facility delivery programs. As a proven technique for improving project performance, benchmarking is a critical component of a mature project delivery system. Benchmarking gives organizations a methodology for gathering information and understanding project performance and best practices, both externally and internally. Whether the driver is cost, schedule, quality, or a combination thereof, benchmarking is an essential part of any continuous improvement process and a boon to capital facilities programs.

In 2007, the revenues of the U.S. pharmaceutical and medicine manufacturing sector amounted to $170 billion, having increased by 69% since 1998 (BEA 2009). Despite this increase, which was accompanied by a significant expansion of capital facilities, Jörg (1999) argued that a lack of benchmarking knowhow has persisted in the pharmaceutical industry, even considering the presence of a number of benchmarking approaches and models. The author suspected that this knowledge gap was not the result of insufficient information or any lack of understanding of the various benchmarking sequence models; rather he attributed it to incompetence in project organization, survey design, and above all, the processing and analysis of benchmarking data. Because of their intensive qualification and validation procedures, pharmaceutical projects often demand a distinct project management, and thus benchmarking approach. For example, Cole (1998) reported that the pharmaceutical industry is unique in its procedures and methods of manufacture since the integrity of its products must be ensured by three main functions: current Good Manufacturing Practice (cGMP), Quality Assurance (QA), and Quality Control (QC). While these functions are necessary to some degree for all projects, they are more pronounced for the pharmaceutical industry. Another distinction is that the cost of the process equipment common to the industry is a significant proportion of a project’s total installed cost (TIC), thus distorting factors such as TIC / process equipment, frequently referred to in the process industry as Lang Factors (Dysert 2001).

Taking all of these considerations into account, this paper presents a industry-specific benchmarking framework for pharmaceutical construction projects, developed and validated using actual project data. The objectives of this study are: (1) to develop metrics tailored to pharmaceutical capital facility projects; and (2) to develop data collection and reporting systems that meet the needs of the pharmaceutical industry for benchmarking.

2. Background

2.1 Characteristics of the pharmaceutical industry

The pharmaceutical industry has experienced fundamental changes caused by increased competition, industry globalization, and numerous mergers (McCormick 2003). McCormick asserted that the industry faced multiple internal and external challenges such as high research and development costs,
government regulations, and stringent manufacturing requirements. These changes and challenges appeared to have caused sharp competition within the industry, raising the case for a relevant, timely, accurate, and cost-effective pharmaceutical benchmarking system.

The pharmaceutical industry employs unique procedures and manufacturing methods to ensure the integrity of the products it produces (Cole 1998). Since pharmaceutical products are critical to health care they must be manufactured to the highest quality standards. Cole (1998) explained that such stringent quality requirements result in the pharmaceutical manufacturing being a highly regulated business. In addition, regulatory requirements for pharmaceutical facilities and their construction are continuously tightened and apply not only to validation and qualification phases, but throughout the life of the facilities, from conceptualization through decommissioning (Cole 1998; Kolkebeck 2005). Due to the regulatory scrutiny they receive, pharmaceutical companies typically require considerable resources in terms of time, money, and specialized personnel to construct and validate a pharmaceutical facility. According to Wrigley (2004), validation activities consume a significant percentage of time and money in most pharmaceutical capital projects, with validation cost having increased over the years in proportion to ever rising standards. For typical pharmaceutical plant expansion projects, total validation costs may run from 4 to 8% of the total project cost (Wrigley 2004). As validation costs increase, the cost and time required to deliver pharmaceutical facilities has escalated.

While industry definitions of validation and qualification for pharmaceutical facilities vary in the wording, they essentially agree that the two procedures when operated under the same prescribed conditions “will consistently produce a product that meets the preset specifications and quality attributes.” (Aleem et al. 2003). Aleem et al. (2003) documented the validation process as a series of successive and systematic steps: installation qualification (IQ), operational qualification (OQ), and performance qualification (PQ). The details of each step can be found in the research conducted by Hwang et al. (2008).

Although the definitions for IQ, OQ, and PQ are clear and distinct, it should be noted that in practice there are no rigid divisions between the different qualification stages. They tend to overlap and sometimes there is significant duplication of tasks at different stages (Aleem et al. 2003).

### 2.2 General benchmarking in the pharmaceutical industry

An organization must have an effective and efficient benchmarking system to fully appreciate benefits from its efforts. According to Maleyeff (2003), performance benchmarking in the pharmaceutical industry has become a component of numerous certification and accreditation systems and many organizations include benchmarking as a component of their performance management system. However, compared to other industries the pharmaceutical industry has been relatively slow to implement comprehensive project benchmarking or other performance measurement systems (Kennedy 1998). This late adoption might be due to concerns over the sharing of information through the benchmarking process. Since competition is keen and speed to market paramount in the industry (Leichter and Turstam 2004), companies are reluctant to share data related
to products or even to the facilities that produce them. Another reason for the unwillingness of pharmaceutical firms to embrace benchmarking might be the lack of universal standards. Such standards are difficult to establish because of the differences among industries and the complexity of the statistical methods involved (Maleyeff 2003). Also, the collaboration needed to develop consensus definitions required for benchmarking is difficult to obtain due to restraint of trade concerns. Nevertheless, Jörg (1999) argued that benchmarking is needed in the pharmaceutical industry since it has enormous potential for raising organizational efficacy and efficiency. Jörg (1999), Maleyeff (2003), and Wilkins (2003) listed the following requirements for successful benchmarking in the pharmaceutical industry: (1) include experts from inside the company; (2) identify the benchmarking partners; utilize external consultants; (3) join a benchmarking group; (4) validate benchmarking data before data analysis; (5) develop a report or graph justification; (6) interpret benchmarking results achieved by analytical means; and (7) avoid comparing “apples to oranges”. The requirements guided this study to develop industry-specific metrics and a benchmarking system using the metrics, measuring and comparing performances of pharmaceutical construction projects.

### 3. Research method

In order to achieve the objectives of this research described in the Introduction section, a research team was formed, including industry representatives from five of the leading pharmaceutical companies (Abbott Laboratories, Amgen, Eli Lilly, GalxoxSmithKline and Merck), and staff from the Construction Industry Institute (CII) Benchmarking and Metrics (BM&M) program.

The team discussed and identified the industry priorities and needs through monthly workshops and then developed a customized pharmaceutical project questionnaire. In addition, pharmaceutical metrics that took into account specific characteristics of the industry were developed to set up their norms. The developed metrics are introduced in the subsequent section. Data collection effort was then initiated by integrating the paper-based questionnaire into the CII BM&M website to allow industry participants to submit recently completed project data via the online system. Then, validation of the collected data was performed to minimize or eliminate inconsistencies or errors in the data, and once completed, data analysis was performed. The preliminary analysis results are also presented later.

The development of a pharmaceutical reporting system commenced while the data were analyzed. Using the reporting system, the Pharmaceutical Project Key Report for each project’s performance and Aggregate Key Report for each company’s aggregate performance sorted by major project types could be generated and returned to all companies that submitted projects. More details on the reports are provided in Chapter 7.
4. Framework and definition of pharmaceutical metrics

4.1 Metric framework

When organizing for this effort, it became apparent that some metrics would apply to most pharmaceutical project types while others would be relevant to only a few types. For instance, pharmaceutical laboratory construction projects require performance metrics that would not be meaningful to either bulk or secondary manufacturing type facility construction. To address these issues and to ensure that projects to be benchmarked are properly grouped, a hierarchical structure as the framework for metric development was established as shown in Table 1.

Various types of pharmaceutical projects were categorized into three major categories. The major categories are bulk manufacturing, secondary manufacturing, and laboratories. Subcategories were also developed for each of the categories as shown in the table. Pharmaceutical bulk manufacturing projects are divided into biological, pilot plant, and chemical (small molecule), with biological projects being further subdivided into vaccines, fermentation, and cell culture projects. Pharmaceutical secondary manufacturing projects are grouped into three types: pilot plant secondary, fill finish, and pharmaceutical warehouse. Only fill finish has additional breakouts divided into parenteral and non-parenteral and both of these categories have three additional subcategories. According to the structure, there are four types of pharmaceutical laboratories: research, quality control (QC)/quality assurance (QA), vivarium, and process development. Research laboratories are divided into biological or chemical laboratories, and process development laboratories are categorized as stability or clinical.

The essence of the hierarchical structure is to produce the most accurate comparison results. For example, the project performance of a syringe project, one of the project types under secondary manufacturing, fill finish, and parenteral in Table 1, should be compared to that of other syringe projects in order to get the most meaningful comparison results. However, there may not be enough syringe projects to provide benchmarks. In this case, to obtain reasonable comparisons, the project is then compared with all projects in the parenteral category, rolling up to one higher level in the structure. If there are not enough projects at that level, the next potential comparison dataset for the syringe will be fill finish, followed by the highest level, that is secondary manufacturing. As in this example, all other subtypes can be compared to the similar projects within the boundary of the hierarchy. This is a strength of the structure developed for the benchmarking system.

Details of the project types and the underlying reasons for the classifications are explained in the research documented by Hwang (2006).
Table 1: Hierarchical Structure of Pharmaceutical Project Types

<table>
<thead>
<tr>
<th>Pharmaceutical Bulk Manufacturing</th>
<th>Biological</th>
<th>Vaccines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fermentation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cell Culture</td>
<td></td>
</tr>
<tr>
<td>Pilot Plant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical (Small molecule)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilot Plant Secondary</td>
<td>Parenteral</td>
<td>Syringe</td>
</tr>
<tr>
<td></td>
<td>Delivery Device</td>
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</tr>
<tr>
<td></td>
<td>Vial</td>
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<tr>
<td></td>
<td>Inhalants</td>
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<tr>
<td></td>
<td>Solid Dosage</td>
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<tr>
<td></td>
<td>Cream Ointment</td>
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<tr>
<td>Fill Finish</td>
<td>Non-Parenteral</td>
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<td></td>
<td></td>
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<tr>
<td>Pharma Warehouse</td>
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<tr>
<td>Pharmaceutical Secondary Manufacturing</td>
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</tr>
<tr>
<td>Research</td>
<td>Biological</td>
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<tr>
<td></td>
<td>Chemical</td>
<td></td>
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<tr>
<td>Quality Control/Quality Assurance</td>
<td></td>
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</tr>
<tr>
<td>Vivarium</td>
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<tr>
<td>Process Development</td>
<td>Stability</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clinical</td>
<td></td>
</tr>
</tbody>
</table>

4.2 Metric definitions

Having developed the framework for benchmarking pharmaceutical projects, performance metrics tuned to characteristics of pharmaceutical construction projects were formulated as listed in Tables 2 and 3. The developed metrics are organized as cost, schedule, and dimension (area) metrics. Table 2 presents metrics referred to as absolute metrics. These metrics are calculated as ratios, for example of actual dollar costs to other measures such as other costs, dimensions, and some cases counts. Absolute schedule metrics are calculated in a similar manner as ratios of various activity durations to dimensions or counts. The absolute dimension metrics provide ratios of dimensions; usually square feet to other dimensions or counts. Absolute metrics make it possible to measure pharmaceutical project performances in terms of hard dollars, time, and gross square footage (GSF). For the absolute cost metrics, adjustments for location and time were required to develop a pharmaceutical project database maintained in current dollars at a common location and details of the procedure can be found in the research conducted by Hwang et al. (2008). As shown and footnoted in Table 2, the metrics can apply to all three pharmaceutical project types, or may be limited to just bulk or secondary manufacturing, or laboratory only.
Table 2: Absolute Pharmaceutical Metrics

| Description                                      | \( \frac{\text{TIC}}{\text{Process Equipment Cost}} \) | \( \frac{\text{Hard Cost}}{\text{Process Equipment Cost}} \) | \( \frac{\text{Process Const. Cost}}{\text{Process Equipment Cost}} \) | \( \frac{\text{Facility Const. Cost}}{\text{GSF}} \) | \( \frac{\text{TIC}}{\text{GSF}} \) | \( \frac{\text{Soft Cost}}{\text{TIC}} \) | \( \frac{\text{Soft Cost}}{\text{Hard Cost}} \) | \( \frac{\text{Process Automation Cost}}{\text{IO Point Count}} \) | \( \frac{(\text{Design} + \text{Construction Mgmt.})}{\text{TIC}} \) | \( \frac{\text{Facility Construction Cost}}{\text{GCF}} \) | \( \frac{\text{TIC}}{\text{GCF}} \) | \( \frac{(\text{Qualification} + \text{Validation Cost})}{\text{TIC}} \) | \( \frac{(\text{Qualification} + \text{Validation Cost})}{\text{Process Equipment Cost}} \) | \( \frac{(\text{Qualification} + \text{Validation})}{(\text{# IQ + OQ Protocols})} \) | \( \frac{(\text{Qualification} + \text{Validation})}{\text{Validated Equipment Piece Count}} \) | \( \frac{\text{TIC}}{\text{Total Equipment Piece Count}} \) | \( \frac{\text{Hard Cost}}{\text{GSF}} \) | \( \frac{\text{Process Equipment Cost}}{\text{Validated Equipment Piece Count}} \) | \( \frac{\text{Process Installation Cost}}{\text{Validated Equipment Piece Count}} \) | \( \frac{\text{Soft Cost}}{\text{Total Equipment Piece Count}} \) | \( \frac{(\text{Design} + \text{Construction Management Cost})}{\text{Total Equipment Piece Count}} \) | \( \frac{\text{TIC}}{\text{LF Benchtop}} \) | \( \frac{\text{TIC}}{\text{Lab Population}} \) | \( \frac{\text{TIC}}{\text{Total Building Population}} \) | \( \frac{\text{Hard Cost}}{\text{LSH Benchtop}} \) | \( \frac{\text{Hard Cost}}{\text{LF Hoods}} \) | \( \frac{\text{Hard Cost}}{(\text{LF Benchtop} + \text{LF Hoods})} \) | \( \frac{\text{Hard Cost}}{\text{Lab Population}} \) | \( \frac{\text{Hard Cost}}{\text{Total Building Population}} \) | \( \frac{\text{HSF}}{\# \text{Total Building Population}} \) | \( \frac{(\text{IQ thru OQ Duration})}{(\text{# IQ + OQ Protocols})} \) | \( \frac{(\text{IQ thru OQ Duration})}{\text{Validated Equipment Piece Count}} \) | \( \frac{(\text{Design thru OQ Duration})}{\text{GSF}} \) | \( \frac{(\text{Design thru OQ Duration})}{\text{GCF}} \) | \( \frac{(\text{Design thru OQ Duration})}{\text{Total Equipment Piece Count}} \) | \( \frac{(\text{Process Space SF} + \text{Process Related Space SF})}{\text{GSF}} \) | \( \frac{(\text{Process Space SF} + \text{Process Support SF})}{\text{GSF}} \) | Mechanical SF / GSF | Shell Space SF / GSF | \( \frac{(\text{Lab SF} + \text{Lab Support SF})}{\text{Lab Population}} \) | \( \frac{(\text{LF Benchtop} + \text{LF Hoods})}{\text{Lab Population}} \) | GSF / # Total Building Population

1. Metrics for Pharmaceutical Bulk or Secondary Manufacturing Projects Only
2. Metrics for Pharmaceutical Laboratory Projects Only

Table 3 provides another class of metrics sometimes called relative metrics. These metrics are often presented as percentages or ratios of planned versus actual, or in some cases, ratios of phase data to overall project data. These metrics are usually considered “softer” metrics in that they require additional data to assess bottom-line impacts. An absolute metric such as $Hard Cost per Gross Square Feet is usually considered to convey more information of value than the relative metric Project Cost Growth. The metric Project Cost Growth compares actual cost to budgeted cost and is more difficult to interpret because performance depends on actual cost and the quality of the original
estimate. Some of these metrics are specific to the pharmaceutical industry while others may be appropriate for various types of industrial facilities. The application of these definitions and the roll up of specific project types in accordance with the hierarchical structure are the essence of the definitions. Definitions and formulas of the relative metrics are included in Hwang et al. (2008).

Table 3: Relative Pharmaceutical Metrics

<table>
<thead>
<tr>
<th>Cost Metrics</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Cost Growth</td>
<td></td>
</tr>
<tr>
<td>Delta Cost Growth</td>
<td></td>
</tr>
<tr>
<td>Installation Qualification Cost Growth</td>
<td></td>
</tr>
<tr>
<td>Operation Qualification Cost Growth</td>
<td></td>
</tr>
<tr>
<td>Pre-Project Planning Phase Cost Factor</td>
<td></td>
</tr>
<tr>
<td>Design Phase Cost Factor</td>
<td></td>
</tr>
<tr>
<td>Procurement Phase Cost Factor</td>
<td></td>
</tr>
<tr>
<td>Construction Phase Cost Factor</td>
<td></td>
</tr>
<tr>
<td>Startup Phase Cost Factor</td>
<td></td>
</tr>
<tr>
<td>Installation Qualification Phase Cost Factor</td>
<td></td>
</tr>
<tr>
<td>Operation Qualification Phase Cost Factor</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Schedule Metrics</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Schedule Growth</td>
<td></td>
</tr>
<tr>
<td>Delta Project Schedule Growth</td>
<td></td>
</tr>
<tr>
<td>Pre-Project Planning Phase Duration Factor</td>
<td></td>
</tr>
<tr>
<td>Design Phase Duration Factor</td>
<td></td>
</tr>
<tr>
<td>Procurement Phase Duration Factor</td>
<td></td>
</tr>
<tr>
<td>Construction Phase Duration Factor</td>
<td></td>
</tr>
<tr>
<td>Startup Phase Duration Factor</td>
<td></td>
</tr>
<tr>
<td>Installation Qualification Phase Duration Factor</td>
<td></td>
</tr>
<tr>
<td>Operational Qualification Phase Duration Factor</td>
<td></td>
</tr>
</tbody>
</table>

5. Development of the benchmarking system

The development of pharmaceutical specific metrics was a major milestone for this study. However, use of the metrics required their integration into a system that tracked additional data to permit a comprehensive analysis of project performance. For example, to properly evaluate the metrics, knowledge of the nature of the project, that is whether it was a grassroots, modernization, or addition could prove to be most important to the final analysis. As a result, the developed metrics were integrated into CII’s project benchmarking system that was developed and tested over a ten year period for use as a benchmarking tool. The system enables the collection of important cost, schedule and other performance data and most importantly captures critical information on the use of best practices to improve project delivery. By integrating the pharmaceutical metrics and framework into the CII benchmarking system, it could be possible to obtain a comprehensive assessment of pharmaceutical construction project performances, permitting the analysis of the pharmaceutical metrics as part of the complete project delivery system.

A benchmarking system requires a survey instrument, a means of collecting data, a database for comparisons, and an analysis and reporting subsystem. Upon integration of the pharmaceutical metrics into the CII system, the pharmaceutical benchmarking system was programmed to take advantage of CII’s web-based data collection and reporting system. The integrated online system takes advantage of web technology to provide interactive assistance and error checking to better ensure the quality of data entered. Following data entry and validation with industry participants, preprogrammed algorithms calculate the metrics and search for like project data sets for comparison.
Then, individual project and company aggregate reports are returned via the online system to the participants for near real time feedback.

Data on 40 pharmaceutical projects was obtained during the first round of data collection using the online system. Table 4 summarizes the characteristics of the 40 projects by project type, nature, size, and location.

Table 4: Pharmaceutical Projects Database Description

<table>
<thead>
<tr>
<th>Project Characteristics</th>
<th>Number of Projects (Total = 40)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td></td>
</tr>
<tr>
<td>Bulk Manufacturing</td>
<td>12</td>
</tr>
<tr>
<td>Secondary Manufacturing</td>
<td>10</td>
</tr>
<tr>
<td>Laboratory</td>
<td>18</td>
</tr>
<tr>
<td><strong>Nature</strong></td>
<td></td>
</tr>
<tr>
<td>Addition</td>
<td>12</td>
</tr>
<tr>
<td>Grass Roots</td>
<td>16</td>
</tr>
<tr>
<td>Modernization</td>
<td>12</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td></td>
</tr>
<tr>
<td>&lt;$15MM</td>
<td>4</td>
</tr>
<tr>
<td>$15MM ~ $50MM</td>
<td>20</td>
</tr>
<tr>
<td>$50MM ~ $100MM</td>
<td>5</td>
</tr>
<tr>
<td>&gt;$100MM</td>
<td>11</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td></td>
</tr>
<tr>
<td>Domestic</td>
<td>30</td>
</tr>
<tr>
<td>International</td>
<td>10</td>
</tr>
</tbody>
</table>

6. Pharmaceutical metric norms

Data analysis resulted in the establishment of pharmaceutical metric norms for cost, schedule, and area (GSF) by the three project types (bulk manufacturing, secondary manufacturing, and laboratory). As sufficient data become available, additional analysis will be provided in accordance with the hierarchical structure presented in Table 1. This chapter presents only a few examples of the metric norms developed to date and these are shown in Figures 1 through 3.

Figure 1, provided for illustration, shows facility construction cost per gross square footage (GSF) in current U.S. dollars at a common location - Chicago. In the figure, quartiles are used to categorize project performance data. The quartiles are shown graphically in Figure 1 as green (first), blue (second), yellow (third), and red (fourth). This numbering and color coding system graphically depicts metric performance where green or first indicates the 25 percent of the projects with best performance and red or fourth indicates the 25 percent with the worst performance. As with most performance metrics, low numbers indicate better performance. Mean values are indicated by the symbol ■, and the ♦ symbol identifies the median, the cutoff between the second and third quartiles.

Figure 2 illustrates another cost metric norm with similar quartile rules as Figure 1. The chart provides the ratio of soft cost to total installed cost (TIC). Soft cost is the sum of the costs for
qualification and validation, and design and construction management. The resulting information can be used by an organization to compare their current soft cost expenditures to that of their peers.

Figure 3 depicts mechanical area norms. In this case, lower scores are not always better when considering non-monetary issues. This chart provides insight into what portion of total space is used as mechanical space, and this knowledge can be used perhaps to assess mechanical space requirements versus more discretionary administrative space requirements.

While only general preliminary conclusions are appropriate due to the small sample size, the results show that mean, median, and data ranges vary as expected for the three project types (bulk manufacturing, secondary manufacturing, and laboratory). This may imply that performance norms are different by project types and that the metrics framework is appropriate for benchmarking comparisons. Project stakeholders should recognize and expect differences in performance and should establish realistic performance targets. As sufficient data become available, more detailed breakouts can be provided in accordance with the hierarchical structure presented in Table 1.

Figure 1: Facility Construction Cost per Gross Square Footage (GSF)
7. Performance reports

In general, two levels of reports are planned for the pharmaceutical metrics: Project Key reports and a pharmaceutical Data Report. Key reports are confidential project and company aggregate reports with comparisons to the pharmaceutical project database. The Data Report is not project specific and provides statistical summaries of metrics from the pharmaceutical database. Key reports have been developed and are addressed further in the following section. The data report is planned as a future activity and thus is briefly introduced at this moment.
7.1 Key reports

Pharmaceutical Key Reports have been developed to provide participating companies confidential, high level summaries of performance and best practice use with comparisons to Pharmaceutical database. Projects are compared with the most similar projects available to achieve the most meaningful results. For most pharmaceutical projects, this currently results in projects being benchmarked at the project type level (bulk manufacturing, secondary manufacturing, or laboratories). As pharmaceutical metric norms are developed, more detailed breakdowns will be provided as sufficient data accumulates. Key reports are returned to all companies that input data into the developed benchmarking system and are available on-line for those with access to the system. Figures 4 through 6 provide extracts from sample key reports. The standardized general information format for a selected pharmaceutical project is shown in Figure 4, including the conversion factors necessary for exchange rates, location, and time. Cost metrics are adjusted for location using the Hanscomb Means Index for international projects and the RS Means Indices for domestic projects. The indices adjust cost data to Chicago for common reference. Time adjustments are made using the RS Means Historical Index to convert all cost data to dollars in 2004 as an example.

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Project Name</th>
<th>Project Driver</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teesco</td>
<td>Testco Pharma Project 0720</td>
<td>PPP - Startup Duration</td>
<td>161 Weeks</td>
</tr>
<tr>
<td>CII Project I.D.</td>
<td>CS032</td>
<td>Design - Startup Duration</td>
<td>124 Weeks</td>
</tr>
<tr>
<td>Industry Group</td>
<td>Light Industrial</td>
<td>PPP - OQ Duration</td>
<td>167 Weeks</td>
</tr>
<tr>
<td>Project Type</td>
<td>Pharma Bulk Mfg.</td>
<td>Design - OQ Duration</td>
<td>131 Weeks</td>
</tr>
<tr>
<td>Project Subtype</td>
<td>Fermentation</td>
<td>IQ - OQ Duration</td>
<td>15 Weeks</td>
</tr>
<tr>
<td>Cost Category</td>
<td>$50MM - $100MM</td>
<td>Construction Duration</td>
<td>98 Weeks</td>
</tr>
<tr>
<td>Project Nature</td>
<td>Grass Roots</td>
<td>Mid Point of Construction</td>
<td>23-Dec-2002</td>
</tr>
<tr>
<td>Location</td>
<td>Intl</td>
<td>Actual Cost (LC)</td>
<td>GBP 47,000,000</td>
</tr>
<tr>
<td>City</td>
<td>London</td>
<td>TIC Actual Cost (USD)</td>
<td>$ 75,684,380</td>
</tr>
<tr>
<td>Country</td>
<td>England</td>
<td>Chicago 2004 Cost (USD)</td>
<td>$ 69,075,504</td>
</tr>
<tr>
<td>Hanscomb Means 2002 Index</td>
<td>London</td>
<td>Currency Exchange Rate</td>
<td>1 USD = 0.621 GBP</td>
</tr>
<tr>
<td></td>
<td>Chicago</td>
<td>GSF</td>
<td>$2,000</td>
</tr>
<tr>
<td>RS Means 2002 Index</td>
<td>London</td>
<td>GCF</td>
<td>1,700,000</td>
</tr>
<tr>
<td></td>
<td>Chicago</td>
<td>PDRI</td>
<td>117</td>
</tr>
<tr>
<td>RS Means Historical Cost Index</td>
<td>Chicago 2002</td>
<td>PPDI</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Chicago 2004</td>
<td>% Modularization</td>
<td>10 %</td>
</tr>
</tbody>
</table>

Figure 4: Key Report – General Information

Figure 5 shows the pharmaceutical cost metrics section from a sample report. Metric scores, database means, performance quartiles, percentile bars, and sample size are provided for the metrics. The quartile statistics that are shown offer a ready comparison to the database where in general, quartile 1 (green) represents the highest performing projects and quartile 4 (red) the lowest. The percentile bars depict location within the distribution and have varying interpretations depending on the specific metric.
As shown in Figure 6, actual values for quartile cutoffs can be accessed in both tabular and graphical formats in the online version of the report by clicking the n number or yellow percentile bar. The resulting graphic includes the selected project’s score for the selected metric, data slice comparisons, mean, median, and quartile cutoffs. Also show by the arrow is the project’s exact position within the distribution.

An aggregate key report is provided annually for each company showing the number of projects submitted and mean metric values for these projects. The means are also compared to the database for a high level assessment of company level performance.
7.2 Data report

The data report is an online interactive report that permits the user to mine metric norms from within the database. Figures 1, 2 and 3 are example norms produced by the data report. The data report allows the user to slice the data by sector and metric of interest. Quartiles of performance, means and median are depicted. Current data report output is manually generated, however, programming to fully automate the report is scheduled to begin this fall.

8. Conclusions and path forward

The unique characteristics of the pharmaceutical industry, regulatory requirements to intensive validation and qualification, largely explain the increased resources required for pharmaceutical capital facility construction. As a result, most of the previous studies argued that the industry is unique in its processes and needs to do benchmarking reflecting this uniqueness. Yet, the industry has been relatively slow to implement benchmarking due to organizational culture reluctance to share information and the previous studies have rarely researched the development and evaluation of pharmaceutical industry-specific metrics or benchmarking systems tuned to these processes.

The purpose of this paper was to develop a system for evaluating pharmaceutical capital facility projects with metrics specific to the characteristics of these unique projects. Development of the data collection instrument included the uniqueness of the industry and relevant industry metrics. Furthermore, analyzing the data collected via the instrument, the preliminary data analysis ensured that the industry-specific metrics can be produced and should be meaningful for pharmaceutical
capital facilities benchmarking. Based on the analysis results, the customized pharmaceutical project key report developed as a feedback tool for projects, included data for performance, and provided an approach for comparison to data within the pharmaceutical database.

It is believed that the developed benchmarking system operated by the set of industry-specific metrics, the survey instrument, the means of collecting data, the database for comparisons, and the analysis and reporting subsystem will provide the industry with a reliable method of measuring and evaluating their project performance, and a basis for continuous performance improvement through benchmarking.

The path forward calls for validation of the development to get wider acceptance of the industry and this may result in modifications of the developed metrics and questionnaire. Modifying to the questionnaire will also result in changes to the current key report. After modifications to the metrics and questionnaire are completed, a second round of data collection is required to commence to further enrich the dataset. Perhaps the most significant effort remaining is that of detailing the data mining tool, the report, to allow the user to custom design reports of interest. The overall objective, however, is to implement this industry-specific benchmarking system to grow the database as a tool to assist with the improvement of capital facility projects for the pharmaceutical industry.

Acknowledgement

This paper is based on a research project sponsored by Abbott, Amgen, Eli Lilly and Company, GlaxoSmithKline, and Merck which was conducted by the Construction Industry Institute. Special appreciation is extended to the participants from the companies. Without their dedication to establishing common definitions and their efforts to collect data using these definitions, development of the Pharmaceutical Capital Facilities Benchmarking framework would not have been possible.

References


Abstract

Several efforts have been made by practitioners and academics in order to establish innovative mechanisms to facilitate the insertion of performance measurement and comparison in the construction companies decision process. One of these efforts refers to the international initiatives for the development of performance measurement benchmarking systems and benchmarking clubs. These clubs can be considered as collaborative groups, providing an environment in which companies can acquire and share knowledge from the external environment with the aim of implementing performance improvements. However, little is known about the conditions under which effective networking takes place and the real benefits achieved by organisations regarding the implementation of improvements and learning. This paper sets guidelines for the development of a collaborative benchmarking process aiming the implementation of improvements in construction companies. These guidelines were developed through the investigation of a learning collaborative process that took place in a Benchmarking Club. Twenty construction companies from the State of Rio Grande do Sul-Brazil were involved in this process. The main outcomes of this were a performance measurement system for benchmarking and the exchange of experience and practice related to the measures and managerial processes of the companies. This study was carried out using an action research strategy, which was divided into four phases: preparation, empirical study, complementary study and final data analysis. As main conclusions, this work identified that the collaborative environment created the opportunity for the construction managers to reflect upon the shared knowledge. Also, this encouraged managers to implement improvements in their companies. The level of improvement was dependent on a set of individual and organisational abilities to absorb the shared knowledge aiming to understand, diffuse, transform and use this knowledge inside of the companies. The main contributions of this study are the understanding of the learning process in the construction companies due to the collaborative process; and the establishment of a set of guidelines for the development of this collaborative process.

Keywords: benchmarking, performance measurement, organisational learning, knowledge management.
1. Introduction

As competition increases, organisations need more effective mechanisms for decision-making. In this context, performance measurement has an important role because it provides the necessary information for process control, enables the establishment of challenging and feasible goals, and improves communication between different managerial levels (Neely et al., 1996).

Despite its importance, the use of performance measurement has not been widely adopted in construction companies. As a result, information on the performance of the construction industry as a whole tends to be scarce. To a great extent this is related to the attitude and lack of training of managers in construction (Formoso and Lantelme, 2000). Conversely, some construction companies have too many measures which often are not linked to the key processes that the company must control (Costa and Formoso, 2004). According to Formoso and Lantelme (2000), the effective implementation of performance measurement systems is not simply a matter of selecting the right measures; it also implies a much deeper change on how decisions are made.

Therefore, there is a need to develop different approaches, which enable construction companies to effectively implement performance measurement into their routines. In this study, the main assumption is that the development of a collaborative benchmarking process would support the implementation of performance measurement systems and practices. It would allow the development of individual and organisational capabilities to use the new knowledge.

In the construction industry there have been several initiatives in different countries, such as USA, UK and Chile aiming the development of collaborative benchmarking processes through Benchmarking Clubs (Constructing Excellence, 2004; Construction Industry Institute, 2002; Grillo and Garcia, 2003). Those clubs can be defined as forums for individuals to learn from best practices, whilst creating a local support network for continuous improvement (Constructing Excellence, 2004). In general, those initiatives involve a set of similar companies comparing results and sharing good practices. The main purpose of this kind of group is to work collaboratively rather than in a traditional competitive benchmarking fashion. A collaborative benchmarking refers to a group of firms sharing knowledge about a particular activity, all hoping to improve based on what they learn (Boxwell, 1994).

Following this principle, an initiative called SISIND-NET Project has been developed in Brazil since April 2004. This group was develop through a partnership between the Building Innovation Research Unit (NORIE) of the Federal University of Rio Grande do Sul (UFRGS) and the Association of Construction Companies from the State of Rio Grande do Sul (SINDUSCON/RS), with the support of the National Council for Scientific and Technological Development (CNPq).

Initially, a group of twenty construction companies was established aiming to design and implement a performance measurement system (PMS) for benchmarking purposes. This group was called the Benchmarking Club. After the definition of the measures, it was observed that the aim of the Club
was not limited to the development of the measures, but it could be used as a space for sharing experiences among participants.

This paper discusses such process and presents a set of guidelines to develop a collaborative benchmarking process aiming to implement performance improvements in construction companies. These guidelines were conceived based on the analysis of the collaborative learning process that occurred during the development of the Benchmarking Club and through a deeper investigation of four participant construction companies.

2. Collaborative learning networks

Recently, collaborative learning networks have been developed as a way in which organisations have to collaborate and share knowledge, skills and expertise, in order to meet the needs of clients (Egbru and Robinson, 2005). The communities of practice (Wenger, 1990), the learning networks (Bessant and Tsekouras, 2001), the best practice groups and benchmarking Clubs are examples of collaborative approaches to learning.

In this paper, the collaborative learning network developed, the Benchmarking Club, has similar characteristics to the learning networks. Bessant and Tsekouras (2001) define a learning network as a network formally set up for the primary purpose of increasing knowledge. For these authors, this is formed by a number of organisations with common need to learn something. Together, these organisations carry out a collaborative process which aims to increase knowledge capacity or the ability to do something more or different. Some enablers of this process are the operating mechanisms, key roles, structure, whilst there are barriers, such as lack of motivation to learn, communication difficulties, blocking behaviour by key individuals or groups influence the effective operation of the collaborative process.

A similar view about learning network is shared by Tell and Halila (2001) and Florén (2003). According to these authors, a learning network can be view as a development method, which allows the learning of tacit knowledge among managers and employees. These authors highlight that the main learning outcomes in this kind of network are source for inspiration, support during the reflection and implementation process and also the identification of a new perspective. Tell and Halila (2001) explain that the network approach has made it possible not only to learn how to do something, but there has also been a wider dialogue concerning why.

3. Learning process in the collaborative networks

The learning networks involve idiosyncratic, social, technical and economics aspects due to the integration and interaction among different organisations. Thus, the learning process for organisations within learning networks is not natural, because it is influenced by some conflicts and barriers created by the diverse culture values of the participant organisations. Besides, the level of knowledge acquisition and utilisation in the organisation due to the learning network depends on
some interrelated factors, such as organisational process, individual limitations and the opportunities and problems which emerge from the organisational structure (Beesley, 2004).

Kakabadse et al. (2003) understand that knowledge is something that can be acquired and managed in a collaborative network. This view relates to a perspective which considers learning as a process in which an organisation understands and manages their experiences (Antonello, 2005). This means that organisations are able to process, interpret and distribute this information internally (Huber, 1996; Garvin, 1993). This learning perspective is classified as normative and is understood as a collective activity, which is possible under certain conditions and specific abilities (Dibella and Nevis, 1998).

The normative perspective is strongly related to the concept of absorptive capacity (Cohen and Levinthal, 1990). The absorptive capacity is the ability of a firm to recognise the value of new, external information, assimilate it and apply it to commercial ends. This capability is understood in this paper as the capability to learn, and it is dependant on previous knowledge and the diversity of background (Cohen and Levinthal, 1990). In order to understand the normative learning process in the collaborative process, some concepts were identified in the literature related to collaborative, individual and organisational learning, as follows.

**Collaborative learning**

The collaborative learning in the networks takes place through a sharing knowledge process among organisations and the relationship of the participant members. This is closely related to the concept of collaboration. For Wood and Gray (1991), collaboration occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms and structures to act or decide on issues related to that domain. Moreover, the collaboration occurs when the participant members perceive a gain in sharing knowledge, even when their interests were not exactly the same (Wood and Gray, 1991). This means that the level of mutual gain in a collaborative process is related to the alignment of individual and collective interests of participant members (Barlow; Jashapara, 1998).

**Individual learning**

The individual learning in the networks occurs through acquisition and understanding of the shared knowledge available in the group. The understanding about how the participant members learn is essential, because the collaborative learning does not take place without the individual engagement in the learning process (Beesley, 2004).

Three theories were adopted in this study in order to help the understanding of the role of the individual in the collaborative process. The first one is the cognitive learning theory from David Ausebel. This theory helps to explain the associations between previous knowledge and new knowledge in the individual minds, which is also discussed by Cohen and Levinthal (1990). The second theory is the Adult Learning (Knowles et al. 1998), which discuss specific characteristics of this kind of learning, highlighting the learning orientation for real problems. The third individual learning theory is the Experiential Learning Model (Kolb, 1976), due to the key role of the concrete
experience in the collaborative process, being a trigger for knowledge creation inside the organisation. For Kolb (1976), learning is conceived of a four stage cycle. Immediate concrete experience is the basis for observation and reflection. This observation are assimilates into a theory from which new implication for action can be deduced. These implications then serve as guides in acting to creating new experiences. To do this, the learner needs four different kinds of abilities: concrete experience, reflective abstraction, abstract conceptualisation and active experimentation.

Organisational learning

The organisational learning or absorptive capacity in the organisation does not simply depend on the exposition of the individual or the organisation to external knowledge, but require also a communication system to link the new knowledge and the user of this knowledge (Cohen and Levinthal, 1990). Thus, the organisational learning in the collaborative process implies in a great effort of the participant members to disseminate the acquired knowledge to other organisational people, and the effort to transform and use it to organisation needs.

Two theories were used in this study. The first one is Knowledge Creation Model (Nonaka, 1991), because it explains the spiralling process of interactions between explicit and tacit knowledge inside organisation. The combination of the two categories makes it possible to conceptualize four conversion patterns, which are: socialisation (from tacit knowledge to tacit knowledge), externalisation (from tacit knowledge to explicit knowledge), combination (from explicit knowledge to explicit knowledge) and the internalisation (from tacit explicit to tacit knowledge. The iterations between these kinds of knowledge lead the creation of new knowledge inside the companies.

The second theory adopted is the learning cycles originally discussed by Argyris and Schön (1996), and also used by several authors as a way to measure the learning product in organisations. For Argyris and Schön (1995), the single-loop learning involves incremental change within an existing framework and the double-loop learning involves transformative change and the testing of underlying assumptions. Sweringa and Wierdsma (1995) discuss also a triple-loop referring to changes in existing principles. There is an expectation that the collaborative process would enable the promotion of learning cycles in the organisation, not limiting it self to the incremental improvements, but also instigating to the innovative improvements through the creation of the new knowledge.

4. Research method

Action research was used in this study aiming to understand the collaborative learning process which took place among the set of construction companies. It also focused on the changes achieved by the companies related to the measurement process and performance comparison. The research process had interventions made by a research staff and the interaction among the participant companies was registered. It was necessary a three years of observation, in order to define the study focus, which was refined in each new cycle of planning, action and reflection.
The empirical study was developed between May 2004 and November 2006, and had three stages. Thirty two meetings were carried out, which also included site visits and workshops. In general, the meetings took place monthly during two hours, and in a neutral environment (University or in the Association of Construction Companies), aiming to restrict the impact of the competition between the companies and to avoid some kind of benefit to one company. The three stages of the empirical study were led by a facilitator (the main author of this paper) and two researchers. Stages 2 and 3 had an additional participant observer with experience in group learning, with the role of to help in the data analysis.

The Benchmarking Club had twenty small and medium size construction companies from the city of Porto Alegre in the South of Brazil. Eighteen companies decided to participate due to an initial workshop organised in 2004, which presented the purpose of the project. The other two companies were invited in Stage 2 in order to substitute companies which left the group. From these twenty companies, 65% focus their business on the development and construction of residential buildings and 35% on industrial buildings for private clients. Concerning the participant members, the Club involved owner-managers of the companies, production managers, quality managers, planning managers, architects, and work placement students from Civil Engineering and Architecture graduation course.

Different methods for data collection were used during the research aiming to assure the quality of data and also increase the reliability of the results. The main data collection instruments used were document analysis, interviews, video recording and, mainly, participant observation.

The findings were analysed from two perspectives: the Benchmarking Club and Companies. Initially, the learning process in the Benchmarking Club during the three stages was analysed, following by the analysis of the collaboration and learning process which took place throughout Stages 1 and 2 in four participant companies (03, 07, 11 and 13). The Club and the companies were analysed according to three constructs:

- **Collaborative Learning**: is understood as the learning process that took place among the members (managers) of the benchmarking club due to the collaborative process in the Club. This construct considered the characteristics of the practices discussed; the happening of exchange of information and practice among members; and also the involvement of the members with the Club. The variables analysed were: (a) intensity of the exchange of practice and information among members and (b) the frequency of the participant companies and managers in the meetings.

- **Efficacy of the Collaborative Learning**: this construct was used to evaluate the efficacy of the infrastructure and strategies adopted during the meetings in order to stimulate the learning process.

- **Implementation of Improvements inside the Companies**: this refers to the observable changes in the performance measurement system (PMS) of the companies and also and managerial process related to the measures, which were stimulated due to the collaborative
process. This construct aims to evaluate the effects of the collaborative process inside the companies, being measured by two criteria: (a) improvement level in the PMS and (b) effective actions for improvements.

The improvement level in the PMS was calculated by the difference between the maturity level of the companies’ PMS after the stage 2 and before the stage 1 of the benchmarking club. The maturity level was evaluated based on the evaluate criteria for performance measurement system developed by Costa (2004), which includes: measure definition, alignment of measures to strategies, benchmarking, insertion of measures into company routine and learning achievement through measures. In each company, the practices related to these criteria were analysed, considering if it was completely implemented, partially implemented or not implemented. A weight was established for each one of the option (table 1).

<table>
<thead>
<tr>
<th>Practices Analysis</th>
<th>Weight</th>
<th>Maturity Level of Companies’ PMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completely implemented</td>
<td>1.0</td>
<td>( \sum (N_{CI} \times 1 + N_{PI} \times 0.5 + N_{NI} \times 0) )</td>
</tr>
<tr>
<td>Partially implemented</td>
<td>0.5</td>
<td>( \sum (N_{CI} \times 1 + N_{PI} \times 0.5 + N_{NI} \times 0) )</td>
</tr>
<tr>
<td>Not implemented</td>
<td>0.0</td>
<td>( \sum (N_{CI} \times 1 + N_{PI} \times 0.5 + N_{NI} \times 0) )</td>
</tr>
</tbody>
</table>

5. Collaborative learning process

This chapter presents the main results obtained during the development of the Benchmarking Club during the stage 1 and 2.

5.1 Development of PMS for benchmarking (Stage 1)

The stage 1 aimed to define the set of measures for benchmarking and to motivate the companies to implement this system. Moreover, the creation of the benchmarking club aimed to promote to the companies an environment for sharing. Seven meetings involving both members of eighteen construction companies and the research team were carried out to define the set of measures. In each meeting a sub-set of measures was discussed, including their objectives, formulae, and data collection as well as analysis procedures. The final version of the set of measures was defined in the end of August 2004. After that, a training course was provided for the companies’ staff involved in the implementation of performance measurement. In end of 2004, the companies started the implementation process, involving more two meetings.

The development of the PMS for benchmarking in the stage 1 was the common interest for the members of the companies. One positive result of this stage was the participatory process that has took place in the definition of the PMS. This participation was measured by the number of procedures sent by members before the meetings, or the participation of these members during the pilot implementation, or speech reports about the implementation process.
Through the meetings, the companies participated in decisions concerning the choice and definition of measures, including the negotiation of data collection criteria. The members of the companies involved understood well the set of measures and they were aware of the relevance of each measure. As a result, they created together a system, which was the representation of what they would like to measure and compare. In this stage, the companies started the sharing process of ideas and practices, because for the definition of each measure, the members showed their experiences and opinions about the subject discussed. Moreover, the sharing of practices started the learning process among the participants related to the use of measures.

During this stage two main lessons were learnt, as follows:

- the common interest of the group was an important factor because influence the cohesion of the group, the collaboration among companies, as well as a major involvement of the companies, mainly those ones which had a clear alignment between individual and collective interests;

- the collective process aiming to develop the PMS for benchmarking promoted the reflection and abstraction of the companies members. This individual learning led most of the members to adapt their PMS, aiming to use the measures to do benchmarking among participant companies. Due to this, it was noticed that the environment of the club could facilitate changes in the managerial process of the companies in different levels of learning.

5.2 Exchange of experience and managerial practices (Stage 2)

The second cycle started in March 2005 and finished in October 2005. It aimed to consolidate the sharing learning environment initiated in the stage 1, thus motivating the implementation of improvement inside the companies. In this cycle, fourteen construction companies participated. Twelve of these companies also participated in the first cycle. The companies shared results and practices through monthly meetings. In these meetings, some themes were discussed, such as health and safety, layout and logistic of construction sites, cost management, as well as good practices in the implementation of the performance measurement system for benchmarking. These themes were chosen because they referred to the processes in which the benchmarking measures took place.

During this stage, it was observed behaviour changes of the companies members concerning the intensity of exchange of experience and practices and also their attendance. These were measured through the number of speech reports or presentations or interventions of the companies members during the meetings. In the first three meetings the members were not very active, and they also had some difficulties to talk openly about the problems of the companies.

Along the other three meetings a better engagement of most members was observed, mainly because they showed that they were improving their PMS and also, they were trying to implement new practices observed in the meetings. During this stage it was observed that the different levels of maturity in PMS of the participating companies influenced the sharing of experiences. In the first
At the end of this stage a perceptible drop in the members’ engagement in the club was observed. According to the data collected in the companies by meetings and interviews, one of the reasons is that despite the connection between the best practices and measures, so many themes to be discussed were not satisfactory. The companies did not have enough time to understand and abstract all practices discussed and also to transfer them to their internal context. Furthermore, based on the interviews and the researcher observation, some other reasons could be linked to this drop, such as: the little engagement of some top managers, the participation of only one member for company, the differences in the maturity of the PMS of some companies and, finally, the lack of active participation of some members of the club.

During this stage two main lessons were learnt, such as:

- the intensity of the experiences and practices in the Club depend on the development level of the managerial process of the construction companies related to the theme in discussion in the meetings;
- the difference of the maturity level of the companies’ PMS implied in different needs and interests of the participant companies. This influenced the cohesion of the group and the frequency of the participants.

6. Implementation of improvements inside the companies

At the beginning of the stage 1 of project, the main scenario of PMS in the eighteen construction companies indicated 19% of the companies had a maturity level above 60%; 31% of the companies had a maturity level between 59% and 30% and 50% of the companies had a maturity level below 29%.

The main problems identified were that some companies used too many measures, which became a barrier to the real understanding about what should be analysed, while other companies used too few measures, which became difficult to identify the important problems in specifics process, and also discourage the systemic view of the organisation. Most of them had difficulties to establish targets for the measures and also to promote a systematic data collection, processing and analysis. Part of these problems is due to the centralisation of the measurement process, and as consequence, measures are hardly ever used to decision-making at middle and lower managerial level, and for data comparison. Due to this scenario the companies were willing to revise their measures, aiming to improve their routine procedures for data comparison.

At the end of stage 2, a new evaluation of the maturity level was carried out in the ten companies, which were highly involved in the project until that time. In general, the ten companies improved
their performance measurement system. 80% of the companies achieved a maturity level above 60% and 20% of the companies achieved a maturity level between 59% and 30%, according to table 2. The main practices improved were the establishment of targets for measures, the development of internal benchmarking, the regular improvement of the measurement system and also the establishment of moments for reflection about results.

Table 2 – Level of implementation improvements in the companies’ PMS

<table>
<thead>
<tr>
<th>Company</th>
<th>Level of Maturity of the PMS (after Stage 2)</th>
<th>Level of Maturity of the PMS (before Stage 1)</th>
<th>Level of Performance Improvement in the PMS</th>
<th>Changes in the PMS</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>91%</td>
<td>46%</td>
<td>45.0%</td>
<td>Effective implementation of PMS</td>
<td>9 8</td>
</tr>
<tr>
<td>07</td>
<td>91%</td>
<td>29%</td>
<td>62.0%</td>
<td>Development and effective implementation of PMS</td>
<td>7 3</td>
</tr>
<tr>
<td>11</td>
<td>88%</td>
<td>29%</td>
<td>59.0%</td>
<td>Effective implementation of PMS</td>
<td>5 3</td>
</tr>
<tr>
<td>12</td>
<td>75%</td>
<td>42%</td>
<td>33.0%</td>
<td>Development and implementation of some measures</td>
<td>9 8</td>
</tr>
<tr>
<td>13</td>
<td>75%</td>
<td>33%</td>
<td>42.0%</td>
<td>Effective implementation of some measures</td>
<td>9 9</td>
</tr>
<tr>
<td>17</td>
<td>72%</td>
<td>67%</td>
<td>5.0%</td>
<td>Adaptation of some performance measures</td>
<td>4 8</td>
</tr>
<tr>
<td>03</td>
<td>69%</td>
<td>21%</td>
<td>48.0%</td>
<td>Development and implementation of some measures</td>
<td>5 6</td>
</tr>
<tr>
<td>05</td>
<td>63%</td>
<td>71%</td>
<td>-8.0%</td>
<td>Adaptation of some performance measures</td>
<td>9 6</td>
</tr>
<tr>
<td>02</td>
<td>56%</td>
<td>29%</td>
<td>27.0%</td>
<td>Adaptation of some performance measures</td>
<td>8 4</td>
</tr>
<tr>
<td>15</td>
<td>47%</td>
<td>8%</td>
<td>39.0%</td>
<td>Adaptation of some performance measures</td>
<td>7 5</td>
</tr>
</tbody>
</table>

The critical point of the evaluation was concerned the minimal use of the measures to do external benchmarking. It was observed that the companies still had great difficulties to analyse their own data, and they hardly ever compare their results with other companies. Besides this, the companies decided to start a internal benchmarking and only after its consolidation, they had an intention to do external benchmarking. These two reasons pointed out that external benchmarking tends to be carried out only by companies which have a PMS in a high level of maturity. Another problem identified was concerned the data base of the benchmarking measures. There was not enough data for all indicators to be compared in the online measurement system, because the frequency of data input was slower than what was planned.

Based on the maturity level of the PMS after stage 2 and before stage 1, it was calculated the level of performance improvement in the PMS of the companies highly involved in the project. The results show that 80% of the construction companies improved at least 27% and companies 16, 07, 11 and 13 improved more than 42%. However, 20% of the companies did not achieve significant improvement during this time (companies 05 and 17) (see table 2).

Concerning the changes perceived in the companies’ PMS, the three main results were identified by companies’ member: (a) adaptation of some performance measures, meaning that the company only add or revise procedure of the measures according to the PMS for benchmarking developed, allowing the data comparison; (b) effective implementation of the PMS, indicating that the
company besides the addition or review of the measures, the company incorporate the use of the measures into its organisational routine; (c) **development and implementation of the PMS**, meaning that the company conceive its measures, taking the PMS for benchmarking as reference, and implement some of these measures.

Through the results, it was possible to identify that some members absorbed a set of information during the meetings, disseminated part of this inside the companies and promoted actions in order to improve the company’s PMS. However some companies did not get to promote such improvement.

Analysing the data collected of two of the participant companies (Companies 07 and 11) was observed that both companies, at the beginning of the research, used their PMS as bureaucratic task, aiming mainly to achieve the requirements of the ISO quality certification. During the process, Company 07 and 11 sought to ask themselves about “why the old structure was not working properly”, and thus, they discussed new principles to select and implement the measures. These changes were encouraged through observation and sharing of experience in the benchmarking club. The members interpreted the information meaning, and they found ways to apply the acquired knowledge in their realities, also using their previous experiences from the point of the person as well as from the company. So, it was observed in these two companies the dissemination of knowledge, its understanding and the its application according to their organisational structure and culture as well as their managerial systems.

The factors which influence the high degree of improvements inside these companies were:

- the ability of the participant member to assimilate and understand the experience and practices discussed in the club. This was closed related to their previous knowledge and also because the implementation of the PMS was part of their tasks in company;

- the ability of the participant member to identify, investigate and understand the problems of their companies. This was influenced by their knowledge about the company and also their internal and external motivation to learn;

- the ability of the participant member to disseminate the new knowledge to the others employees in the companies, due to their abilities of communication and leadership;

- the ability of the participant member to transform the new knowledge in something useful for the companies. These members received the support of the high administration to implement the improvements in their PMS and also these companies had their managerial process (related to the measures implemented) well developed.
7. Requirements to the development of a collaborative benchmarking process

The results of this study led to the elaboration of a set of requirements for each learning level (group, individual and organisations). These aim at support the development of effective collaborative processes and also the promotion of substantial performance improvements in the construction companies (figure 1). The requirements are presented in the following.

![Diagram](https://via.placeholder.com/150)

**Figure 1 – Requirements to the development of the collaborative process**

### Group

The collaborative environment represents the space where the interaction among different individuals will happen (mainly companies members) in order to support the negotiation and communication of knowledge and practices without interfering in distinctive norms, cultural values and interest. The collaborative environment has the role of stimulating reflection about the practices and to promote actions for improvements inside the companies. As a result of this process, there is an expectation of increasing knowledge, also promoting the capability of the organisation to do something more or different. Therefore, the collaborative group should be developed aiming to achieve four requirements (table 2), which are closely interrelated.

<table>
<thead>
<tr>
<th>Group</th>
<th>Individuals</th>
<th>Organisations</th>
</tr>
</thead>
<tbody>
<tr>
<td>•Oriented-space for real problems discussion;</td>
<td>•Ability to interact and share knowledge in the group;</td>
<td>•Ability to disseminate knowledge inside the company;</td>
</tr>
<tr>
<td>•Open, impartial and trust space;</td>
<td>•Ability to reflect and abstract shared knowledge;</td>
<td>•Ability to recognise the value of the new knowledge;</td>
</tr>
<tr>
<td>•Space which enables reflection, abstraction, and systematic actions;</td>
<td>•Ability to identify and investigate critical problems of the companies;</td>
<td>•Ability to explore the new knowledge;</td>
</tr>
<tr>
<td>•Alignment of individual, collective and organisation interests.</td>
<td>•Ability to transform the acquired knowledge in something useful;</td>
<td>•Ability to preserve the new knowledge.</td>
</tr>
</tbody>
</table>

### Individuals

Individuals have an essential role in the collaborative process, because they are the link between the group and the organisations, therefore bridging the gap between the collaborative learning and the organisational learning. These individuals have a facilitator role in the implementation of substantial changes in the companies. These changes may take place through an effective communication of the ideas to the others, as well as doing collective or individual actions. Besides, in the collaborative group, the individuals have the role of promoting the sharing of experience among the companies, having active and critical attitude during the collaborative process. Table 2 presents four individual capabilities aiming to engage the individuals in the collaborative process and to promote performance improvements.
Table 2: Requirement for the collaborative benchmarking process

<table>
<thead>
<tr>
<th>REQUIREMENTS</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group</strong></td>
<td></td>
</tr>
<tr>
<td>Oriented-space for real problems discussion</td>
<td>The sharing of experiences and practices should be based on problems which make part of the organisational routines.</td>
</tr>
<tr>
<td>Open, impartial and trust space</td>
<td>The sharing of experience and practices should take place in an openly way, without prejudice and prejudgment.</td>
</tr>
<tr>
<td>Space which enables reflection, abstraction, and systematic actions</td>
<td>It is necessary the establishment of mechanism to stimulate the members to reflect and abstract in a structured way.</td>
</tr>
<tr>
<td>Alignment of individual, collective and organisation interests</td>
<td>The cohesion of the group depends on individuals and companies being satisfied with objectives and activities of the group.</td>
</tr>
<tr>
<td><strong>Member</strong></td>
<td></td>
</tr>
<tr>
<td>Ability to interact and share knowledge in the group</td>
<td>The members should be able to share their experience to the other members of the group as well as to identify new critical knowledge from the amount of relevant knowledge available in the group.</td>
</tr>
<tr>
<td>Ability to reflect and abstract shared knowledge</td>
<td>The members should be able to reflect about the shared experiences, to observe them from different perspective, to establish rules and to create their own generalisation.</td>
</tr>
<tr>
<td>Ability to identify and investigate critical problems of the companies</td>
<td>The members should be able to understand the critical problems of the companies in order to use properly the new knowledge inside the company</td>
</tr>
<tr>
<td>Ability to disseminate knowledge inside the company</td>
<td>The members should be able to interact with other people in companies, in order to circulate the new knowledge. Also the company should provide communication mechanism which encourage an openly communication among people, including the top managers.</td>
</tr>
<tr>
<td><strong>Organisation</strong></td>
<td></td>
</tr>
<tr>
<td>Maturity level of the performance management processes</td>
<td>The organisation should have their managerial process developed according to the level of changes desired.</td>
</tr>
<tr>
<td>Ability to recognise the value of the new knowledge</td>
<td>The organisational members should have a clear view about the type of knowledge which is more valuable to implement performance improvement in the companies.</td>
</tr>
<tr>
<td>Ability to transform the acquired knowledge in something useful</td>
<td>The organisation should be able to develop and refine their organisational routine, combining the existing knowledge with the new knowledge acquired by the organisational members.</td>
</tr>
<tr>
<td>Ability to explore the new knowledge</td>
<td>The organisation should be able to refine, amplify and transform existing competences or create new ones, internalising them to their organisational routine.</td>
</tr>
<tr>
<td>Ability to preserve the new knowledge</td>
<td>The organisation should be able to create structured mechanism which allow the storage of new knowledge and the easy access of the organisational members</td>
</tr>
</tbody>
</table>

**Organisations**

Organisations have the role of providing an appropriate context for knowledge creation, making possible the conduction of group activities and the accumulation of knowledge from the part of the participant member. Therefore, organisations should be prepared to absorb new knowledge from outside, transforming it and applying it to their needs. This involves the interaction of the participant members with other people involved in the implementation of improvements in the company.
8. Conclusions

This research concludes that the developed Benchmarking Club created opportunities for the acquisition of knowledge, identification of new perspectives and also the development of a contact network with a set of companies from the same and different market sector. Furthermore, the Club encouraged companies to make changes in existing organisational daily practices due to the collaborative process.

Moreover, this study identified that most of the participant members were not prepared to participate in the initiative, despite the fact that their jobs (quality coordinators, production managers, planning managers) were related with the themes discussed in the Club. During the research, it was observed that the participant members should have a set of specific abilities, such as leadership, communication and also the domain of technical knowledge in order to facilitate the understanding and dissemination of the acquired knowledge.

Finally, in respect to the participant companies, this research concluded that this kind of initiative demands a previous analysis between the current level of the development of the company’s managerial processes, which will be the focus in the network and the desired level of changes to be achieved with the benchmarking collaborative process. This analysis aims to understand the potential of the companies to promote double loop learning.

References


Benchmarking – A Tool for Judgment or Improvement?

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Abstract

Change in construction is high on the agenda for the Danish government and a comprehensive effort is done in improving quality and efficiency. This has led to an initiated governmental effort in bringing benchmarking into the Danish construction sector. This paper is an appraisal of benchmarking as it is presently carried out in the Danish construction sector. Many different perceptions of benchmarking and the nature of the construction sector, lead to an uncertainty in how to perceive and use benchmarking, hence, generating an uncertainty in understanding the effects of benchmarking. This paper addresses these issues, and describes how effects are closely connected to the perception of benchmarking, the intended users of the system and the application of the benchmarking results. The fundamental basis of this paper is taken from the development of benchmarking in the Danish construction sector. Two distinct perceptions of benchmarking will be presented; public benchmarking and best practice benchmarking. These two types of benchmarking are used to characterize and discuss the Danish benchmarking system and to enhance which effects, possibilities and challenges that follow in the wake of using this kind of benchmarking. In conclusion it is argued that clients and the Danish government are the intended users of the benchmarking system. The benchmarking results are primarily used by the government for monitoring and regulation of the construction sector and by clients for contractor selection. The dominating use of the benchmarking results is judgment oriented and this is argued to generate competition among the contractors, thus, undermining the distribution of best practice and voluntary knowledge sharing among contractors. It is argued that benchmarking in the Danish construction sector to a certain extend constructs an overall comprehension of what constitutes project success.

Keywords: benchmarking, construction, evaluation theory, effects
1. Introduction

Benchmarking is a powerful concept and is widely considered to be essential to serious organizational improvement process (Chen, 2005; Dawkins et al., 2007). But through a quick glance at the literature on ‘benchmarking per se and ‘benchmarking in construction’ it becomes clear that ‘benchmarking’ is perceived and operates in many different ways in various countries and contexts (e.g. Cox et al., 1997; Beatham et al., 2004; Haugbølle and Hansen, 2006; Triantafillou, 2007; El-Mashaleh et al., 2007). The literature on benchmarking is also theoretically underexposed focusing on pragmatism and practice rather than epistemology (e.g. Cox et al., 1997; Bowerman et al. 2002; Moriarty and Smallmann, 2009). The literature on benchmarking in construction shows the same tendencies: The predominant part of the literature is pragmatic focusing on e.g. development of new benchmarking models and presentation of benchmarking cases and application of benchmarking results.

Fernie et al. (2006) point out that ‘ [...] it is also necessary to recognize that different industry sectors and organizations are characterized by recipes, logics and organizational routines that reflect a historical understanding of both context and practices. [...] [T]he philosophical study of causation, has been given very little attention in the construction literature and much more emphasis has been put on describing the ‘symptoms’ than unraveling their origins’

The different perceptions of benchmarking and the lacking attention on the underlying nature of construction, lead to an uncertainty in how to perceive and use benchmarking in the construction sector. This paper is an attempt to address this issue doing an appraisal of the present use of benchmarking in the Danish construction sector. Utilization focused evaluation theory and public benchmarking are brought into the discussion in order to transcend the existing benchmarking literature within construction research.

The basis of this paper is taken from the governmental effort in bringing benchmarking into the Danish construction sector. These efforts include benchmarking of contractors, architects and consulting engineers that are involved in state construction projects and social housing projects. This paper will primarily focus on how benchmarking benefits the contractors, the clients and the Danish government, relative to whose interest that is taken into consideration. It will be emphasized that the development of benchmarking has increasingly undermined the intentions of distributing best practice and voluntary knowledge sharing among the contractors; substituting these with compulsive performance comparison that creates competition when clients uses the benchmarking results for contractor selection. This utilization of the benchmarking system will be discussed and be held together with the issue raised in the above-mentioned quotation by Fernie et al. (2006).

It is neither the aim of the paper to be prescriptive nor to favor one use of benchmarking rather than another. The paper should be regarded as a reflective contribution to the debate about the different effects of benchmarking, and as an attempt to widen the theoretical perception of benchmarking in the construction sector.
2. Two different types of benchmarking

Two very distinct perceptions of benchmarking are used to address the issues and considerations associated with the effects, benefits and risks for benchmarking as it is carried out in the Danish construction sector. The two types are; public benchmarking comparable with benchmarking dominating the public sectors and best practice benchmarking as the perception of best practice benchmarking commonly used in the private sectors.

2.1 Best practice benchmarking

This perception of benchmarking derives from the private industry and is built on trust, collaboration and a mutual benefit over a period of time. It is synonymously with the most prevailing interpretation of best practice benchmarking used in the private industry. It aims at gaining competitive advantage by means of continuous improvement of processes learned from the successful practices of others (Watson, 1993; Camp, 1995). Best practice benchmarking is not simply competitor analysis, espionage or theft from rival companies. It aims not simply to measuring the organization against the best in class and adopting their methods but on understandings of how to achieve superior performance by improving methods, practices and processes learnt from others (Watson, 1993; Zairi, 1997; Beatham, 2004; Moriarty and Smallman, 2009). The critical characteristic is the examination of processes. Benchmarking results are inapplicable, if there is provided no comprehension of the processes leading to the results. ‘Benchmarking is used to improve performance by understanding the methods and practices required to achieve world-class performance levels. Benchmarking’s primary objective is to understand those practices that will provide a competitive advantage; target setting is secondary’ (Camp, 1995, p. 15).

Best practice benchmarking only uses results (indicators) from the benchmarking system to identify performance gaps and locate superior performance. Subsequently methods, practices and processes fit to the specific need of the organization are adapted from excelling companies (Camp, 1989). The evaluation theory has interesting similarities to benchmarking theory, e.g. Peter Dahler-Larsen (2008) addresses the consequences indicators give rise to when used in evaluation objectives. He points out that the learning element in the utilization of indicators is crucial in order to generate best practices, learning and continuous improvement. Indicators and the criteria set up for them must be under constant development, interpretation and adaption. The results must make sense and must be useful to those responsible for the processes that need improvement. He also (as Camp, 1995) points out that in the leaning objectives it is not sufficient to identify the performance gap. It is necessary to affiliate organizational processes to the results of the indicators in order to provide continuous learning and improvement. Ownership, involvement, reflection and relevance are keywords in using indicators with learning objectives (Dahler-Larsen, 2008).

Another interesting perspective from the evaluation theory that addresses the utilization of indicators comes from Michael Quinn Patton (1997). He operates with program evaluation when using the concept utilization-focused evaluation. In comparison to best practice benchmarking, he introduces improvement-orientated evaluation; ‘Improvement-orientated evaluation [...] includes using information systems to monitor programs efforts and outcomes regularly over time to provide feed-
back for fine-tuning a well established program. That’s how data are meant to be used in as part of a Total Quality Management (TQM) approach’ (Patton, 1997, p. 69). Similar to best practice benchmarking, this improvement-oriented evaluation focuses on improvement rather than rendering summative judgment of the evaluation results. It is orientated towards a gathering of data on strengths and weaknesses that are used to produce continuous reflections and innovation on where efficiencies can be made. Purpose, method and criteria for judging success must be decided by the intended users of the evaluation. The questions that the evaluation seeks to answer must be at a minimum. This begins by narrowing the list of ‘stakeholders’ of the evaluation down as much as possible and let their request be the basis for the focus of the evaluation. By doing this it is avoided that stakeholders have different perception of the evaluation because they are interested in different things (Patton, 1997).

2.2 Public benchmarking

Public benchmarking is the predominant in public sectors. It is a compulsive systematic measurement and comparison of performance driven by an external agency (e.g. the government). Indicators from the benchmarking system are utilized to support the external agency in decision making and judging the success of those being measured on performance (Triantafillou, 2007). Public benchmarking is useful in clarifying whether a provider of a product or a service compares well against competitors. Only little focus is given to the processes leading to the results (Bowerman et al. 2001). The external agency is the intended user of the benchmarking system and the results are used to regulate, control and monitoring those being measured on performance. Benchmarking in the public sector can ‘[…] be seen as a form of power that depends on the capacities of organizations to govern themselves in a proper manner’ (Triantafillou, 2007, p. 831). It becomes a powerful tool for the external agency to create incentives in market areas where the competition is inexpedient, rationalization is not naturally provided or more transparency is requested (KonkurrenceStyrelsen, 1998). Benchmarking indicators become synonymous with the ambitions of success set up by the external agency, thus, activating individuals and organizations to seek equivalent ambitions (Triantafillou, 2007).

From the evaluation theory Dahler-Larsen (2008) characterizes it as control when indicators are exposed to judgment and used by an external agency for decision making. The primarily focus is on the process of measuring and the results from the evaluation. The evaluation becomes a tool for the external agency to control, monitor and regulate another public agency. Often external agency is not concerned with the effects the regulation has had on other parts of the system (Dahler-Larsen, 2008; Andersen, 2004). It should be emphasized that, the control use does not necessarily counteract learning and improvement (Dahler-Larsen, 2008). If formulated sufficient, the same set of indicators can be use for several purposes.

Patton (1997) calls it judgment-oriented evaluation when evaluation results are used to determining worth or value of something. The intended user of the evaluation is the external agency who uses the results to decide whether the program is satisfactory or not. Evaluation results are used to judge efficiency and quality and to create comparative rating or rankings of programs (Patton, 1997). Measures in judgment-oriented evaluation are highly maintained, to make comparability of performance possible over a longer period of time, hence, the most critical and central part of judgment-oriented evaluation is specifying the criteria for judgment.
2.3 Public benchmarking vs. best practice benchmarking

An analogy by Scriven (in Patton, 1997, p. 69) gives us a suitable distinction between improvement- and judgment-oriented evaluation, comparable with the distinction between public benchmarking and best practice benchmarking: ‘When the cook tastes the soup, that’s formative; when the guests taste the soup, that’s summative.’

Patton (1997, p. 69) explicate this quote as follows: ‘More generally, anything done to the soup during preparation in the kitchen is improvement-oriented; when the soup is served, judgment is rendered, including judgment rendered by the cook that the soup was ready for serving (or at least that preparation time had run out.).’

In the context of this paper, the guests obliviously represent the external agency and the cook represents the organizations or individuals being benchmarked. This separation in who is rendering judgment (the guest or the cook) could help clarifying how improvement is expected to follow in the wake of benchmarking when using the two types of benchmarking. When the soup is served to the guests, the cook (might) get feedback from the guests on his/her performance. In the long term, a plausible effect could be that the cook gets better in knowing the criteria the guests use to judge the soup, hence, making suitable modifications using the time and ingredients available. Following this line of metaphors; if the cook tastes the soup and renders judgment, he/she makes use of own expertise, expectations and success criteria, hence continuously modifying the soup during the process of preparation. This may or may not result in an acknowledgement of needing higher professional competences in the kitchen, new ingredients to change the content or more efficiency during the preparation of the soup.

When used formative, performance of the provider is judged. When the judgment has consequences for the provider it becomes an element in regulating the provider to meet the expectations of the judge. When judgment is used summative, improvement is possible during the process and becomes an element for the provider to achieve better processes.
Table 1: A summary of the distinctions between the two benchmarking types

<table>
<thead>
<tr>
<th></th>
<th>Public benchmarking</th>
<th>Best practice benchmarking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sphere</strong></td>
<td>Public sector</td>
<td>Private sector</td>
</tr>
<tr>
<td><strong>Evaluation term</strong></td>
<td>Summative, judgment-oriented</td>
<td>Formative, improvement-oriented</td>
</tr>
<tr>
<td><strong>Intended users</strong></td>
<td>External agency</td>
<td>The market/companies</td>
</tr>
<tr>
<td><strong>View</strong></td>
<td>Outside view on performance</td>
<td>Inside view on processes</td>
</tr>
<tr>
<td><strong>Benchmarking affiliation</strong></td>
<td>Compulsive</td>
<td>Voluntary</td>
</tr>
<tr>
<td><strong>Measuring process</strong></td>
<td>Retrospective (after completion)</td>
<td>Ongoing</td>
</tr>
<tr>
<td><strong>Expected benefits</strong></td>
<td>Provides basis for decision, identifies best in class, regulates, controls, monitoring, explicate success criteria and target setting</td>
<td>Provides learning of best practices, mutual benefits to participants, continuous improvement of processes</td>
</tr>
<tr>
<td><strong>Risk</strong></td>
<td>Limited learning for others than the intended users, limited process improvement</td>
<td>Many interests, fragile due to participation requirements (e.g. collaboration, dedication, involvement and trust), difficulties in benefit every participant equally</td>
</tr>
</tbody>
</table>

3. Benchmarking in the Danish construction sector

Change in construction is high on the agenda for the Danish government and a comprehensive effort is being made to achieve high quality and efficiency (The Danish Government, 2003). This discourse of changes in the Danish construction sector is a phenomenon that doesn’t differ much from the reform movement in the UK. The motives to initiate the changes are almost equivalent to the areas of weakness described by Latham (1994) and Egan (1998). Inspiration has been drawn from the UK and during the recent years the concept of benchmarking has been gaining ground in the Danish construction sector.

Since January 2004 the Danish government has made benchmarking of Danish state construction projects and social housing projects (since marts 2007) compulsory when the contract sum exceeds 5 million DKK (~ 1 million USD). Project information is reported in the beginning of the construction project and performance information shortly after hand-over. The performance information is transformed into indicators in the following categories; customer satisfaction, defects, compliance with time schedule and accident frequency at the workplace (http://www.byggeevaluering.dk). There are no demands for ongoing reporting of information during execution of the project. An additional requirement is that, contractors bidding for Danish state construction projects and social housing projects must substantiate their capabilities in form of indicators/results from previous construction projects. These are used by state clients to prequalify contractors.

The legal requirements evoked new demands in measuring the performance in the construction sector. As a result of this, the Benchmark Centre for the Danish Construction Sector (BEC) was established
in 2002. BEC was formed by several organizations in the construction sector including the National Agency for Enterprise and Construction. BEC was established with the purpose of providing the necessary service to meet the governmental requirements for benchmarking the construction sector (The Danish Government, 2003), and to create a national benchmarking system that could benefit the private sector as well. The origin objectives of the benchmarking system was to enhance transparency in the market concerning the relationship between price and quality (The Danish Ministry of Economic and Business Affairs, 2008) and improvement of quality and efficiency within the construction sector through competition and learning.

Today the target groups are primarily construction clients. Since its establishment in 2002 BEC has extracted information from more than 1600 building contracts divided among more than 500 building projects. BEC primarily focuses on customizing and promoting their product to Danish construction clients in order to make them use the benchmarking results in prequalification of contractors.

Since the implementation of the benchmarking system 60 % of the construction projects have been benchmarked on a voluntarily basis (projects not subjected to the governmental demands). There has been only little use of the data collected by BEC in the creation of best practices. BEC has recorded an increasing interest from contractors for indication of their companies marked position.

4. Challenges in benchmarking the construction sector

Before considering the benchmarking characteristics and objectives of the Danish benchmarking efforts, it is relevant to be reflective about the reality that surrounds the benchmarking system. It should be taken into consideration, that implementing and framing a complete benchmarking system for the construction sector is a challenging task. This is often argued to be caused by the characteristics that distinguish the construction sector from other industrial sectors. Some of the barriers most commonly pointed out is that the construction sector is project based and the projects are temporary, short-term, complex and with many changing participants each having different criteria of project success (e.g. The Danish Government, 2003; Costa et al., 2004; Chan and Chan, 2004; Lee et al., 2005; Lin and Shen, 2007). This leaves a comprehensive task in providing a benchmarking system that fulfills the demands of best practice benchmarking; meeting the interests of each participant and measuring on methods, processes and practices during the project period (Lin and Shen, 2007). This in mind, it should also be taken into consideration that the Danish contractor companies are known to be very conservative to changes (Dræbye, 2003).

Focusing on the barriers and interest of implementing benchmarking in construction companies, it is interesting to note, that a research of four different benchmarking initiatives for construction from Brazil, Chile, the UK and the USA, concludes that many construction companies have difficulties getting involved on a permanent basis (Costa et al., 2004). The same research identifies that the main interest of construction companies to get involved in benchmarking initiatives is to compare their performance against other companies.
5. Appraisal of the effort in benchmarking the Danish construction sector

‘What gets measured gets attention, particularly when rewards are tied to the measures’ (Eccles, 1991).

Comparing the Danish benchmarking system to best practice benchmarking (the inside view on processes), the system falls short; the contractors are not provided any learning about methods, practices and processes used by others. Best practice benchmarking is encouraged by trust, collaboration and mutual benefit leading to continuous improvement of processes learnt for others (Watson, 1993; Camp, 1995). The critical characteristics of the Danish benchmarking system are limited to competitive comparison of contractors for contractor selection. There is no measuring or initiated research towards an understanding of the processes leading to the results of superior performance of contractors, indicating a high degree of public benchmarking. This competitive and controlling use of results is undermining the intentions of sharing knowledge of processes leading to superior performance (Camp, 1995; Dahler-Larsen, 2008). This development could be an outcome of what Dahler-Larsen (2008) and Patton (1997) emphasize as: the erroneous in evaluating on interest of others than the intended users. Addressing benchmarking from this perspective, the intentions of an overall improvement of quality in the sector using best practice benchmarking (with contractors being the intended users) is in contradiction to utilization of indicators for contractor selection (with clients being the intended users). An important factor in this conflict of interest could be caused by the government’s role; the government determined the objectives of the benchmarking system when initiating benchmarking in the construction sector, hence benchmarking has become a way to visualize the target of government ambitions, causing the private market to act with ‘a responsibility for the governing of a particular field or set of activities’ (Trianafillou, 2007, p. 836). Dahlberg and Isaksson (1996, p. 36) point out that; ‘[t]his “outsider” effect can represent a challenge for the development of a benchmarking culture within the agencies concerned. This “ownership” aspect of the benchmarking process can substantially influence attitudes towards the concept of “learning from others”’.

As a result of the government’s role (as external agency), and the clients being intended users of indicators for competitive comparison, the benchmarking system is insufficient in content of information that are useful for contractors to learn from each other in order to improve their performance. Ownership, involvement, reflection and relevance are lacking in the objects of providing best practice benchmarking for contractors. The governmental long term desire for achieving quality and efficiency in the construction sector trough learning from the practices of others are overlooked in favor of the intentions of the clients and the government.

As emphasized by Dahler-Larsen (2008), results of an evaluation must make sense and be useful to those responsible for the improvement process. The clients and the government have increasingly become the intended users of the benchmarking system, using it as a regulation tool driving contractors towards achievement of good results in order to compete in the prequalification in future projects. The benchmarking results provide transparency of the sector within the areas defined by the
government. It could be interpreted as a positive and successful development of the interest in benchmarking that 60% of the construction projects are conducted on a voluntarily basis.

It is evident that the stakeholders of the benchmarking system have been narrowed down, which is a positive tendency for a benchmarking system, since it is crucial not to have too many intensions with the same system (Patton, 1997; Dahler-Larsen, 2008). But it is also evident that the adjustments have not favored the contractors in the objectives of best practice benchmarking; the benchmarking system primarily profits the clients (for contractor selection) and the government (for regulation and monitoring) leaving no more than competitive performance comparison to the contractors. (Luckily) Costa et al. (2004) identified comparison of performance as the main interest of contractors to get involved in benchmarking.

The underlying reason to the decreasing number of stakeholders could be found in the problematic in framing a complete benchmarking system beneficial to every participant involved a construction project (Costa et al., 2004; Chan and Chan, 2004; Lee et al., 2005). It may be this challenging element in benchmarking the construction sector that creates a tension field between compulsive comparison and voluntarily process improvement of contractors, leading to a necessity in narrowing down the stakeholders and the intensions for benchmarking. These tendencies have occurred in Denmark, making the clients and the government the intended users and the governmental intensions dominate the use and scope of benchmarking. The outcome of the development is limited to a gathering of information that can be translated into something measurable (indicators) which clients can use for contractor selections and the government for monitor and regulate the construction sector.

6. Discussion

The compulsory element in benchmarking the Danish construction sector has led to a substantial amount of comparable indicators, but there are important considerations to be made, when using the indicators in the perception of public benchmarking.

Setting up the indicators for a benchmarking system, the diversity in perception of project success is evened out across the project participants. This arises a problem, since project success varies significantly according to whom is defining success (Dahler-Larsen, 2008) and particular in the construction sector (Chan and Chan, 2004; Lee et al., 2005). Unintended effects are in the risk of emerging when focusing and rendering judgment based exclusively on the governmental fixed indicators. Indicators often become (intentional or unintentional) a determination and reflection of the problem areas, identifying where success is rendered or where improvement is needed. They help capturing and translating something complex to numbers which allow decisions to be made at a distance. The indicators become a view of the performance of contractors through the eyes of the government and the clients. The governmental identification and visualization of problem areas through indicators, constructs a prevalent comprehension of the problems dominating the sector. This could make the ability of judging and visualizing the problem areas more important than improving of the processes construction the problem areas. Dahler-Larsen (2008) uses the term indicator fixation as a concept for having too much focus on a set of indicators. He uses the concept to emphasize an effect often followed in the wake of the establishment of indicators; the construction of a simplification of
excellence. The indicators risk become the definition of quality and project success, hence becoming targets themselves and could influence the self-understanding and attitudes of those exposed to judgment based on their performance indicators.

‘The emergency rooms in England had problems with patients being on waiting lists for a long time. Accordingly a quality system was implemented in order to measure the time it took from a patient entered the emergency room until he or she was contacted by healthcare personnel. As a result, the hospitals hired so called ‘hello-nurses’, with the job function simply to approach incoming patients and say ‘hello’” (translated from Dahler-Larsen, 2008, p. 19).

This story reveals that unintended effects are in risk of emerging, if measures are becoming the definition of quality and meanwhile deficient described. If the indicators in a benchmarking system are a poor reflection of what they try to capture, it generates a risk in other elements being unintended affected in the quest of fulfilling the criteria best possible. Inadequate indicators could end up influencing the action of those being measured, leaving a dichotomy of the comprehensions of success; is success achieved through well executed processes or through a fulfilling of the criteria set up in the indicators? This stresses the point that when consequences are attached to indicators, the determination of them is the most crucial element in benchmarking. The indicators must be able to answer the right questions as well as answering the questions right.

The actual effects of the benchmarking in the Danish construction sector will remain unanswered in this paper. The only certainty is that benchmarking always has effects.

7. Conclusions

The governmental efforts in bringing benchmarking into the Danish construction sector have been discussed. It has been attempted to widen the theoretical spectrum of benchmarking in construction by supplementing the discussion with elements of public benchmarking and utilization focused evaluation theory.

The benchmarking efforts in the Danish construction sector have been discussed using two distinct perceptions of benchmarking; public benchmarking and best practice benchmarking. In conclusions it has been argued that construction clients and the government are the intended users of the benchmarking system. The benchmarking results are primarily used by clients for contractor selection and the government for monitoring and regulation of the construction sector. This is argued to undermine the intentions of distributing best practice and voluntary knowledge sharing among contractors. In closing, reflection of possible effects and risks of the present use of benchmarking in the Danish construction sector has been laid out. It has been emphasized that unintended effects may follow in the wake of using benchmarking to define success and judge the performance of contractors, hence constructing an overall comprehension of what constitutes project success in the construction sector.
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ELODIE: A Tool for the Environmental Assessment of Building

Abstract

In 2007, the CSTB developed an environmental impacts assessment of buildings tool named ELODIE. Based on a Life Cycle approach, this tool meets the need of construction sector in quantifying the building performances and contributing to the environmental friendly design of buildings. In its first version it allowed to calculate only the products contribution to the environmental impacts of the building. The model uses Environmental Products Declarations (EPD) provided by manufacturers in the INIES database. ELODIE is now a complete building assessment tool integrating contributory elements as energy and water consumptions, transport of users'(in line with NF P01-010 and NF P01-020 methodology). ELODIE can also use the information of the Building Information Model (BIM) to facilitate the calculation of the building's quantity take off. As a result, ELODIE provides an environmental multi criteria profile of the building and will provide at the end of 2009 a complete score of the building that will enable an easier environmental comparison of buildings. ELODIE also provides tools to help designers to identify major environmental improvement solutions. ELODIE has now solid bases to integrate or develop links with new modules.
on comfort aspects (acoustic, lightning, thermal comfort’) and economic and social aspects to become a more complete tool to assess the environmental sustainability of buildings.

**Keywords:** building impact assessment, life cycle assessment, environmental product declaration, INIES, ELODIE
1. Introduction

ELODIE was developed in order to meet the need of construction sector in quantifying the environmental building performances and to use the environmental data produced by manufacturers (EPDs on construction products). If several LCA-based analysis tools have been developed in the past few years around the world, none is specially adapted to the French context or use a methodology based on the product scale data. FDES is the French equivalent for EPD’s, which contains Life Cycle Assessment (LCA) data (made for a French context), together with health and comfort aspects. The tool ELODIE provides assistance for the choice of environmentally friendly constructive solutions. It allows comparing several alternatives for the same building or for the same part of work realized with different components, different materials, and even different constructive modes. Within few years, it will become a complete environmental assessment tool (with environment, but also health and comfort aspects as in HQE approach) and will be developed in coherence with sustainability assessment tools. It will be consistent with standardization basis and SBA work about a core set of indicators shared by number of countries and the French HQE approach. Based on a life cycle approach and on the standard XP P01-020-3, the software can be used to set up models of new buildings or existing ones.

2. Scientific model

The model is based on the quantification of the flow’s balance. At the building scale, we named these flows contributory elements. The model (illustrated by the following figure) considers the sum of the impacts of various flows as material and products, as energy and water consumptions.

Figure 1: The building environmental performance calculation model
The quantification of the contributory element “product and material” is based on the FDES. French construction sector has decided to develop common rules to establish environmental declarations of construction products (EPDs). This decision led to the development of a standard, (i.e. NF P01-010) issued in 2004. The adopted methodology for the EPDs establishment is based on Life Cycle Assessment (LCA) approach and includes also the health and comfort aspects. In order to improve the dissemination and the accessibility to these type III declarations, the EPDs, a public free access data base has been created in 2004, i.e. INIES database (www.inies.fr). At present, there are about 420 EPDs. The LCA is based on a cradle to grave analysis including packaging, and complementary products.

French EPDs contain 16 environmental indicators to evaluate the environmental impact of one product.

Table 1: The environmental indicators of French EPDs

<table>
<thead>
<tr>
<th>Environmental Impact</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Energy consumption</td>
<td></td>
</tr>
<tr>
<td>Total primary energy</td>
<td>MJ</td>
</tr>
<tr>
<td>Renewable energy</td>
<td>MJ</td>
</tr>
<tr>
<td>non renewable energy</td>
<td>MJ</td>
</tr>
<tr>
<td>2 Resource depletion (ADP)</td>
<td>kg Sb eq.</td>
</tr>
<tr>
<td>3 Water consumption</td>
<td>L</td>
</tr>
<tr>
<td>4 Recovered waste</td>
<td>kg</td>
</tr>
<tr>
<td>Eliminated solid waste</td>
<td></td>
</tr>
<tr>
<td>hazardous waste</td>
<td>kg</td>
</tr>
<tr>
<td>non hazardous waste</td>
<td>kg</td>
</tr>
<tr>
<td>inert waste</td>
<td>kg</td>
</tr>
<tr>
<td>radioactive waste</td>
<td>kg</td>
</tr>
<tr>
<td>5 Climate change</td>
<td>kg CO2 eq.</td>
</tr>
<tr>
<td>6 Atmospheric acidification</td>
<td>kg SO2 eq.</td>
</tr>
<tr>
<td>7 Air pollution</td>
<td>m3 of air</td>
</tr>
<tr>
<td>8 Water pollution</td>
<td>m3 of water</td>
</tr>
<tr>
<td>9 Destruction of the stratospheric ozone layer</td>
<td>kg CFC eq.</td>
</tr>
<tr>
<td>10 Formation of photochemical ozone</td>
<td>kg ethylene eq.</td>
</tr>
</tbody>
</table>

Manufacturers of electric components and equipments (as ventilation, boilers, etc.) had chosen a similar format of environmental data expression: the PEP (Profile Environmental Product).

EPDS and PEP both can be used in the tool. At present, there are about 300 PEP, disseminated on various data database.

2.1 The tool’s structure

From the quantity survey of a building and EPD’s, the tool allows calculate the contribution of products to the environmental impacts at the building scale.

From the quantity of consumed energy and water and ESD’s (Environmental Service Declaration), the tool calculates the impacts of the building during its design life.
The ELODIE introductory part collects data about the building and constructs the functional unit of the evaluation. This data record concentrates common data for calculation in different modules and contains information such as: the building design life, the size of a building as measured by its floorspace, the construction period, the location of buildings, operating periods, the number of occupants or workers in a building, etc.

### 2.2 Materials and products contribution

ELODIE calculates the environmental impact of a building from the quantity of each product inserted in this building and their FDES (functional units must be the same). It is also possible to use other sources of environmental data for one product. To calculate the results, the model require an estimated lifetime (DVE) for each product, which is taken as the lifetime of the FDES initially but can be adapted to the project and the service life of the building (DVP). Consequently ELODIE calculates the number of replacement for each product, the quantity to insert, and then the environmental contribution of each product.

<table>
<thead>
<tr>
<th>Number of replacing:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>if DVE≥DVP</td>
<td>There is no replacing: the product is used only one time</td>
</tr>
<tr>
<td>if DVE&lt;DVP</td>
<td>The number of replacing is ( t = \text{ENT}(\frac{\text{DVP}}{\text{DVE}}) + 1 )</td>
</tr>
</tbody>
</table>

The sum of the impact of the products is one part of the environmental profile of the building.

### 2.3 Energy consumption contribution

ELODIE allows connecting energy concerns to environmental ones. From the impact of placing energy at disposal (under an ESD), and amount of consumed energy resources during the building service life ELODIE calculates the environmental impacts of the site energy consumption. These impacts are dependants of factors such as: the losses in production, transmission and distribution of energy on the grid scale, generation and distribution efficiency in the building itself, nature of combustible (coal, wood, fuel, etc.), etc. Among the multi criteria results, the amount of primary energy used to provide end users site energy is specified. ELODIE database contains few generic ESD, but the user can create his own ESD.

### 2.4 Water consumption contribution

ELODIE estimates the water consumption of a building using as input data: 1) some building characteristics such as floor area and its geographical location 2) the number of occupants and their behaviour 3) some characteristics of the water distribution network such as the hot water production device and the presence or not of the water pressure regulator 4) the characteristics of the water-using equipments (toilet flush type, shower flow, washing machine type etc.). The user can choose several types of equipment intended for the same use (e.g. a 6L toilet flush and a 6L/3L dual flush toilet) as well as the equipment which he wishes to integrate in total calculation (e.g. to not take into account the consumption of the washing machine or to take into account only the inside uses etc). ELODIE
could also estimate the cost of consumed water and to highlight the equipments whose impact is most important on the total water consumption.

![Pie chart showing water consumption](image)

**Figure 2:** Example of results on water consumption of a housing

### 3. ELODIE and the building information model (BIM)

ELODIE has an internet interface which is connected to the INIES database. ELODIE is compatible with IFC (Industry Foundation Classes) formats, allowing a full integration in building project processes. The quantity of each product already occurs in the numeric description of the building. Those quantities can be easily transferred to the ELODIE software if the IFC format is used. In the best cases ELODIE will only need to ask for the lifetime of the building, and will calculate alone immediately the environmental impact of the building describe in the IFC format. The goal of the compatibility with the IFC format is to avoid having to capture data twice.
4. ELODIE’s results

ELODIE provides, as a principal result, an environmental profile of the building, which compiles all the contributions of the various products, the site energy consumption and the water supply. This profile corresponds to the environmental indicators of the NF P01-010 standard, preserving all of them for a better transparency of the results. ELODIE allows considering distinctively the contributory impacts: building products, energy and water supply.

The calculation of the contribution of the construction products gives as results the opportunity for construction sector actors (designers, client, project managers…) to design a building with an environmental friendly approach : it makes possible to compare several alternatives for the same building or for the same part of work realized with different components, different materials, and even different constructive modes.
Figure 4: Analysis of results: Comparison of various constructive solutions for a single house, on the environmental impacts of the building.

The results of the product module contribution must be considered with energy and water contribution results in order to consider the whole environmental performance and avoid impacts transfers.

Impact : Déchets non dangereux éliminés

Figure 5: Analysis of results: Example for one impact indicator for a whole building, displaying the main contributors.
5. Experience feedback:

We worked with manufacturers, designers, association to analyze the impacts of constructive solutions, to identify the contribution of products and operating energy consumption in building environmental performance, etc. For example, we evaluate – on the whole all life cycle environmental - the contribution of few specific products, considering several standard buildings, corresponding to different level of French thermal building rules, different technical solutions, a potential optimum (between environmental and thermal performances), etc.

The used data were the following ones:

- French Environmental Product Declarations (EPDs, according to NF P-01-010 standard),

- environmental contributions of Operating energy consumption (heating, sanitary hot water, air cooling, air conditioning, lighting) are considered using French environmental Service Declarations (ESDs),

- the service life of building is considered to be 50 years.

Figure 6 : Example of results: the environmental impacts of thermal insulation for a housing.

A first benchmarking has been done from the first building simulations on ELODIE. Results have been statistically analysed in order to define average data for each element of the building typology (house, tertiary, etc.), maximum and minimum targets. The influence of the structure product
(concrete, wooden, bricks, etc.) as the typology and the level of insulation have been considered. These results have to be consolidated before to be the base of a future regulation.

Figure 7: Building environmental Performance

6. The tool’s perspectives

After one year of testing with stakeholders, (they were about 1200 to be enrolled), ELODIE is diffused to a professional use after one-day training. A free version will still be available for testing and private use. By the middle of 2010, the tool will integrate new aspects (i.e. user’s transportation, site waste) in its environmental assessment model. Step by step, ELODIE will integrate health and comfort aspects (hydrothermal, acoustic, visual comfort and olfactory comfort, serviceability, indoor air quality).

Construction sectors actors became more and more aware to environmental aspects at product and building scale. They are asking for a quick dissemination and evolution of environmental assessment tools or models as ELODIE. Moreover, professionals need reference scales to analyse their own results, and methodology guidelines.

Several evolutions are planned to improve the tool, in order to propose a making-decision tools and more analysis elements. One of the next steps will be to propose an evaluation model adapted to every typology and every conception and construction stage, with the objective to simplify of the physical building model.

Endly, this kind of tool will become support for the French energy and environment labels on buildings (HQE certification, energy labels derived from the French energy regulation on buildings…).
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Developing Indicators for Transparency and International Benchmarking in Construction and Real Estate Industry

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Abstract

CREDIT (Construction and Real Estate - Developing Indicators for Transparency) was a 27 month research and development project (2008-2010) that aimed at improving transparency on value creation in real estate and construction. Its objective was to develop methods and tools that support the identification and understanding of user needs and the interpretation of these needs as requirements for building performance. CREDIT has developed a comprehensive performance assessment and management framework with Key Performance Indicators (KPIs) to measure and verify the compliance of performance in use throughout the lifecycle of buildings. It also drew recommendations as to how sectoral, national and international benchmarking of construction and real estate may be carried out. This paper describes the CREDIT performance indicator framework, shares findings from implementing different benchmarking schemes and analyses experiences from implementation of CREDIT indicators in pilot projects. The challenges of achieving true value metrics and to do successful cross border benchmarking are discussed.

Keywords: key performance indicators, performance, value creation, case studies, cross-border benchmarking
1. Introduction

Providing complex public facilities, such as hospitals, schools and universities that meet both the internal and external stakeholders’ needs and requirements is not without complications. The aims and demands of different stakeholders within a project can sometimes create conflict with each other’s interest. Understanding the needs and requirements of these stakeholders are essential to staying competitive in today’s market environment. A client who pays attention to the needs of the end-users can be rewarded with a high-performance property. Simultaneously, this shift seeks to solve many drawbacks associated with inadequate building conditions and resulting in poor building serviceability. Due to the amount of both public and private money being invested in delivering public and private facilities, decisive measures must be adopted. Collaboration with the relevant stakeholders will help building owners in identifying the required performance indicators to create high-performance facilities. (Bertelsen et al, 2010b)

This paper describes the work undertaken in CREDIT project (Construction and Real Estate - Developing Indicators for Transparency) that was finished early 2010. The project developed methods and tools that support the identification and understanding of user needs and the interpretation of these needs as requirements for building performance. The approach also allows continuous measurement of the effectiveness of the applied requirements and the model as such so that it may be improved as more knowledge and experience of it is achieved.

The project was based on collaboration in five Nordic and two Baltic countries giving a solid and evidence-based transparent ground for communicating results and improving the competitiveness of construction and real estate business. These results have been achieved through active cooperation between the most prominent research institutes within benchmarking and performance indicators in construction and real estate SBi (Denmark), VTT (Finland), SINTEF (Norway) and Lund University (Sweden), and partners from Iceland (The Icelandic Center for Innovation), Tallinn University of Technology (Estonia) and Vilnius Gediminas Technical University (Lithuania).

We see many impacts of the project for construction and real estate on a national and European level. The work increases understanding of end user needs and satisfaction to client's performance requirements. Further, the methods and tools considered in the research for cost and value enhance transparency of products and services in both national and international level. This transparency may also be used for comparing neighbouring countries. These experiences during the project are also building a more solid and evidence-based ground to launch new public policies to improve the competitiveness of construction and real estate business. (Bertelsen et al, 2010b)

This paper provides a sectoral view to benchmarking from varied building types and is organized as follows. First, the benchmarking model of CREDIT is described. Second, the indicator classification for managing performance indicators to identify end user needs and value creation in real estate and construction is described. Third, we introduce the set of Key Performance Indicators (KPIs) that were selected based on findings from the case studies addressed in the project. Next we also explain our
findings from these 28 case studies. Finally, we draw recommendations for using these KPIs in a cross-border benchmarking pilot to office buildings in Norway and Finland.

2. The CREDIT indicator and benchmarking model

2.1 The product model

The CREDIT project covered housing, office buildings, schools and nurseries, universities, hospitals and shopping centres. The performance of the whole building and internal spaces and rooms are of special interest for the end-user, the owner and the surrounding society. Contrary to that the construction companies and producers normally are more interested in the construction of building parts. The performance of the building and assessment methods will also depend on the actual location of the building. The CREDIT case studies have been executed in all seven participating countries: Denmark, Finland, Norway, Sweden, Iceland, Estonia and Lithuania.

An important part of the project was the development of a model. We see that the design of building concerns two interlinked designs; internal space and rooms with different functions, and building parts as an envelope for the rooms and an external climate protection for the activities in the building. The product model in CREDIT looks primarily at the following three physical segments in the product model; the building parts and components, the building and internal spaces and rooms, and the location of building site, city, region and country. We analyse them from inside out as well as from outside as shown in Figure 1.

![Figure 1: Product model in CREDIT showing linkage between different segments.](image)

2.2 Performance indicator classification

The performance classification framework developed in a 'gross' inventory of indicators relevant in relation to the building and real estate sector in the seven Nordic and Baltic countries: Denmark,
Finland, Norway, Sweden, Iceland, Estonia and Lithuania. The content is based on the findings from 28 case studies in the project as well as on the input from national building regulations, different national or international standards and research studies. The performance indicator framework has been developed as an iterative process in parallel to the case studies, experiences from assessing methods and tools, and collecting feedback from enterprises on the application of benchmarking in their organization.

These promising results have been comprised to a structure of performance indicators in seven independent categories (Bertelsen et al, 2010a). The first category is on costs and price through the life cycle of the building, while the next five categories address performance from various perspectives: location, buildings, building parts, facility management and the design and construction process. They all include both an objective for measurable performance indicators and indicators addressing less measurable properties such as end-user experiences. The last category deals with impact of the building on external environment, social life and economy. Each of the seven main categories is divided to groups that contain an increasing level of detailing ending up with about 200 indicators (see Table 1).

Each indicator is titled and described shortly; see Bertelsen et al (2010a) for details. In addition to that the unit of how the indicator is measured is also described, and when possible also predefined values that the indicator may have are described based on standards and national regulations. In relation to earlier, the common target for performance indicator definitions is grades in 5 levels e.g. class A, B, C, D and E, where class A is the best.
An example of indicator assessment is the Danish energy labelling system. Data on what the building consists of, how well it is insulated and the convective properties of the building components are collected by inspections of the building and the drawing material. This data forms the basis for the calculation (processing and evaluation in Figure 6) of the buildings energy consumption. Output data is the calculation presented as classes ranging form A – G.
We see that the developed performance indicator classification framework can work as a tool to improve performance of buildings as well as to support the cooperation between the parties in the construction and real estate sector. Further, it is also important to get a better understanding on how the built environment can create value for the end-users and enhance activities in the building. End-user's experience and sensations are considered in five of the seven categories.

### 2.3 Selection of key performance indicators

The case studies revealed that there are only a few performance indicators that turn up in all cases or therefore may be selected as Key Performance Indicators (KPIs). In the case studies focusing on existing benchmarking systems we also noticed that there are certain general measures used as a baseline for other indicators, such as location, building type, size/area and price/costs. However, the values of indicators are also changing greatly between the different building types.

We have tested the applicability of these indicators in a CREDIT cross-border benchmarking pilot. The pilot tested a short list of 36 indicators to compare six office buildings in Norway and Finland. From the building owner and client perspective a set of 10 KPIs is proposed in Table 2 (Bertelsen et al., 2010a). Other proposals may be prepared in the future as alternatives and for other purposes to accommodate for different needs and wishes for benchmarking.

Table 2: A set of 10 Key Performance Indicators selected from CREDIT performance indicator classification framework for cross-border benchmarking pilot.

<table>
<thead>
<tr>
<th>Core 1:</th>
<th>1. Cost, price and life cycle economy (LCE)</th>
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<tbody>
<tr>
<td>Core 2:</td>
<td>2. Location, site, plot, region and country</td>
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<tr>
<td></td>
<td>23 Plot opportunities</td>
</tr>
<tr>
<td>Core 3:</td>
<td>252 Distance to public transport</td>
</tr>
<tr>
<td>Core 4:</td>
<td>3. Building performance and indoor environment</td>
</tr>
<tr>
<td></td>
<td>331 Adaptability to needs (now and over time)</td>
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<tr>
<td>Core 5:</td>
<td>34 Thermal comfort</td>
</tr>
<tr>
<td>Core 6:</td>
<td>352 Pollutants in indoor air</td>
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<tr>
<td>Core 7:</td>
<td>4. Building part and product performance</td>
</tr>
<tr>
<td></td>
<td>521 Rental agreement</td>
</tr>
<tr>
<td>Core 8:</td>
<td>5. Facility performance in operation and use</td>
</tr>
<tr>
<td></td>
<td>622 Working plan and time consumption</td>
</tr>
<tr>
<td>Core 9:</td>
<td>6. Process performance in design and construction</td>
</tr>
<tr>
<td></td>
<td>721 Climate change (CO2)</td>
</tr>
<tr>
<td>Core 10:</td>
<td>731 Energy efficiency</td>
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</table>
3. Findings from case studies and cross-border benchmarking pilot

This chapter describes how indicators are assessed and benchmarked in enterprises, building projects and international benchmarking systems. First, we describe findings from 28 case studies from Porkka et al (2010) addressing the common interest for indicators in case studies in Nordic and Baltic countries. The CREDIT case studies are distributed to different building types; 4 benchmarking systems and indicators, 7 office buildings, 8 housing cases, 5 school and nursery buildings, 3 shopping centres, and one hospital building. Then, we also introduce a cross-border benchmarking pilot implemented to office buildings in Finland and Norway. We also discuss about the challenges of achieving true value metrics and to do successful cross border benchmarking.

3.1 Findings from case studies

There are some good practices for benchmarking in large scale. At the moment, those are addressing mostly process and investment indicators, and do not yet cover performance indicators. Front-runner enterprises are already recognizing the potential of benchmarking, rating to highest class may increase interest from investors and building owners. Otherwise, some national and international rating systems are available in the market.

Few frontline owners are already using cost and performance indicators in daily operations, such as Senate Properties in Finland and Statsbygg in Norway. Their focus is mostly directed to investment, costs, and energy efficiency. Altogether, it seems that systematic procedures are needed in the industry for evaluating performance and compliance to end result to needs.

There is no commonly agreed or standardized global or European Key Performance Indicator system, but some national and international rating schemes are available. During the past five years the number of rated buildings has grown greatly, and motivation for using those is increasing.

Market signals are also showing paradigm shift towards end user involvement, and standardized methods for involving end users and making continuous monitoring of satisfaction should be agreed. When committing end users, they need help in order to be able to contribute in value adding way. Workplace management in office buildings is used for tailoring spaces better to end user needs. Senate Properties in Finland develops services where spaces are a strategic asset that can help to contribute an organizational change.

National and international indicator systems do not cover all important business matters and companies are developing their own systems. Some contractors have been developing national systems for process performance monitoring. Indoor environment is important in shopping centres, and performance level for spaces is an opportunity to owner to enhance cash flow through rental agreements. In the future, building automation systems could provide real-time monitoring of
performance indicators continuously contributing changes automatically to reach desired performance.

Organizations are looking for an indicator system that could help them to measure and enhance performance of buildings. Apparently some indicators are more important than others; regulations for accessibility have become tighter, location is still the core driver, common interest towards operations and reducing annual energy consumptions is growing. There is potential to improve energy efficiency of buildings. Indicator systems should be implemented in tools to encourage usage in projects; those processes are now rather manual. Building Information Models (BIMs) may be suitable tool for managing those more automated way. Based on findings in CREDIT project, offices and shopping centres are most attracting building types in terms of benchmarking.

### 3.2 Cross-border benchmarking pilot in Nordic countries

During the last quarter of the CREDIT project a cross-border benchmarking exercise was carried out in six offices (Figure 2) in Norway and Finland (Huovila et al, 2010). The Norwegian part was implemented by SINTEF at Skattens Hus (Skanska as main contractor) and Statistics Norway (Statsbygg), while the Finnish projects were collected by VTT at Lappeenranta and Vuorimiehentie 5 office buildings (Senate Properties), Tulli Business Park (NCC Finland) and Baltic Sea House (Sponda/Ovenia). Besides these six cases, Senate Properties in Finland wanted to test indicators also in one of their recent projects – the office building at Hakaniemenranta 6. Hakaniemenranta was a very challenging project, some years back the building was voted to the ugliest building in Helsinki. Multiple methods and tools were used during the development project; Building Information Models (BIMs) and workplace management to mention few of those.

![Figure 2: Six office buildings from Norway and Finland used in cross-border benchmarking pilot (Huovila et al, 2010)](image)
The indicator set that was assessed comprised ten KPIs, which were selected based on case experiences and other relevant indicators. Altogether, these indicators gave a great overview and included enough challenges that had to be solved in developing an indicator system. On the other hand this pilot also pointed out that it’s not an easy task to develop an indicator system that is applicable for international use. We managed the cross-border benchmarking data with web-based benchmarking tool (Huovila et al., 2010). The benchmarking system provides tools for indicator storage, management, benchmarking and analyses. Further, it also provides reporting functions for the building stock or trends in the building stock. When the data from cases was added to the system, we perceived that the user interface is very important and has influences the motivation of users. Therefore, VTT added map-user interface to the tool. One screenshot from tool demonstration is presented in Figure 3, and the user may select the buildings from the map to access the indicator data. The system also enables users to see the cross-section of the building stock and consider trends.

It is also hard to capture and formalise end-user needs and experiences, and soft values are often easier to collect in interviews and satisfaction surveys. We used professionals to judge rather many indicators comparing usability, adaptability, and architectural quality. One of these cases promoted flexible design solution. In Finland, Tulli Business Park is a solution that takes people to centre stage and enhances job satisfaction by minimizing negative stimuli in the working environment. The design concept is flexible to built open space, cell offices or mixed office solutions. Recently also indoor environment and conditions have gained much attention. We collected indoor climate indicators in measurements and evaluated also technical systems.
Figure 3: Screenshot from web based cross-border benchmarking tool (Huovila et al, 2010).

During the benchmarking pilot, we perceived challenges of achieving true value metrics and to do successful cross border benchmarking. We noticed that some indicators may result in incomparable values. For example the plot opportunities that address size of the site, building efficiency and density, and quality of outdoor spaces were hard to evaluate. Two rather similar buildings in town milieu may actually be totally different. How we rate those, depends greatly on do we judge areas with high or low density.
4. Conclusions

This paper has presented the sectoral view to benchmarking from the CREDIT project. Our goal has been to improve transparency on value creation in construction and real estate industry through methods and tools that support the identification of user needs for building performance.

First, we have explained our research focus on benchmarking from product perspective. Then, based to earlier, the CREDIT performance indicator classification system that builds up from seven independent facets to aggregate about 200 indicators was introduced. The classification was developed in parallel to research in 28 case studies on existing benchmarking systems, ON various types of firms, like clients and contractors, and on different types of buildings like offices, housing, schools and nursery, shopping centres and hospitals.

However, the case studies have also shown that built environment gives value for the end-users, and a lot needs to be changed until the end-users are actively involved in projects. Yet they are rather undervalued stakeholders. Third, we draw conclusions from the case studies and based on the findings, we formulated a set of 36 performance indicators that we tested in the cross-border benchmarking pilot of six office buildings. The results from this exercise were encouraging.

Enterprises are benchmarking indicators to some extent but systematic process has not yet been developed and a uniform indicator system considering also building performance and value creation is missing. We foresee that the work may direct actors to increasingly consider building performance and value creation. Therefore, we propose that actors define several sets of performance indicators based on their specific needs and requirements.

To conclude, we see that the project has improved understanding of end user needs, performance indicators and international benchmarking. It also has created a solid and evidence-based transparent ground for communicating results and improved the competitiveness of the construction and real estate business.

Acknowledgement

The CREDIT project wishes to thank industrial partners and the four Nordic funding agencies that sponsored the project as part of the ERABUILD collaborative research funding scheme: The Danish Enterprise and Construction Authority in Denmark (funding SBi), TEKES in Finland (funding VTT), The Nordic Innovation Centre (NICe) (funding SINTEF in Norway, TUT in Estonia and VGTU in Lithuania) and FORMAS in Sweden (funding Lund University)
References


Assessing the condition of infrastructure assets is a task of major relevance to public agencies. For transportation agencies, this is especially important for gathering data to be used in pavement management programs. This data not only provides information on the current condition of the asset, but it also helps the agency to make decisions on future maintenance and rehabilitation activities. For pavement condition assessment, two major data collection techniques have been identified: automated surveys and manual surveys. Automated surveys have been found to be safer and quicker, but manual surveys have been proven to offer preciseness and cost-effectiveness. Manual surveys still have the stigma that the results are based on subjective judgments by the individual evaluators. Therefore, agencies could benefit from a system for assessing the performance of manual pavement condition surveys. The inter-rater agreement measure is proposed as a method for assessing the performance of multiple evaluators. Inter-rater agreement refers to the degree to which people are interchangeable; in other words, the extent to which the results of the assessment stay the same when different people perform the evaluation. When the inter-rater agreement measure is applied to actual pavement condition data collected manually by ten different evaluators, the results show that it is an effective method for identifying data collection issues. The benefit of this measure is that it provides performance data during the data collection process, thus minimizing the risk of subjectivity. The inter-rater agreement measure can be used as part of an asset management program, and could be particularly beneficial in the continual training of manual evaluators.

**Keywords:** manual condition surveys, Inter-Rater agreement, asset management.
1. Introduction

Quality inspections are often performed for engineering projects to assure that the work complies with applicable standards. Compliance with some standards can be objectively assessed (i.e., rely upon a measurable amount), while other standards entail criteria that cannot be measured and, therefore, the assessment of their compliance depends on subjective judgement. This is particularly true in asset management, where the large number of elements subjected to assessment, and the different aspects to be assessed, make it difficult and not cost-effective to perform objective evaluations over the entire inventory of a system (e.g., each mile of a pavement network).

Nevertheless, these assessments are of considerable importance. In the case of pavement management, judgment of pavement condition by multiple evaluators is necessary to be able to cover such a large network. The data from the evaluations are typically used to make decisions on repair or reconstruction projects. Therefore, the quality of these assessments is very important. Public entities as well as private project owners would benefit from the use of a process that can be used to monitor the performance of subjective evaluations made by multiple people.

The objective of this paper is to present a method for measuring the performance of manual evaluators for asset management. While the application presented in this paper is for the manual evaluation of pavement condition data, the proposed method can be applied for measuring the performance of any group of evaluators. This paper proposes the use of Inter-Rater Agreement (IRA) measures as a quick and effective means to assess performance of subjective evaluations made by multiple people. Data were collected from manual pavement condition surveys performed by a panel of 10 evaluators. Average Deviation (AD) indices were computed, and the results demonstrate how IRA measures can be effectively used to monitor and control performance of manual assessments.

2. Manual pavement condition surveys

According to the U.S. Federal Highway Administration (FHWA), asset management is a “strategic approach to allocating resources - dollars, people, and data - for the preservation, operation, and management of . . . transportation infrastructure.” (FHWA 2009) With this same idea, researchers in the 1960s and 1970s began to use the term pavement management system (PMS), referring to the framework of methodologies and processes applied for the activities of planning, designing, constructing, and maintaining pavements (Haas & Hutchinson, 1970).

An important feature of a PMS is the ability to determine both the current condition of a pavement network and predict its future condition (Shahin, 2005). Evaluation is a key part of pavement management because it provides the means to realize how well the planning, design, and construction objectives have been satisfied. This is done by measuring and assessing pavement factors such as structural adequacy, performance, surface distress, safety, and maintenance and user costs. This has to be done in order to a) provide data to revise and update design predictions, b) reschedule rehabilitation measures as indicated by the updated predictions, c) improve design models, d)
improve construction and maintenance practices, and e) update network programs (Haas et al., 1994). The four measures that represent the most important outputs of the process of evaluation are (Haas et al., 1994; and Huang, 2004): (1) surface distress; (2) roughness; (3) structural adequacy; and (4) surface friction.

During evaluation, data can be generally collected according to two different approaches: 1) manual condition assessment, where the different pavement measures are visually assessed by a pavement evaluator, on site; and 2) automated techniques, which consist either of the use of automated tools and devices to measure the distresses of the pavement onsite, or of image scanning onsite and data analysis offsite. While it has been noted in the literature that automated pavement condition data collection is safer and faster, it has also been reported that the data gathered by onsite manual assessments (i.e. walking surveys) is more precise (Haas et al., 1994; Shahin, 2005). On the other hand, federal and state agencies are concerned about the consistency of data collected with manual condition assessments. In fact, manually collected data may include variability due to the fact that manual collection methods involve multiple evaluators. Variability in manual data collection methods is still an issue that has not yet been resolved (Rada et al., 1997).

3. Inter-Rater agreement measures

The main concern regarding the use of manual pavement evaluations is its subjective nature that, accumulated along the whole team of evaluators, produces a degree of variability that may make the outputs of the evaluation not reliable enough to support a critical decision regarding rehabilitation and maintenance budgets. Reliability is the extent to which any measuring procedure yields the same or consistent results on repeated trials (Carmines & Zeller, 1979); in the case of manual pavement evaluations, reliability would refer to the extent to which pavement evaluators rate pavement the same way, regardless of the exterior factors involved as well as the differences in judgement among evaluators.

Two statistical concepts that address these concerns are inter-rater reliability (IRR) and inter-rater agreement (IRA). IRR refers to the relative consistency in ratings provided by multiple judges of multiple targets (Bliese, 2000; Kozlowski & Hattrup, 1992; LeBreton, Burgess, Kaiser, Atchley, & James, 2003). Estimates of IRR are used to address whether judges rank order targets in a manner that is relatively consistent with other judges (LeBreton & Senter, 2008). In contrast, IRA refers to the absolute consensus in scores furnished by multiple judges for one or more targets (Bliese, 2000; James, Demaree, & Wolf, 1993; Kozlowski & Hattrup, 1992; LeBreton et al., 2003). Estimates of IRA are used to address whether scores furnished by judges are interchangeable or equivalent in terms of their absolute value. The concepts of IRR and IRA both address questions concerning whether or not ratings furnished by one judge are “similar” to ratings furnished by one or more other judges (LeBreton et al., 2003). These concepts only differ in how they define inter-rater similarity. Agreement emphasizes the absolute consensus between judges and is typically indexed via some estimate of within-group rating dispersion; reliability emphasizes the relative consistency or the rank order similarity between judges and is typically indexed via some form of a correlation coefficient (LeBreton & Senter, 2008).
Both concepts have been erroneously used as the same in the literature. However, the difference between them is that the concern of IRR is with relative consensus (consistency), while IRA measures absolute consensus. Since the main concern with manual pavement evaluations is not the consistency, but the absolute consensus among evaluators, IRA measures serve better the goals of measuring and monitoring performance of manual pavement evaluations. There are many IRA measures that have been developed in the literature, and their use has extended from strategic management to health sciences applications (LeBreton & Senter, 2008). The most commonly used measures of IRA are $r_{WG}$ Indices, Standard Deviation Indices, and Average Deviation Indices (LeBreton & Senter, 2008).

Arguably, the most popular estimates of IRA have been James, Demaree, and Wolf’s (1984, 1993) single-item $r_{WG}$ and multi-item $r_{WG(I)}$ indices. When multiple evaluators rate a single target (e.g. a pavement or road sample) on a single variable (e.g. a distress’ degree of severity) using an interval scale of measurement, IRA may be assessed using the $r_{WG}$ index, which defines agreement in terms of the proportional reduction in error variance. The use of $r_{WG}$ is based on the assumption that each target has a single true score on the construct being assessed (e.g., longitudinal cracking degree of severity). Consequently, any variance in evaluators’ ratings is assumed to be error variance. Thus, it is possible to index agreement among evaluators by comparing the observed variance to the variance expected when judges respond randomly. Basically, when all evaluators are in perfect agreement, they assign the same rating to the target, the observed variance among judges is 0, and $r_{WG} = 1.0$. In contrast, when evaluators are in total lack of agreement, the observed variance will asymptotically approach the error variance obtained from the theoretical null distribution as the number of evaluators increases. This leads $r_{WG}$ to approach 0.0.

Schmidt and Hunter (1989) critiqued the $r_{WG}$ and $r_{WG(I)}$ indices, largely based on semantic confusion arising from earlier writers’ labels of the $r_{WG}$ indices as reliability coefficients (James et al., 1984) versus agreement coefficients (James et al., 1993; Kozlowski & Hattrup, 1992). Their primary concern with $r_{WG}$ was that it was not conceptually anchored in classical reliability theory – where reliability is defined as one minus the ratio of the variation of the error score and the variation of the observed score. Although this was an accurate statement, it is not necessarily a limitation of the $r_{WG}$ indices because they are not reliability coefficients. In any event, Schmidt and Hunter recommended that when researchers seek to assess agreement among judges on a single target, researchers should estimate the standard deviation (SD$_X$) of ratings and the standard error of the mean rating (SE$_M$).

Kozlowski and Hattrup (1992) rejected this approach to estimating agreement because the SE$_M$ is heavily dependent on the number of judges and because the Schmidt and Hunter approach failed to account for the level of agreement that could occur by chance. The sensitivity of the SE$_M$ to sample size limits its usefulness as a measure of rating consensus (Lindell & Brandt, 2000; Schneider et al, 2002). These researchers have stated that the SD$_X$ is most appropriately conceptualized as a measure of inter-rater dispersion or disagreement. Consequently, this index is not necessarily an optimal index of agreement.
The average deviation (AD) index has been proposed as another measure of IRA (Burke, Finkelstein, and Dusig, 1999). This measure, like $r_{WG}$, was developed for use with multiple evaluators rating a single target on a variable using an interval scale of measurement. The index is described as a “pragmatic” index of agreement because it estimates agreement in the metric of the original scale of the item (i.e., it has the same units as the item targeted). The AD index may be estimated around the mean ($AD_M$, Equation 1) or median ($AD_{Md}$, Equation 2) for a group of evaluators rating a single target (i.e. pavement distress):

$$AD_{M(j)} = \frac{1}{K} \sum_{k=1}^{K} |X_{jk} - \overline{X}_j|$$

*Equation 1: Single-item Average Deviation Estimated Around the Mean (Burke et al, 1999)*

$$AD_{Md(j)} = \frac{1}{K} \sum_{k=1}^{K} |X_{jk} - Md_j|$$

*Equation 2: Single-Item Average Deviation Estimated Around the Median (Burke et al, 1999)*

where k=1 to K evaluators, $X_{jk}$ is the kth evaluator’s rating on the jth item, and $\overline{X}_j$ and $Md_j$ are, respectively, the item mean and median taken over evaluators. It has been noted that the use of AD for medians may be a more robust test (Burke et al, 1999). Similar to $r_{WG(j)}$, AD can be calculated for J essentially parallel items rated by K evaluators as follows, where all terms are as defined above and j=1 to J essentially parallel items (Equations 3 and 4).

$$AD_{M(J)} = \frac{1}{J} \sum_{j=1}^{J} AD_{M(j)}$$

*Equation 3: Multi-item Average Deviation Estimated Around the Mean (Burke et al, 1999)*

$$AD_{Md(J)} = \frac{1}{J} \sum_{j=1}^{J} AD_{Md(j)}$$

*Equation 4: Multi-item Average Deviation Estimated Around the Median (Burke et al, 1999)*

As explained by Burke & Dunlap (2002), the AD index is actually a measure of disagreement, such that a value of zero (e.g., $AD_M = 0$ or $AD_{Md}= 0$) means that there is zero disagreement (i.e., total agreement). Since there is rarely total agreement among evaluators, a cut-off value of c/6 can be used to determine whether there is a consensus among evaluators, where c represents the number of response options (Burke & Dunlap, 2002). Values lower than the cut-off point mean acceptable levels
of consensus, while a value that falls over the cut-off point would indicate a problem of consensus between evaluators.

After analyzing these commonly used measurements of inter-rater agreement, the question that arises is which measurement applies best to assess the performance of a pavement condition surveying panel, where the presence of different distresses in a road, or the combination of more than one, is evaluated by assigning either a categorical (i.e. “poor”, “good”, etc.) or a numerical discrete (i.e. a number between 0 and 3) value; all this based on established protocols, as well as on the knowledge and judgement of the evaluators.

These requirements suggest the use of the AD indices as the most appropriate measures for performance assessment and monitoring of manual pavement condition surveys. SD, and SE have already been rejected as measurements of agreement (Kozlowski & Hattrup, 1992; Lindell & Brandt, 2000; Schneider et al, 2002). The r WG indices have the shortcoming that a null distribution has to be modelled in order to implement their use. This represents an important inconvenience for manual pavement evaluation performance measurement, since shaping a null distribution is time-consuming and, even more important, it has to be done each time the protocols are adjusted. Therefore, the use of mean and median, single- and multi-item, AD measures are recommended to measure inter-rater agreement.

4. Data collection & analysis

In order to show how IRA measurements can be used to assess and monitor performance of manual pavement condition surveys, data were collected from the 2009 Northern New Mexico Pavement Evaluation Project. The New Mexico Department of Transportation (NMDOT) contracted with the University of New Mexico (UNM) for the condition assessment of the northern half of NMDOT’s pavement network. For this, UNM hired 10 pavement evaluators who would stop at each mile marker along all Interstate, United States Federal, and New Mexico highways in the northern half of New Mexico, to assess the condition of a 0.1 mile-long, one lane-wide flexible pavement segment. The evaluators assigned a discrete number ranging from 0 to 3 to eight different distresses for both severity and extent, based on criteria developed by the NMDOT.

The numbers assigned by the evaluators represent the degree to which the road is affected by a particular distress (distress severity), and a second number is assigned to the portion of the sample evaluated that is affected by that same distress (distress extent). A value of 0 represents a “null” presence of the distress evaluated, or “no presence”; a value of 1 represents the “low” category; a value of 2, “medium” presence of that distress; and 3 means that the distress has a “high” presence in the road sample. Figure 1 shows an excerpt of the severity and extent criteria used for the Pavement Evaluation Project for one distress – rutting and shoving. Table 1 contains the descriptions of each of the eight distresses evaluated during the Pavement Evaluation Project.
Figure 1: NMDOT Severity and Extent Descriptions for Rutting and Shoving

UNM developed and implemented a quality assurance and quality control (QA/QC) plan, as part of the agreement with NMDOT. Part of the plan consisted of having each evaluator perform a distress evaluation at the same 24 locations at two different times, so that the results could be compared across evaluators and across time. In order to avoid biases among the evaluators, these two rounds of evaluations were performed several weeks apart. The data gathered during these quality checks were analyzed using both ADM and ADMd multi-item indices.

Table 1: NMDOT Distress Descriptions (from Miller & Bellinger, 2003)

<table>
<thead>
<tr>
<th>Distress</th>
<th>Description</th>
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<tbody>
<tr>
<td>Raveling &amp; Weathering</td>
<td>The wearing away of the pavement surface, due to dislodged aggregate particles and loss of asphalt binder.</td>
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<tr>
<td>Bleeding</td>
<td>A film of bituminous material on the pavement surface.</td>
</tr>
<tr>
<td>Rutting &amp; Shoving</td>
<td>Longitudinal surface depressions in wheel path.</td>
</tr>
<tr>
<td>Longitudinal Cracks</td>
<td>Cracks predominantly parallel to pavement centreline. Location within the lane (wheel-track, mid-lane, and centreline) is not of significance.</td>
</tr>
<tr>
<td>Transverse Cracks</td>
<td>Cracks that are predominantly perpendicular to pavement centreline and that extend over the entire width of the lane.</td>
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<tr>
<td>Alligator Cracks</td>
<td>Pattern of interconnected cracks resembling chicken wire or alligator skin.</td>
</tr>
<tr>
<td>Edge Cracks</td>
<td>Cracks which occur on the edge of the pavement.</td>
</tr>
<tr>
<td>Patching</td>
<td>An area where the original pavement has been removed and replaced with similar or different material.</td>
</tr>
<tr>
<td>Distress</td>
<td>Description</td>
</tr>
<tr>
<td>Low:iltro inch to ½-inch in depth.</td>
<td>Low: 1% to 30% of test section.</td>
</tr>
<tr>
<td>Mid: ½-inch to 1-inch in depth.</td>
<td>Mid: 31% to 60% of test section.</td>
</tr>
<tr>
<td>High: More than 1-inch in depth.</td>
<td>High: 61% of test section, or more.</td>
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</tbody>
</table>
5. Results

For the purposes of showing how IRA can be used to assess the performance of manual evaluations, the data collected were analyzed by using Equations 2 and 4. The raw data used in the study represent each of the assessments of 16 different distresses (8 distress severities and 8 distress extents) performed by 10 evaluators over 24 locations at two different times for a total of 7,680 data points. The data were grouped by round, then by distress type, and finally by each of the 24 locations. This way, using equation 2, single-item average deviations around the median were computed for each location. Then, Equation 4 was applied using the $AD_{Md(j)}$ indices to compute $AD_{Md(J)}$ for each type of distress. Then, the values of $AD_{Md(J)}$ were used to plot graphs comparing the data of each assessment round that show some of the many ways IRA can be used to monitor and control the performance of manual evaluations. As recommended by the introducers of the AD indices, a cut-off value of c/6 was used to determine whether there was a consensus among evaluators—in this case, the cut-off value equals to $4/6 = 0.67$. Values lower than 0.67 mean acceptable levels of consensus, while a value that falls over 0.67 would indicate a problem of consensus between evaluators.

The results of this analysis are shown in Figure 2. The column graph shows the $AD_{Md(j)}$ values of each distress during each of the two QA/QC rounds performed in the study. All values in Figure 2 met the consensus cut-off value of 0.67; however, the higher values for the degree of bleeding severity and extent were of concern for the project team (see labels A and B in Figure 2). In response, the project managers conducted an additional training session to reinforce the concepts of bleeding among the evaluators. It can be noted that for the second round of assessments, the AD values of both bleeding distresses had the largest amount of improvement. From Figure 2, it can also be noted that the AD values for other distresses considerably decreased (labels C, D, E, and F in Figure 2), which supports the idea that the performance of manual assessments has to be continuously tracked and controlled. Another aspect to be considered is the fact that in all the distresses during both QA/QC rounds, the assessments passed the cut-off value of 0.67, which indicates an overall acceptable performance.

Since one of the most important concerns about manual evaluations is its performance over time, a plot like the one shown in Figure 3 can be created. It is a graph that stacks the AD values for both QA/QC rounds in a single column for each distress, which shows the proportion of each assessment relative to the other. If the AD values were the same for both rounds, then the portion of the bar representing round 1 would be 50% and the same for round 2. Figure 3 shows the boundaries of a ±5% of variability band between QA/QC rounds as dashed lines. Bleeding and Rutting-Shoving are two distresses that show a difference greater than 5% between the two rounds. Since there is no standard for what should be the range to define acceptable variability available in the literature, the selected range will depend on the quality policies and standards of the project/activity.
Figure 2: Column plot of the AD values for each distress on each QA/QC round.

Figure 3: 100% Column-Stacked plot of the AD values for each distress.
Another aspect that could be of concern is the degree to which the data are spread. Figure 4 is a column graph that shows the maximum and minimum AD values on each QA/QC round for each distress. It can be seen from the columns of both bleeding severity and extent on round 1 that AD values did not show any "perfect" level of consistency among evaluators which would be denoted by an AD=0. It can also be noted that the range within which the AD values fell for bleeding extent on round 1 is less wide than for round 2, in spite of the improvement observed in Figure 2. Since the analysis was performed over the AD values around the median, it can be concluded that the overall spread of the data observed in Figure 4 is due to outliers whose influence is taken out by the multi-item measure (AD_{Md(J)}). A graph like the one shown in Figure 4 could be used if it is of importance to identify a particular evaluator who is not performing as the rest of the panel do.

![Figure 4: Column Graph with the maximum and minimum single-item AD values of each distress.](image)

### 6. Conclusions

Manual evaluations of asset conditions are a common practice of considerable importance, although their subjective nature is still a concern for many entities. Because of the subjective nature of manual assessments, there is a need to identify a method for measuring the performance of manual evaluators to improve the quality of the data they collect. To assess the performance of manual evaluators, this study found IRA indices to be an effective way to measure the consensus among a group of evaluators. There are several types of IRA indices, but the average deviation index was determined to be well-suited for asset management applications. As shown using data from a pavement evaluation program, the AD index allowed project managers to identify areas where consensus may be lacking.
thus, the project managers were able to focus additional training for evaluators in those specific areas. The results of the AD analysis were presented in three different ways to illustrate the different aspects that can be considered when evaluating the performance of manual condition assessments. A structured and more formal implementation process of these measurements can serve practitioners of any engineering field as part of a performance management plan for asset management.

References


Abstract

Many Studies on project performance evaluation have been focused on descriptive statistical findings based on the data collected. These methods lack in customizing individual projects by incorporating particular project characteristics. The objective of this study is to develop a new technique in quantifying the project management performance for the purpose of identifying the core business viability factors. To achieve the objective, the study followed the steps: (1) Identify the project characteristic factors and develop evaluation criteria for management performance (2) Cause-effect analysis between project-level influential factors and performance indicators (3) Develop a performance diagnosis system for predicting the level of potential risk factors on individual projects. Main research methodology applied for this study includes a literature search and expert interviews, followed by multi-variate statistical analysis. The final output is a multi-dimensional project data mining technology to effectively link the project characteristics with the performance level. By applying the proposed method, which may effectively converses the subject project characteristics with the predicted performance level. The findings from this study will contribute to the body of knowledge on the project evaluation strategy and innovative building construction project management practice. In addition, the results of this study enable the building industry to benchmark in a whole sense by maximizing the performance level. Finally, the guideline suggested in this study will be used for prioritization of the information usage in the industry based on the multi-dimensional project measurement system.

Keywords: project performance, multi-variate, project characteristic, management practice
1. Introduction

Since the construction companies are operated with a structure to create profit through order awarding, successful project performance is very important for them. However, as the recent construction projects become larger and complicated, importance of project management is embossed. Accordingly, acquisition of competitiveness from construction period, cost and quality aspects of the construction projects through systematic project management become important issues. As the construction projects contain a number of potential risks due to a feature to produce unique products on the site and have various kinds of resources to be put, they have a characteristic of difficult project management. Accordingly the recent construction projects require efficient project management and performance measurement of construction project has been utilized as a management tool. An economist, Peter F. Durcker emphasized importance of the performance measurement, saying “If you can't measure it, you can't manage it." 1 In order to establish reasonable project management strategies by removing inefficiency of the construction project and identifying its own level, performance measurement of the construction project is essential. From a viewpoint of the construction company continuing to carry out construction projects, it is required to properly utilize performance data accumulated experiences from the previous construction projects in order to maximize project productivity. It cannot be possible to ensure competitiveness until we find out reasoning factors for project performance based on performance measurements for successful and failed projects, build a system to improve them or reflect the results into the projects to be carried out afterwards and increase productivity of the continued construction projects. It is important not only to utilize results of project performance measurements within the corporation to compare them with those of other companies, since it is possible to benchmark superior project management strategies and find out essential factors to increase the construction project performance on the basis of performance measurement results of the construction projects carried out others. Because of importance of the construction project performance measurement, advanced countries such as CII BM&M (Benchmarking and Metrics) of USA, DTI (Department of Trade and Industry) of England, etc. are striving for conducting project performance measurements and utilizing them for project management. Construction project performance measurement system should be able to compare performance measurement results between individual projects each other and clearly define variables having influence on the project performance in order to find out improvements for the construction projects and utilizing them strategically by using the performance measurement results. However the construction projects are very diverse and even same type of projects has different characteristics. Project characteristics such as size, contract type, site conditions, legal, environmental conditions, owner, designer, contractor, etc. of the projects have small or large effect on the project performance. Therefore, it is unreasonable to simply compare project performance measurement results without considering different characteristics of the projects and it acts as a limit on benchmarking of the performance measurement results.

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Many studies on project performance evaluation have been focused on descriptive statistical findings based on the data collected. These methods lack in customizing individual projects by incorporating particular project characteristics.

The objective of this study is to develop a new technique in quantifying the project management performance for the purpose of identifying the core business viability factors. To achieve the objective, the study followed the steps: (1) Identify the project characteristic factors and develop evaluation criteria for management performance (2) Cause-effect analysis between project-level influential factors and performance indicators (3) Develop a performance diagnosis system for predicting the level of potential risk factors on individual projects.

2. Background research

The existing studies on the performance measurements have been executed by development of measurement method and indicators to evaluate level of normal companies from a viewpoint of business administration, and recent studies have continued to research on performance measurement systems and indicators of the construction companies with different characteristics from other industries. For performance measurement of construction industry, studies have been executed mainly for performance measurement of the construction companies. Simons & Davila had not only measured indicators to be quantified but also emphasized measurement of qualitative indicators. Kaplan & Norton suggested BSC (Balanced Scorecard) that allows performance measurement of both resultant indicators, i.e. financial indicators and those caused the results by defining them into Customer, Internal Process, and Learn & Development Perspective for the purpose of performance measurement for the corporations. In addition, CII BM&M (Construction Industry Institute Benchmarking & Metrics) of USA and DTI (Department of Trade and Industry) of UK have implemented systems to measure project performances to allow performance measurement results to be comparable for each project and utilize them as benchmarking tools. Especially, CII of USA has implemented a system to measure performances of the construction projects and collected project performance data from their members. It inputs the data into the performance evaluation system and provides consulting services on direction of project management through analysis of accumulated data and comparison between cases in order to actively utilize measurement results of project performances for the project management. Recently, as interest on performance measurement becomes exited, studies to measure performance of the construction industry effectively are tried, but measurement of the individual project performances and analysis methodologies are deficient. Especially, as the construction projects have different features, methods to convert project performances into the same level to be compared are also deficient.
3. Multi-variate performance evaluation framework

3.1 Needs for multi-variate performance evaluation technique

The first existing advanced study concerning about the construction performance measurements is a study on performance measurement including factors with influence on the project performance and performance results (Kaplan & Norton, 1992; Yu, 2007). It emphasizes the performance measurement including process and results upon an assumption that factors having effect on the project performance will be appeared on the subsequent project performance results. It aims to utilize performance measurement results to compare levels between construction companies or projects and carry out benchmarking.

The second one is a study to examine a cause-effect between factors having effect on the project performance and performance results through statistical technique (CII, 2001; Cha, 2008). This study has main purposes to find out factors having effect on the project performance from utilization aspect of performance measurement results and improve project performance through improvement of them. The existing advanced studies have a problem that the performance comparison considering characteristics of each project for comparing performance of the individual projects. In order to enable comparison of performance measurement with other projects, it requires a methodology to convert the construction projects with different characteristics into same conditions, since, for an example, conducting benchmarking with a comparison a project performance with optimal conditions for performance of construction project with those having disadvantageous environments or conditions at same level may result in distortion on the performance measurement results. Accordingly, it is required to define characteristics of the construction projects and establish effects of the characteristics on the construction project performances and it would not be possible to establish more reasonable and correct project management strategy until we convert the performance results from the construction projects with different characteristics at same level before comparison.

The existing studies related to the performance measurement and this study have a same purpose to compare levels between projects using the performance measurement results, utilize it as a benchmarking tool and suggest a strategy to improve performance results. However, a performance measurement system through establishment of 2 dimensional relation between factors having effect on the existing project performance results and performance results has some problems from an aspect of utilizing results. Therefore, in order to achieve the purpose to compare with other projects, conduct benchmarking, and improve performance by utilizing the performance measurement system as an efficient management tool of the construction projects, It is necessary to establish a new concept of performance measurement system. It is determined that it would not be possible to achieve the purpose of construction project performance management until a multi-dimensional performance measurement system has been implemented by considering project characteristics in addition to the existing effect factors on the project performance and project performance results.
3.2 The framework of multi-variate performance evaluation

This study has suggested a framework of Multi-variate project evaluation technique as shown on Fig. 1 in order to develop comparable performance measurement system. The framework of construction project performance measurement system consists of three elements including 1) Project Characteristics, 2) Influence Factors, and 3) Performance Indicator.

![Figure 1: Framework of performance evaluation technique](image)

Construction projects individually have different project implementation conditions, which have in turn large effect on project implementation results. In addition, the construction project contractor and manager strive to perform project management practice and improve project implementation results. Therefore, the construction performances are largely influenced from project implementation conditions and capabilities of the contractor and manager. It is required to calculate a conversion index to correct project performances by quantify project implementation conditions of the individual projects according to the PMS Framework defined above and also quantify project implementation results through the project performance indicator. In addition, it is required to make the project management practice into an index with influence factor. Project performance index is corrected with the project difficulty index and converted into the Converted Project Performance Index considering characteristics of the projects. And, it is necessary to find out variables to have influence on improvement of the project performance through Cause-Effect Analysis of the Converted Project Performance Index and Project Management Practice Index through which the project contractor and manager can derive action items to improve the project performances and establish performance improvement strategy.
4. Conceptual model of multi-variate performance evaluation

In order to compare, performance measurement results between the construction projects, conduct benchmarking and utilize them as a project management tool, it is necessary to implement a performance measurement system considering different project characteristics. It is required to develop a multi-dimensional performance measurement system considering construction project measurement results, influence factors and project characteristics in complex and it is possible to implement such a performance measurement system as shown on Figure 3.
Multi-dimensional performance measurement system first needs a process to quantify influence level of the project characteristics on the project performance. For that purpose, it is required to conduct a survey against the specialists on the project management area and quantify them to derive Conversion Index. As the Conversion Index is utilized a value to correct different characteristics of the individual projects, its reliability is very important. Afterwards, it needs to evaluate project characteristics and collect data on the project performance. It is required to design a systematic measurement indicator for collecting reliable data. It is possible to correct performances considering project characteristics by taking characteristic evaluation results of the concerned project, project performance and conversion index into account comprehensively. It is also possible to find out deficient capability of the relevant project through Cause-Effect Analysis between the corrected project performance in such a way and project management practices. On the basis of it, the project contractor and manager can derive action items to improve the project performances and establish the project performance strategies.

5. Identifying key factors for multi-variate performance evaluation

Three axes to configure the multi-dimensional performance system are project characteristics, performance influence factor and performance measurement results, and it is important to develop index to measure three items in order to realize a model of the performance measurement model implemented previously. We are now carrying out a study to develop indicators of 3 axes to be a framework of the multi-dimensional performance system. This paper has suggested indicator development results being progressed till now, even though they need verification and complement. The indicators of the multi-dimensional performance system have been derived through analysis of the advanced studies and project characteristics consist of 4 categories and 16 characteristics. And Project Management Practices have arranged with 7 categories and 22 factors, and Project Performance Indicators have been derived with 6 categories and 18 indicators.
Table 1: List of key factors (in progress)

<table>
<thead>
<tr>
<th>Components</th>
<th>Category</th>
<th>Key Factors</th>
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<tbody>
<tr>
<td>PC01. Project General Attribute</td>
<td></td>
<td>PC0101. Project Type</td>
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<td></td>
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<td>PC0102. Project Size</td>
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<td>PC0103. Contract type</td>
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<td>PC0104. Relative Level of complexity</td>
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<td>PC0105. Site Conditions and Location</td>
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<td>PC02. Project Participant Attribute</td>
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<td>PC0201. Owner previous experience</td>
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<td>PC0202. Identification Owner's Requirement</td>
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<td>PC0203. Owner profile and participation</td>
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<td>PC0204. Attitude/Ability of A/E</td>
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<td>PC0205. Contractor ability and experience</td>
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<td>PC03. Project Information Attribute</td>
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<td>PM01. Contract</td>
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<td>PM0102. Changes in Contact</td>
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<td>PM0103. Realistic obligations/clear objectives</td>
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<td>PM0104. Implement of Partnering</td>
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<td>PM0701. Effective project organization structure</td>
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<td>PM0702. Strong and capable project team</td>
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<td>PP0102. Accuracy of Cost Expectation</td>
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<td>PP0602. Labour Productivity</td>
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6. Conclusion

Different from the existing construction project measurements, it is expected that this study could convert performances of the construction projects with different characteristics at a sale level and achieve purposes of performance management such as comparison with construction project performances, benchmarking and establishment of project performance improvement strategy based on it. However, the result suggested on this study is a concept to implement a performance measurement system and we intend to carry out derivation of performance measurement areas and indicators and weights, verification of cause-effect between indicators, etc. through additional studies in the future. The findings from this study will contribute to the body of knowledge on the project evaluation strategy and innovative building construction project management practice. In addition, the result of this study enables the building industry to benchmark in a whole sense by maximizing the performance level. Finally, the guideline suggested in this study will be used for prioritization of the information usage in the industry based on the multi-dimensional project measurement system.

Acknowledgement

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Reducing risks with the Performance Information Procurement System (PIPS) in Finnish Construction Management Projects

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Abstract

This paper introduces three applications of the Performance Information Procurement System (PIPS) for advanced response to risks in Finnish Construction Management (CM) projects. As a context, the CM contract form offers more potential and risks related to multi-organizational collaboration compared to traditional contracting. Unlike in traditional contracting, the decision power remains with the project owner throughout the CM project. Another major difference is the concurrent performance of design, procurement, and construction under the management of a professional CM. Although one of the contract form’s aims is to improve construction performance by unifying the goals of the parties, the intentions do not always reach their full potential. The procurement-based, collaboration-intensive, and risk-bearing features of CM supported adopting a hitherto unexploited risk management method in Finnish CM projects. The Performance Information Procurement System (PIPS) is a process for buying best value by identifying vendor’s potential performance in the targeted project and supporting vendor’s self management. In the United States the PIPS has gained encouraging success rates and the described experiences imply similar results in Finland. The results are discussed in terms of the PIPS process implementation, observed results, and the risk management implications of the PIPS. In the case projects, the PIPS has enabled identifying and purchasing best value, developing innovation and minimizing the need for external control. Furthermore, construction management contracting and the PIPS together help dealing with demanding project time scopes, i.e. pace, which intensifies construction project risks. The presented cases support our view that a wider use of the PIPS process would increase construction performance, enable better control of risks, and provide a more reliable method for buying best value. The benefits may be substantial in Finland where a considerable share of the largest construction projects is performed under a CM contract. Unfortunately, traditional contracting and risk management models, procurement regulations, as well as the conservative construction organization culture may restrain the adoption of the PIPS even in collaboration-intensive CM contracts.

Keywords: risk, construction management contracting, CM, performance, PIPS, selection of construction manager
1. Introduction

Construction management (CM) projects require high professional performance and intense collaboration between the owner and the CM. Unlike in traditional construction contracting, the CM project is frequently commenced with unfinished designs, concurring design, procurement, and construction, and withholding the decision power with the owner throughout the project. Thus, we have observed, the risks related to collaboration between the main parties, to unfinished designs, and to division of the trade contracts repeat themselves often when working with this contract form.

Experience and research demonstrate that traditional risk management models are not alone enough to cover the complexity and uncertainty of the project-based business environment such as CM project business. For example McMillan (2008) and Shenhar and Dvir (2007) explain how the various dimensions of complexity, i.e. the scope, dynamics, and pacing of the project, environment, stakeholders etc. create a more demanding risk management task. The same applies to highly uncertain environments. Several researchers have suggested that such situations are better encountered with an adaptable and dynamic mindset and RM methods (see e.g. McMillan 2008, Murray-Webster & Hillson 2008). Similarly, a recent study by Lehtiranta et al (2010) shows that the RM literature is directing attention towards human-based models that claim to better accommodate uncertainty and complexity.

Procurement methods, on the other hand, change towards more objective decision making and less emotion and intuition driven approaches, as reported by Boer et al (2001) based on an extensive research review. What seems not to be changing in the main stream professional procurement is the buyer’s responsibility for control, decision making and risk management. None of the reviewed methods direct the vendor to take responsibility of risks and to justify selection based on potential future performance. Some of the most underdeveloped procurement method areas lie in the core of CM projects; the vendor selection criteria and qualification for novel tasks and strategic items, as well as the whole service procurement context. The selection phase itself is widely covered with systematic, mostly mathematical methods. The PIPS accounts for the notion of objectivity, but on the contrary to the main stream, aims at activating the vendor in control and risk management.

This paper presents experiences on filling the human-based risk management gap with the Performance Information Procurement System (PIPS). The PIPS is a process for identifying the best value vendor for a targeted project and directing the quality control from the client to the vendor, as described by the developer Kashiwagi (2010). The method differs greatly from traditional methods, which fail to identify and support the vendor’s present potential performance. Traditionally, the control, i.e. supervision is practiced regularly by the project owner and site management. Savicky et al (2003) emphasize the difference between identifying performance and managing performance. The former is highly recommendable for best value procurement whereas the latter may actually infer performance through tight control measures.

We introduce three different stances on managing construction project risk by using the PIPS and CM contracts. The first case describes the selection of the CM service provider. The PIPS process enables finding the potentially best CM service provider to perform in a project where the end requirements
and details are unknown, thereby minimizing the respective risks related to e.g. quality, schedule, and
budget. In the second case, the PIPS is used to select the best value trade contractor, and thus to
reduce the risk of non-performing procurement. The third case demonstrates a PIPS-enabled response
to adapting a design solution to the restrictions of project budget and to market conditions. We show
that the Performance Information Procurement System (PIPS) combined with construction
management contracting (CM) will not only enable better value procurement but also provides a
means for reducing complexity and uncertainty driven risks in the construction projects by enhancing
the collaboration in organizations.

### 2. The role of PIPS in CM projects

#### 2.1 Construction management (CM) projects in Finland

Construction Management (CM) contracting is studied and used in Finland in far greater proportion
than the mere size of the country implies. The development of the contract form started during high
economic growth in the 1980’s in Finland and boomed during the recession in the 1990’s. Now
construction management contracts are common in large building projects and their share of
construction projects value equals the share of the traditional general fixed sum contracting, being
one of the highest shares in the world.

Kiiras et al (2002) define construction management as a form where a professional, consultant-like
construction manager leads the project collaborating closely with the owner. Unlike in the US and the
UK, main contract with some multiple assigned prime contracts is not kept one of the CM contract
forms in Finland. In Finland, as in the US and the UK, two generic CM contract models are in use,
i.e. construction management consulting and construction management contracting. In the US these
are known as Agency CM and CM @Risk, and in the UK Construction Management (CM) and
Management Contracting (MC), respectively.

The CM project is two-phased. In the target setting phase the construction manager prepares the
general or overall design and the project plan. In the execution phase the design development,
procurement and construction are carried out concurrently divided into separate packages. In this text
we refer to the execution of each package a trade or specialty contract consistent with the US
standard. In Finland, such trade contracts may also consist of, for example, construction material
procurements.

CM implementation has two major differences compared to traditional construction contract forms.
First, the procurements are split into independent packages and aligning design, procurement and
construction phases. This procedure allows starting the construction and procurement with unfinished
designs. The traditional construction project model presents the design and construction phases
following each other without overlapping. Breaking the consecutive implementation of design and
construction into concurrent implementation will favor shorter overall schedules (see e.g. Kiiras et al
2002, CMAA 2003). The schedule-impact of the traditional consecutive implementation vs. the
concurrent CM implementation is compared in Figure 1. Second, contrasting traditional contracting, in CM implementation the owner decides on each trade contract together with the CM. That is, the owner has an opportunity (and a requirement) to simultaneously decide on the quality, price, and supplier of each construction item during the project execution phase. The CM is responsible to actively propose alternative solutions and report of the project cost, schedule and risk status.

![CONSTRUCTION FORM PROJECT SCHEDULE CHART](image)

**Figure 1: The influence of the CM contract on the project schedule (Kiiras et al 2002)**

### 2.2 Risk management in CM projects

We have identified three focal risk types that are inherent in CM contracts, i.e. risks stemming from the close collaboration between the owner and the CM, risks inherent in starting procurement and construction phase with incomplete designs, and risks of dividing the project into procurement packages. Along with these categories, responsibility sharing and trade contract borders often cause conflicts, as described in Keinänen’s (2009) dissertation. Thus, development in the risk management in CM projects should take into account the described inherent features of the CM project and the uncertain and complex project business environment. The essence of proactive risk management is, therefore, either to reduce the complexity, e.g., by dividing the project into several unrelated management packages or to reduce the uncertainty, e.g., by acquiring more information. A third, complementary and reactive rather than proactive approach, is to prepare for the risk outcomes that may not be avoided. This paper focuses on displaying experiences on proactive risk management, i.e. on reduction of complexity and uncertainty with the help of the Performance Information Procurement System (PIPS) in construction management (CM) projects.

Traditional, structured, and systematic risk management frameworks, such as the one by Flanagan and Norman (1993), have become commonly used in construction projects. Anyhow, according to a recent survey by the Helsinki University of Technology (TKK) and the Finnish Association of Building Owners and Construction Clients (RAKLI ry) only roughly one third of Finnish CM projects go through a systematic risk management process in each of their project. 80 % are systematic but not regular risk managers. The lack of regularity may imply a lack of suitable RM frameworks or the lack of perceived utility.
A new approach to risk management, which may prove a success in CM projects, is to address the complexity and uncertainty in the project, organization, and environment, and to deal with it with an open mindset and dynamic framework, as described by the complexity scientist McMillan (2008). The human-based new frameworks are supported by Bourne’s (2008) insights arising from various organization experiences worldwide; “most organizational risk is about people not cooperating, not delivering, or not supporting the work being planned or undertaken. The TKK/RAKLI survey results reveal similar concerns.

2.3 The performance information procurement system (PIPS)

The PIPS is a process of vendor selection and committing so that the vendor is encouraged to self regulating best performance and risk management (Kashiwagi 2010). The procedure’s suitability for construction projects is validated with the developer’s persistently tested hypotheses that construction nonperformance is a process based problem (Kashiwagi and Savicky 2003).

The PIPS aims to increase the performance and utilization of vendor expertise as well as improve risk management by assigning all control and responsibility to the party performing the works. Increased vendor accountability and innovation has been detected in real world case projects internationally. Risk management is addressed in the procurement process as direct requirements for the vendor’s risk assessment contribution. The process is applied through the following tasks, which are fundamentally different from the traditional low-price competition (Kashiwagi 2010). The client starts a performance-based competition by requiring vendors to submit prior clients’ evaluations of the past performance instead of traditional unrated references. A project-specific risk management and value added plan is required with the bid, and allows the vendors to differentiate based on their potential performance in the targeted project. These data are evaluated in a blind review, and only afterwards combined with the price information. After interviewing the vendor’s key team members and applying cost verification measures, the client will award the best value vendor. During the project, the vendor is expected to take care of all related risk management activities and inform the client with a weekly risk management plan. The complete PIPS procedure is depicted in Figure 2, where the area under the red line represents the increasing quality and the area above the red line the decreasing number of remaining potential vendors.

The PIPS culture differs greatly from the traditional design-bid-build approach, in which the buyer specifies certain minimum standards for the performance. In practice, a specified minimum standard is the maximum level of performance a buyer should expect. The PIPS user will find it improving risk management on two levels. First, it creates the overall awareness of risks in the project at an early stage. Second, the PIPS directs the responsibility to the actor itself, which is more efficient than excess controlling.

Lately, a non-selection oriented sister method, the PIRMS (Performance Information Risk Management System) has been launched. Both, the PIPS and the PIRMS have been applied in several industries including construction, ICT, and health care (e.g. Kashiwagi and Byfield 2002; Kashiwagi et al 2003) The results show that the move from a price competition environment offers the high
performing vendors an opportunity to differente based on their quality and innovation. Furthermore, in more than half of the cases best value equals the lowest price bid. The reasons include the vendor’s increased ability to suggest suitable alternatives and to control their risk, which means lower risk margins on the bid.

Figure 2 Vendor selection process and risk management plan development using the PIPS filters (Performance Based Studies Research Group website, retrieved 26.2.2010)

3. Case studies – pioneering applications of the PIPS in Finland

3.1 Rationale for the research

The incentive for testing the PIPS in Finnish CM projects was to find processes to support project owner’s late space decisions and the utilization of the CM implementer’s and vendors’ expertise in the construction project. The PIPS had not been implemented in Finland before and the tests relied on the examples from the United States (e.g. Kashiwagi and Byfield 2002). The first author worked as the CM service provider (owner’s representative) and participant observer in the case projects. An action research approach was adopted, as introduced by Eden and Huxham (1997). The researcher started a collaborative development attempt with the target organization on a matter that was of concern to the organization.

The described case studies were originally carried out to test the hypotheses that the PIPS supports exploiting CM service provider’s and vendor’s expertise (see Kruus et al 2005, Kruus et al 2006, and Kruus 2008). In this paper, we focus on the PIPS process’s applications for risk management, which have not been presented in detail in the previous outcomes of the study. From the risk management point of view, the aim in testing the PIPS has been two-dimensional; first, to find a means to encourage the CM contractor’s and vendor’s self-regulation to ensure that the implementers
themselves are providing their best performance, and second, to direct the CM contractor to actively take part into the risk management process during the whole project. The latter is ensured by a direct requirement in the PIPS process.

Herein, we present the key findings of case studies, which each represent a different view on using the PIPS procedure and PIPS culture. In these case studies, a lighter version of the original PIPS process has been applied leaving out detailed decision models, communication restrictions, and weekly reporting obligations. The first case, selection process of a CM contractor, is the most decisive for CM construction project success. There, the PIPS was applied to deal with the cooperation risks. Second case, the selection of an elevator vendor represents the means for PIPS-enabled performance control and quality management in a selected package. The third case gives an example on how implementing the design and construction concurrently as well as utilizing the CM contractor’s and the vendors expertise has led to better value for the project owner. Furthermore, the third case is an example of cost and quality risk management utilising vendor’s expertise.

3.2 Case Porthania – A performance-based CM contractor selection

The PIPS can be used as a means to direct the need for supervision and control from the project owner to the CM contractor. This will enable better management of the collaboration risk, which is inherent in the CM contracts. Finding a competent and cooperative CM and maintaining smooth information flows are crucial for the project success. The selection of a construction management service provider should never be based solely on the lowest bid.

The case project for using the PIPS in CM contractor selection was the renovation of Helsinki University main building, Porthania (21000 m²), which took place year 2006. The façade and interior from 1950’s are protected by zoning laws. The first author’s role was to act as the owner’s representative. The client decided to choose the CM contract form based on the need to maintain onsite control, to manage the uncertainties of renovation works, and the possibility to gain from price, quality, and supplier alternatives.

The selection of the PIPS was justified by the need to gain information of the implementer’s anticipated performance in the present project. In the case of a unique refurbishment site past performance gained from the traditional reference lists would not necessarily drive towards best value in the project in question. Furthermore, the aim was to test whether the prospective CM contractors would submit a risk management plan attached to the bid if required, and whether it would lead to additional value to the project owner.

The PIPS process was applied partly; the contractors were requested to provide a risk analysis and an introduction of key individuals attached to their bid. Four of the five bidders added these unfamiliar components in their bid. The analyses were evaluated in terms of presented significant risks, presented risks that were new to the owner side, and the responses to risks presented by the contractor. All the given risk information was gathered and the most advanced contractor was selected to execute the project based on anticipated performance more than bidding price.
The project was exceptionally successful; it received the Finnish annual award for the best construction project. The owner and owner’s representative were satisfied in the number and quality of the acquired risk analyses and they proved useful in the project planning and execution, along with their communication support between the owner side and the contractor side. The PIPS was deemed to promote the CM contractor’s sense of responsibility and innovation during the project, leaving little to control from the owner side. Based on the experience of this case, we recommend advancing the process so that the owner more clearly expresses the goals of the project in the bid, and the part of the contractor is to find risks related in achieving the goals.

3.3 Case university elevators – a performance-based vendor selection

A CM consultant or contractor is responsible for searching the best value trade contractor’s in the interest of the owner. The second case project was an elevator contract as a part of the Helsinki University renovation project. The PIPS, in this case, promoted controlling quality risk of a selected vendor. In large CM contracts the procurements are divided into even hundreds of such procurement packages.

The project owner, Helsinki University, had previously had problems with the quality of elevators, and thus, required using a 5-year liability period including maintenance. To ensure selecting the best value vendor for the owner’s representative, i.e. corresponding writer, decided to apply the PIPS process. In this case the value added report, which is a part of tender in the PIPS process, was replaced by a self evaluation report. The vendors were required to describe the functional reliability of their elevators during last seven years. The aim was to promote the vendors’ internal quality control and thereby provide better quality elevators for the project owner.
The owner’s representative consultant called five renowned companies to bid but only one submitted the bid according to the request including the self evaluation report. Supported by the Finnish public procurement law which requires disregarding bids diverging from the request, the only conforming vendor was awarded.

The owner was surprised by the low percentage of submitted self evaluation reports, which may be due to the vendor’s disability to gather or unwillingness to report performance data. We argue that maintaining and submitting such information would enable the vendors sell their services and the buyers to recognize value better.

3.4 Case bridge – utilization of vendor expertise in procurement

In the third case project, CM and the PIPS were used especially to combat cost risks stemming from incomplete or incompatible designs. Such risks may cause budget overdrafts due to unexpected solutions. Kashiwagi et al (2003) describe a similar setting in the Dallas Independent School District, where the aim was to increase the performance of a procured roofing system without increasing costs. The goals were achieved by increasing competition, promoting vendor participation in the design, directing vendor attitude towards service-orientation.

The first author, again, worked as the owner’s representative with a task to find the best value contractor to construct a connection bridge between two University buildings. In the bidding phase the design for the connection bridge was complete but there was a need for substantial cost savings. The owner received bids but none of them fit the budget. As a solution, the owner’s designer and a best value vendor revised the design together, which led to a cost efficient alternative.

The case study proved that considering vendor’s own value adding suggestions did benefit the owner as lower cost. Utilizing vendor’s expertise reduces technical risks in installation phase and quality risk during utility phase, as well. The process will, nevertheless, raise a question of responsibility if defects are later discovered. The new design is planned by the vendor but designed by the owner’s designer, which set new demands for the contract. In this case the cooperation between the owner’s designer and a vendor resulted into a solution that fits the budget and environment.

4. Discussion and conclusions

The case studies indicate positive results in risk management and best value procurement when combining the construction management (CM) contract form with the performance information procurement system (PIPS). In the recent years, the PIPS has been advanced towards wider applicability as a part of construction project risk management (RM) throughout the project. When the PIPS applications were carried out in Finland, the system was still perceived as a procurement method. As the case projects proceeded, we concluded similarly with simultaneous development efforts in the USA; perceiving the PIPS as a means for reducing the complexity and uncertainty in the project organizations and, hence, reducing risks throughout the project.
CM is characteristically a procurement intensive contract form. We see the PIPS as a means to overcome the method development gap reported by Boyer et al (2001) in the most crucial areas of procurement in CM projects. Furthermore, the PIPS contributes to construction projects’ growing demand for more advanced and human-based project and risk management models. The three categories of risks that are stressed in CM contracts stem from collaboration between the owner and the CM, from dividing the project scope into several procurement packages, and from working with incomplete designs. Risk management in each of these categories will benefit from PIPS applications, as demonstrated in the case studies, turning risks into positive gains and opportunities.

The most valued aspect of the PIPS, referring to the cases, was to transfer risk management and supervision from the owner to the implementer. It was, furthermore, conceived to promote innovation and commitment. The combination of CM and PIPS enables the owner to gain from the CM’s and vendors’ expertise, which leads to quality and cost advantages. The elevator contractor case highlights clearly the lack of self evaluation in the Finnish tender culture. Arguably improvement of self evaluation and control will lead to improved performance and quality.

In Finland, the PIPS or similar type of risk management is not used, disregarding a few pioneering projects. In the United States a vendor evaluation register has been established to promote performance information. In Finland, the construction market is considerably smaller and actors known, which does not support a similar attempt. An institution promoting construction quality as competitive advantage exists, and it maintains a data bank on construction firms. Nevertheless, we recognize a niche for more collaborative risk and performance management, and thus suggest advancing the use of the PIPS among owners and CM service providers. This may well alter the traditional price competition and the minimum-standard-based performance. Anyhow, in the Finnish public construction projects the PIPS may still be difficult to engage, because the Finnish public procurement law opposes to using knowledge of past performance.

The relatively young field of performance based procurement in construction and its combination with CM projects raises several questions. How would the collaboration between the owner-side, implementer-side, and designer-side be further advanced? How to plan and implement performance and risk management measurement? What kind of contract forms support advantages from design alterations without leaving responsibilities unbound? Aalto University’s Department of Construction Economics and Management, among other research institutes, is committed to continue studying the subject.

**References**


In the spring of 2008 a large planned community in Anthem, Arizona approached the Performance Based Studies Research Group (PBSRG) at Arizona State University (ASU) to increase efficiency within the community’s procurement process. The PBSRG are forerunners in the area of best value procurement and utilize the Performance Information Procurement System (PIPS), which was created using principals from Information Measurement Theory (IMT). The Anthem community council board of directors implemented the PIPS process to rate competing property management services vendors based upon their primary financial and performance information. The PIPS rating system that was implemented identified the top two vendors to be nearly identical, which demonstrated the need for a human decision making model to be utilized to converge upon the true best value vendor. This model focused on the inherent risks to the project as well as further investigation of cost and performance information in order to properly compare the value offered by each vendor. This is the first test application of the Performance Information Procurement System in property management services.

**Keywords:** procurement, best value, performance
1. Introduction

A ten thousand home community in Anthem, Arizona, USA was transitioning from a developer controlled community council to a board of directors elected by community residents. The first community elected council (seated in April 2008) invited the Performance Based Studies Research Group (PBSRG) to assess the functionality with which the board approached the task of procuring property management services for the community. Among the property management services needed were the collection of homeowners’ association dues, management of parks and a community center, and the enforcement of community bylaws. These services were currently provided for the community by an outside vendor, but a strained relationship between this vendor and the community had motivated the board of directors to explore alternative options. Yet changing vendors represented a great risk to the community since data associated with homeowner accounts and dues could potentially be lost during the transfer of data between different software systems used by the vendors. If this risk were to be realized it would be potentially fatal to the community’s operations. In order properly award a new property management services contract, the city of Anthem chose to implement the PBSRG’s performance information procurement system (PIPS) to identify which vendor offered the best value.

2. Procurement of property management services

2.1 PIPS background

The Performance Information Procurement System (PIPS) is a best-value selection and management process that can be used to purchase any type of product or service. Since its creation in 1994, the PBSRG has researched and tested the PIPS process on hundreds of projects. The PIPS process provides users with a tool to assist them in making informed decisions based upon performance information, as opposed to basing decisions solely on price or marketing information. A result of this process is that the user is able to identify the vendor that will provide the best value, wherein the best value environment is characterized by high performance of the vendor and minimal efforts of owner management and control (Kashiwagi, 2009). Beyond the selection a high performing vendor, PIPS also incorporates a mechanism to document and manage the vendor/service throughout the duration of the project.

The PIPS process has been implemented by many different clients in both the private and public sectors. The PIPS process is easily adapted and tailored to meet the differing rules and regulations that constrain each user. Clients have used the system on construction projects ranging from under $10,000 to over $100 Million, and have also used the process outside of the construction field on service contracts exceeding $400 Million. Over this period of time PIPS has maintained a 98% percent satisfaction rating with its users.
2.2 The PIPS process

The PIPS process provides clients with a tool to identify, select, and manage a best-valued vendor. In order to accomplish this task and ensure the operation of a true best value system, the PIPS process uses multiple filters to provide the owner with the information necessary to determine the best value vendor. As shown in Figure 1, each filter serves a particular purpose in a step by step process with the overall purpose to assist the user in minimizing risk. The six steps of the PIPS process are briefly discussed below:

Figure 1: PIPS Process to Identify Best Value (Kashiwagi, 2009)

Filter 1 - Past Performance Information: Past performance information (PPI) is collected for all critical team components that have been identified by the client prior to the project. In a property management contract, for example, the critical personnel may include the: the management firm, executive director, community manager, accountant, and facilities manager, etc.

Filter 2 – Proposal and Project Assessment Plan: Vendors are required to submit a cost proposal in addition to a Risk Assessment and Value Added (RAVA) plan for the project being proposed. The RAVA plan enables the user to differentiate the vendors based upon the expertise they offer, rather than their marketing information.

Filter 3 – Interviews: Critical project individuals from the various proposing vendors are interviewed individually by the client. The purpose of the interview is to assess critical personnel and their ability to preplan, identify and minimize risk, and remain accountable for their performance throughout the duration of the project.

Filter 4 – Identification of Potential Best-Valued Vendor: Several decision making models are used to assist the client in quickly analyzing all of the data that has been collected via the previous filters. The models select the potential best value vendor by utilizing a pre-established weighting system, which is specifically determined by the client for each project. The two
models that were used for this particular procurement were a Linear Relationship Model (LRM) and a Displaced Ideal Model (DIM).

Filter 5 – Pre Award Period: The potential best-value vendor is required to carefully preplan the project in detail and prepare a risk management plan. The risk management plan is a document that addresses all risks that are outside the vendor’s control. Since the best value vendor is high performing, technical concerns of the project comprise all of the risks that the vendor can expertly control. Uncontrolled risks are outside of the vendor’s area of expertise, and must be identified in the preplanning process to establish the owner’s responsibility to compensate the vendor’s efforts to minimize such risks.

By using these filters, the owner ensures that poor performing vendors are filtered out. Thus only the vendor that represents the best value to the owner is able to successfully pass through these filters, as shown in Figure 2.

![Diagram of filtering process](image)

Figure 2: Filtering Process to Identify Best Value and Remove Poor Performing Vendors (Kashiwagi, 2009).

Filter 6 – Weekly Risk Reporting System and Final Rating: Once the award has been given to the best value vendor, the vendor is required to submit a weekly report during the project that documents any additional risks that impact time, schedule, or customer satisfaction. Upon completion of the project the client will evaluate the performance of the vendor, and the rating is used to determine whether the contract will be reopened for bids from other firms or if the contract with the current vendor will simply renewed.

3. Project initial conditions

The Anthem community council structure consisted of four separate boards of directors. Three of the boards governed and set policies for specific geographical regions within the community, and the fourth board served as the overall community council that governed all assets and geographic areas shared by the three communities. The purpose of the outsourced property management provider was then to enforce any policy enacted by the boards. This community structure was inefficient since the
separate boards did not respond to one central authority and each pursued its own specific agenda. Additionally, each individual board required a majority vote on all decisions.

The board of directors collectively decided to procure a property management service vendor together under a single Request for Proposal (RFP). The boards chose to utilize a single RFP for the whole community simply because that was how the community council historically operated. Yet each of the four boards of directors had different agendas regarding the outcome they desired from outsourcing the community’s property management services. The differences in opinions between each board, as well as the personal biases of their individual members, all manifested themselves to cause the community council to function as an emotionally driven bureaucracy that ultimately hindered the procurement process.

4. Test results

4.1 PIPS results

After running the models utilized by the Performance Information Procurement System (PIPS), two of the proposals were identified as being the best value vendors. These proposals were submitted by Vendor A, the incumbent vendor, and Vendor B. As shown in Table 1, the PIPS modeling results scored Vendor B slightly ahead of Vendor A, but the separation identified by the models was almost negligible and identified no significant difference between the two vendors. As previously noted, one of the largest risks facing the city was a loss of data during the transition from one property management firm to another. Since the decision to retain Vendor A would prevent the risk of lost transfer data from being realized, the PBSRG subsequently identified Vendor A as the best value since it had otherwise been rated to be equivalent with Vendor B in cost and performance. In fact, the ratings listed in Table 1 reveal that the board did not accurately score Vendor A in relation to the transition schedule. Since Vendor A was the only vendor that avoided the transitional data loss risk, it should have received the highest score in this category. If Vendor A has been properly rated in this manner, it is likely that it would have received a higher point total than Vendor B. Overall, the knowledge that selecting Vendor A would absolve the biggest risk faced by the community eliminated any reason for Vendor B to still be considered a possible decision.

Many of the board members still desired a change of vendor and proceeded to protest the identification of Vendor A as the best value. Certain board members refused to acknowledge the data presented by the PIPS process that showed no price or performance difference between the two vendors. The board insisted that Vendor B was the better choice because this vendor would bring change. Regardless of the fact that changing vendors as identified as the greatest risk to the community, one board member still stated that “with great risk comes great opportunity.” This mentality is in great conflict with the best value approach, with favors conservative baseline expectations over aggressive potentially overreaching goals.
Table 1: PIPS Modelling Result

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Scale</th>
<th>Weight</th>
<th>Vendor A</th>
<th>Vendor B</th>
<th>Vendor C</th>
<th>Vendor D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interview (Average)</td>
<td>1-10</td>
<td>35</td>
<td>7.1</td>
<td>6.6</td>
<td>5.8</td>
<td>6</td>
</tr>
<tr>
<td>RAVA</td>
<td>1-10</td>
<td>25</td>
<td>6.2</td>
<td>6.2</td>
<td>6.4</td>
<td>3</td>
</tr>
<tr>
<td>Cost (In $ Per Lot Per Month)</td>
<td>$</td>
<td>18</td>
<td>$8.33</td>
<td>$8.25</td>
<td>$7.65</td>
<td>$8.00</td>
</tr>
<tr>
<td>Maximum Yearly Increase in Cost (%)</td>
<td>%</td>
<td>2</td>
<td>2.50%</td>
<td>2.50%</td>
<td>5.00%</td>
<td>5.00%</td>
</tr>
<tr>
<td>Transition Schedule</td>
<td>1-10</td>
<td>5</td>
<td>6.8</td>
<td>7.5</td>
<td>5.4</td>
<td>4.9</td>
</tr>
<tr>
<td>PPI (1-10)</td>
<td>1-10</td>
<td>7.5</td>
<td>9.91</td>
<td>9.7</td>
<td>7.45</td>
<td>9.62</td>
</tr>
<tr>
<td>PPI # of Different Jobs/Clients</td>
<td>1-15</td>
<td>7.5</td>
<td>12</td>
<td>15</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total Points</strong></td>
<td></td>
<td>100</td>
<td>91.0</td>
<td>91.5</td>
<td>82.2</td>
<td>74.8</td>
</tr>
</tbody>
</table>

Other board members argued that the best method to evaluate Vendors A and B was not based on the risks they minimized, but instead by announcing each vendor’s current contracting price and then allowing the two vendors to re-compete and propose a best and final offer. The PBSRG strongly opposed this idea, as this method failed to account for the reduced performance that each firm would provide once they were forced into a low bid environment. In order to lower their cost, each firm would be required to reduce the scope of services that would be offered to the community. One board member even verbalized his opinion that any community management firm that was contracted should not be entitled to a profit. Fortunately, the board was discouraged from this decision once the PBSRG explained that this procedure would ultimately sacrifice the performance of the property management firm, which would undermine the entire purpose of the best value system. Thus the PBSRG was able to use the PIPS data in addition to the logic of minimizing the potential transfer data loss risk to convince the board members that the incumbent was truly the best value. Once this decision was made, Vendor A proceeded into the Pre Award stage of the PIPS process to be further evaluated by the city of Anthem before the contract was finalized.

4.2 A Note about vendor interviews and a managing and controlling client

It is important to note that the sole reason the board of directors desired to change vendors stemmed from strained relations that had developed with the incumbent vendor under the previous contract. However, the PBSRG concluded that the boards themselves were to blame for this relationship due to their repeated efforts to control and manage the incumbent, which did not allow Vendor A (the incumbent) to use their expertise to perform the contract in an efficient manner. The community boards, who freely admitted they had no knowledge of the property/asset management industry, were documented to routinely micromanage and force operational decisions upon the vendor. The boards consistently overrode Vendor A’s directives, ignored necessary information when making decisions, and were heavily motivated by internal politicking and personal emotions, as opposed to simple logic, in their efforts to control the vendor.
Despite this information, Vendor A strove to rectify the situation by introducing new, better representatives to run the new contract. As is shown in Table 1, Vendor A (the incumbent) performed better in interviews than any other vendor, which confirmed expectations of higher performance.

### 4.3 Pre award struggles

Once the board of directors had decided to identify Vendor A as the best value, the vendor encountered trouble developing a Risk Management Plan (RMP) with the Community Council. The vendor was unable to focus on risks that might occur during the life of the contract because Community Council members were busy creating risks that might prevent a contract from even being signed. Although Vendor A was identified as the best value since they eliminated the potential risk of millions of dollars in lost homeowner dues and assessments that may be caused in a transfer between vendors, some members of the community council still chose to disregard this piece of information and instead attempted to further focus on the pricing differences between Vendor A and Vendor B. In the initial RFP, the Community Council had only requested that potential vendors submit pricing to manage the community in terms of dollars per lot per month. This primary pricing criterion was accounted for within the PIPS modelling results and Vendor A was shown to be less than one percent more expensive than Vendor B. However, during the Pre Award phase members of the council suddenly became interested in comparing secondary financial information for each vendor. The secondary financials in question were nonrecurring fees that would not impact the council itself; rather, the fees would impact various homeowners within the community. These non-recurring fees included account transfer fees on home sales, disclosure fees, demand fees, lien fees, insufficient funds fees, rebilling fees, and lender planned unit development certification. Although most of the fees only applied to delinquent accounts, these fees were suddenly proclaimed to take precedence in the minds of the council.

Since Vendor A had been identified as the best value, subsequent negotiations at this point in the PIPS process were only to exist between the client and the vendor that had proceeded into the Pre Award phase. However, there was evidence indicating that some members of the council were still in contact with Vendor B and the council periodically approached the topic of non-recurring costs and demanded that an additional head to head analysis be conducted for secondary financials. Obtaining a fair comparison of secondary financials proved to be difficult since Vendor B was in a position where they could influence negotiations between the council and Vendor A without providing any concrete costing data. Therefore pricing information provided by Vendor B was often incomplete and designed to deceive the council into believing that Vendor B would be less costly to homeowners affected by the non-recurring costs.

After multiple requests for specific information and comparisons of fees process, it was determined that the Vendor B had been attempting to buy the contract away from Vendor A. Yet as Vendor B was pressed for more complete pricing information, the costs for non-recurring fees became closer and closer between the two vendors. The final fee pricing comparison between Vendor A and B was completed by the PBSRG and is shown in Table 2 below. Since the difference between the two vendors for this specific class of fees was only $74,960, the board of directors finally concluded that
the difference was negligible in comparison to the much larger risk of data loss in the transfer between property management companies.

Table 2: Fee Comparison Between Vendors A and B

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>New Home Sales</td>
<td>458</td>
<td>100</td>
<td>$45,800</td>
<td>458</td>
<td>130</td>
<td>$59,540</td>
</tr>
<tr>
<td>Re-Sales</td>
<td>721</td>
<td>125</td>
<td>$90,125</td>
<td>721</td>
<td>-</td>
<td>$0</td>
</tr>
<tr>
<td>Disclosure</td>
<td>721</td>
<td>125</td>
<td>$90,125</td>
<td>721</td>
<td>300</td>
<td>$216,300</td>
</tr>
<tr>
<td>Demand</td>
<td>3,427</td>
<td>40</td>
<td>$137,080</td>
<td>3,427</td>
<td>-</td>
<td>$0</td>
</tr>
<tr>
<td>Document Prep.</td>
<td>294</td>
<td>150</td>
<td>$44,100</td>
<td>294</td>
<td>150</td>
<td>$44,100</td>
</tr>
<tr>
<td>Recording</td>
<td>294</td>
<td>-</td>
<td>$0</td>
<td>294</td>
<td>15</td>
<td>$4,410</td>
</tr>
<tr>
<td>Release</td>
<td>99</td>
<td>-</td>
<td>$0</td>
<td>99</td>
<td>35</td>
<td>$3,465</td>
</tr>
<tr>
<td>NSF</td>
<td>6,358</td>
<td>-</td>
<td>$0</td>
<td>6,358</td>
<td>-</td>
<td>$0</td>
</tr>
<tr>
<td>Re-Bill</td>
<td>9</td>
<td>50</td>
<td>$450</td>
<td>9</td>
<td>55</td>
<td>$495</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>$407,680</td>
<td></td>
<td></td>
<td>$332,720</td>
</tr>
</tbody>
</table>

A second problem facing Vendor A was that the same board that had admitted to having no knowledge of property management decided to explore whether money could be saved by creating a structure where property management services were handled in-house. The council began investigating the possibility of hiring their own executive director and controller to replace the individuals employed by Vendor A. When the council proposed this idea to Vendors A’s employees currently holding those two positions, these individuals made it clear in no uncertain terms that they did not wish to become employees of council. The PBSRG determined that the board’s motivation to hire their own staff stemmed from the fact that it would then be easier for the board to manage, direct, and control property management individuals who were directly under their employment than it would be to manipulate an individual working for a contracted service provider. In fact, the community council even expressed ideas of eventually transitioning from hiring their own executive director and controller to the point where they would no longer require any legal or accounting support from a property management firm. Base upon this behaviour, it can be inferred that the board, made up of volunteers living within the community, did not understand the complexities involved with managing property policies enacted within a community that is essentially the size of a small city. The cost savings and benefits provided by a property management firm are considerable when considering their significantly greater expertise as well as their employment of a legal accounting.

4.4 Pre award results

The Pre Award phase of the PIPS process functions by requiring vendors to become proactive and pre plan their service prior to the finalizing and signing a contract. This step is a critical element in the PIPS process since it allows the client to identify the vendor’s expertise prior to actually signing a contract. If the vendor reveals that they are incapable of achieving high performance or fails to meet
the client’s expectations, the client is then able to end negotiations and proceed to enter the pre award phase with the next highest ranked vendor.

One deliverable that is required of the vendor during the pre award phase is a Risk Management Plan (RMP). A risk is considered to be any deviation from the expected performance documented in the contract that might have an impact on customer satisfaction, cost, or schedule. The risk management plan also documents the vendor’s plan of action should any risk be realized during the project. Developing a risk minimizing plan of action requires the vendor to be proactive in identifying any possible risks that may occur during the life of the contract. The RMP is extremely important in developing the contract that may be awarded to a vendor since it holds the vendor accountable to minimize risks to the project’s success.

Three of the four boards, not including the Community Council, eventually signed contracts with Vendor A prior to establishing a RMP. The three boards decided it was easier for the time being to simply sign new contracts and continue in the same fashion that caused them to become so dissatisfied in the first place. This decision revealed that the boards were blind to the fact that they would not gain any change in performance from the vendor unless the structure around the contract was changed. The three boards would then continue to involve themselves in operational policy setting as opposed to strategic planning and policy setting. The boards were unable to see that their decisions were potentially responsible for causing their dissatisfaction with the original contract.

If the RMP had been correctly utilized, the risks faced by the parties to the contract would have been more clearly defined along with a proposed solution protocol to resolve these risks. In the document the actual risk should be defined, the cause should be clear, and the solution should provide step by step details as to how the risk would be minimized. Based upon the PBSRG’s experiences with the Anthem board of directors, examples of risks that should have been included within the RMP include:

- The Council Board of Directors involve themselves in operational versus strategic planning and policy setting.
- Council Board Members each have their own agenda which is not necessarily the consensus of the Board of Directors or in the best interest of the community.
- Board members acting unilaterally without Board of Directors approval.
- The Council Board of Directors and or their President not following legal advice.
- The Council Board of Directors and or their Treasurer not following advice from their controller and or outside accounting firm.

By developing an RMP and agreeing upon a course of action to minimize any risks that do occur within the project contract, the vendor is able to successfully perform their services without intervention from the client.
4.5 Weekly reporting

Once the vendor has completed the Pre Award phase and is awarded the contract, the weekly reporting process requires the vendor to document any unforeseen risks that occur during the life of the contract. An unforeseen risk is now defined as any risk that not previously identified in the RMP. For each unforeseen risk, a new entry is made into the tracking spreadsheet. The spreadsheet requires the vendor to identify any possible impact to customer satisfaction, schedule, or cost for the unforeseen risk and enter this impact on the spreadsheet. The next step is to categorize the risk into one of the following:

1. Vendor Issue
2. Client Issue
3. Homeowner Issue
4. Client Scope Change
5. Unforeseen Condition

The vendor is then also required to answer questions regarding the risk. The questions are as follows:

1. What is the risk / why was it unexpected?
2. What will be done / what is your plan to minimize this risk?
3. Who is responsible for resolving the issue?
4. What kind of impact will this have?
5. Any updates to this risk (if applicable)

By requiring the vendor to complete these tasks, the weekly report is a tool that is critical to the property manager in that it allows them to track project risks and hold individuals accountable for decisions made that lead to decreased performance. The most common risks are simply bad decision making and micromanagement by the Council Board of Directors. These decisions caused a large amount of wasted time, energy and dollars by the property management team throughout their previous contract and the procurement process. By tracking the actions and decisions of board members in addition to the impact those actions have on project performance, the vendor is able to document the client’s responsibility for instances of reduced project performance. When the vendor is working with an extreme Type C organization such as the Anthem board of director’s, this serves as a valuable tool to focus efforts on improving project performance.
5. Conclusion

Thus the Anthem property management services case study clearly demonstrated that the PIPS model is not a fool proof, black box process that is able to automatically select the best value contract. Instead, the Anthem case study revealed various difficulties that may be encountered in identifying which vendor represents the best value to the client. Although the PIPS scoring system is constructed to account for the most pertinent risks and considerations affecting a contract, scores for each vendor are still subject to error in the client’s ratings. This issue greatly influenced the PIPS scores of Vendors A and B, since Vendor A was given a lower transition schedule rating even though they were the only vendor that avoided the large risk of transitional data loss. If this rating had been entered correctly and consistently for each vendor, Vendor A would likely have received a higher PIPS score. Furthermore, the client did not properly assess the importance of the interview process in their evaluation of the each vendor. Vendor A clearly performed the highest in interviews due to the fact that they brought in better, representatives to the contract that were expected to provide higher performance if awarded the contract. These new representatives were also a clear indication that Vendor A had heeded the community of Anthem’s concerns about the perceived strain in relationship between the council and the previous representatives.

The most important conclusion drawn from this case study is that the PIPS process should be implemented as a useful tool that factors into a larger human decision making model to identify the best value vendor. In the Anthem project, for example, the PIPS process did not identify a better vendor than Vendor A. Yet since Vendor A’s scores were comparable to those of the competing Vendor B, the responsibility to accurately assess the two companies based upon their value fell upon the client. Since the client had already identified the potential loss of homeowner data as the largest risk of transitioning to a new vendor, it was clear that selecting Vendor A had a large advantage over Vendor B. The Anthem board of director then had to weigh this advantage in relation to their concern over each vendor’s potential costs in the form of secondary financials. Once the secondary financials for Vendor A and B were identified in an equal comparison, the relatively small difference between the costs caused the board to conclude that Vendor A represented the best value, and Vendor A was therefore awarded the contract. In this manner, the Anthem board of directors utilized the PIPS process to narrow their decision to the two top performing vendors and then were able to focus their human decision on pertinent information that separated the two vendors in such a way that the best value was easily identified.

In summary, this test project showed that as in all other areas of PIPS research, the client is the biggest risk and barrier to project optimization.

References

A New Project Management Model

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Abstract

A new project management model has been created that is a process that delivers a service to a client. The process is different from other processes due to the following factors: the client does not have to clearly define their requirement, the process defines the requirement during the process, the client does not need an expert to represent them, the process requires the vendor to write the contract and administer the contract, and the process minimizes cost, management, transactions, and the flow of information while increasing value, vendor profit and transparency. The continual modification of the Performance Information Procurement System (PIPS) has created a new project management model which defines the project from client intent to the delivery of the service. It minimizes the client's risk/project management transactions by up to 90%, can increase vendor profit up to 100% at no additional cost to the buyer, and delivers projects on time, with no cost deviations, and with high customer satisfaction at a 98% rate. The new project management model has the potential to impact many of the construction/project management roles in the industry.

Keywords: new project management model, new supply chain management, management of systems
1. Introduction

The problem of construction non-performance has been difficult to solve over the past 20 years (Lepatner, 2007; CFMA, 2006; Simonson, 2006; Flores and Chase, 2005; Adrian, 2001; Chan, A., 2004; Post, 2000). Although many solutions have been proposed, such as lean, continuous improvement, partnering, alliances, alternative delivery methods (design-build, construction management at risk, design, build operate and private public partnerships) there has not been a clear solution proposed, that has been tested, results documented, system modified and retested and the solution implemented successfully (Kashiwagi et al., 2008; Adeyemi et al., 2009; Egan, 1998; Cahill, 1994; Chan, A., 2004; Cox, 2003).

A client’s project manager’s (PM) responsibility is to deliver a construction project successfully. The project manager’s responsibility includes the identification of the requirement (planning and programming), the communication of the requirement to the contractor delivering the service (design), the selection of the contractor (selection and procurement), and the management of the delivery of the service by the contractor (contract administration.) A successful PM delivers a project on time, with minimal deviation, and meeting the expectations of the client.

The problem has been difficult to solve by research academia because academic research is primarily funded by government research groups and not by industry groups, who are the party at risk. The problem lies in the industry assisting the testing of academic research created solutions. The problem is perceived as complex with multiple participants (owner/client/buyer, contractor, designer, lawyer, manufacturers, subcontractors,) with no one having complete control over the project (the owner controls using a contract and a project manager, and the contractor using their own project manager, and having someone manage and control the risk that they do not control).

2. Hypothesis

The stubbornness of the problem of construction performance may be caused by, as Deming (1982) identifies, a stable system that does not have high performance. The authors propose to change the system of construction service delivery instead of concentrating on the technical adequacy of the individual components. The authors also propose to use deductive logic, instead of inductive logic to solve the problem.

3. Deductive logic instead of inductive logic

The majority of breakthroughs in technology are caused by deductive logic or confirmatory testing of concepts that someone identified as a dominant concept that already existed. The majority of university based research is inductive logic, or exploratory testing. This research will use deductive logic.

The difference between deductive (confirmatory research) and inductive research (exploratory research) is that in using the deductive approach, the authors will:
1. Not consider and use the latest perceptions and concepts of other researchers and practitioners.


3. Identify existing deductive concepts that are accepted in most industries and align them in a process, which will be tested to confirm if the deductive concepts are accurate.

4. Use only dominant concepts which are readily accepted by the majority as “no brainers” or “obvious.”

5. The dominant concepts will be organized in a new manner which may not be dominant, but will be tested to identify if the concepts.

An attempt will be made to use only dominant deductive logic. Dominant is in terms of easy to understand, simple, does not require technical expertise, or experience to understand. The test of dominance is to identify the percentage of people who can understand the logic. If the percentage is very high, it is dominant. Dominant concepts are understood by the majority of people. The following are dominant concepts being proposed by the paper:

1. It is inefficient for an expert to be managed, directed, and controlled by a non-expert.

2. Risk may be caused by someone who cannot clearly perceive the initial conditions of an event, and therefore makes decisions (using their own minimal experience,) and forms expectations which may not be able to be met due to the inaccurate perception of the initial conditions. The difference between what they expected and what actually transpired will be defined as the client’s perceived risk.

3. Management, direction, and control of one entity by another are inefficient and ineffective concepts that are a source of transactions (activities that could be eliminated if resources were aligned.)

4. An expert can perceive a project from beginning to the end, before it happens, and therefore has minimal technical risk.

5. The risk to an expert is the risk that is not under their control.

6. Experts manage and minimize risk that they do not control before it happens.

7. Experts preplan because they can see the project event before it happens due to their experience and expertise.

Many of the dominant concepts have been put into a process, and have been continually developed for the past 15 years. The process is called the Performance Information Measurement System (PIPS).
4. Performance information procurement system (PIPS)

The PIPS test results have been dominantly better than traditional delivery of services (PBSRG, 2010):

1. 98% on time, no contractor created cost or time deviations (30% over traditional services.)
2. Minimized up to 90% of client’s project/risk management transactions and activities.
3. Increased vendor profit up to 100%.
4. Motivated clients to use structure/system even though it has not been validated and accepted by the entire industry.
5. Dutch infrastructure group is now testing on a $1.2B test of highway improvement projects, and planning on using it to procure another $3B of projects.
6. Bank of Botswana and other Botswana groups testing PIPS in Africa.
7. General Services Administration (GSA), the largest buyer of services in the U.S. is now testing PIPS in the heartland region.

PIPS uses the following concepts that define the client’s project manager’s new responsibilities:

1. Identifies and selects the best value expert based on performance and price.
2. Transfers risk and control to expert vendors, forcing them to manage their own project.
3. Minimizes direction and control from the client.
4. Transforms the client’s project manager’s role to quality assurance (running a process that ensures that the contractor knows how to do their work, and is using a risk management/quality control structure that minimizes risk.)

PIPS is composed of three phases (Figure 1). The selection phase, the pre-award phase, and the management by risk management phase. The most important phase is the Pre-Planning or Pre-Award Phase. It is where the risk and control is transferred to the vendor, and they preplan to manage and minimize the potential risk that they do not control using a risk management plan (RMP.) The award of the contract is between Phases 1 and 2. The entire PIPS is a closed loop (Figure 2).
5. Selection phase

The selection phase uses three main criteria: past performance information (PPI), identification of the capability of the vendor to do the subject project, and an interview with the key personnel. The process is a natural set of capability filters that prioritizes the vendors. Because the client’s selection committee is instructed not to make decisions, and only give credit when the difference from the contractors is dominant, the contractors have the responsibility to prove that they are the best value using dominant information. If they do not, the project will go to the best value, which is the lowest price. Because of the closed loop system, the vendors must perform to stay in the loop. The vendor who gets the project is at risk, and the performance rating on the last project becomes 50% of the future performance rating for the next project competition. The past performance information is from previous projects, on the key personnel and the vendor, and is controlled by the vendor. The capability of the vendor to do the work forces the vendors to submit the following submittals:
1. Two page description of the technical risk of the project and how they will minimize the risk.

2. Two page Risk Assessment and Value Added (RAVA) submittal that will identify the risk that they do not control on the project and how they will manage and minimize the risk, and dominant value added of the vendor that the vendor brings more value to the project.

3. A one page milestone schedule.

4. A one page submittal of how the vendor will measure their performance and manage the deviation of time and cost.

5. A detailed cost breakout.

Figure 3: Selection Phase Filters

The capability of the vendor to do the project is rated “blind” by the client’s professional and selection committee.

The submittal package was designed to consider the following:

1. Submittals were designed to be short because the larger the submittals, the more competitive the poorer performers would be. Only experts can concisely and simply explain projects before they do them.

2. If the submittal is not dominantly better than the competition, the rating committee is requested to give average ratings. The committee is advised not to make decisions and give credit if the difference is not dominant.

3. The RAVA plan was added because the only individuals/vendors who would know this would be expert vendors. Expert vendors have no technical risk. The only risk they have is the risk that
they do not control. In order to be successful, these vendors manage and minimize the risk they do not control.

The interview of key personnel is to define:

1. Accountability.
2. Vision of the project from beginning to end.
3. Prioritization of risk that the vendor does not control.
4. Ability to preplan.
5. Ability to identify the uniqueness of the project.
6. Ability to identify what they will do differently on this project to increase performance and value.

The three performance factors and cost are pre-weighted, rated, and a linear matrix is used to prioritize the competing vendors. A quick cost check is done to ensure that the best value vendor is within a preset cost range of the next best value, or if they are not, is there dominant information that justifies their selection. If not, the selection group will go to the next best value into the next phase, the pre-award phase.

6. Pre-planning/pre-award phase

During this phase the identified best value vendor is given all the risks and concerns of the client, both technical and non-technical that the vendor does not control. If the risk is non-technical, the risk is listed in the risk management plan (RMP); if the risk is technical and within the scope of the project, it becomes a part of the technical scope. The vendor creates a weekly risk report which will track deviations of time and cost of the project. The WRR will contain the following:

1. List all the personnel who will interface with the project and vendor.
2. A milestone schedule which will track actual against the initial plan.
3. Listing of any cost modifications to the project.
4. A risk page that will identify risks that result in cost modifications.
5. The RMP which is a living document and constantly added to during the project.

If a risk has not happened yet, it goes on the RMP with the plan to manage and minimize the risk from happening. If the risk happens, it goes on the risk page. The impact of time and cost deviation is annotated on the risk page and connected to the modifications page.
The WRR and RMP become a part of the vendor’s contract and the vendor’s contract administration and risk management for the project. The Pre-planning Phase is the most important phase of PIPS. Tests have actually used the WRR and RMP when the award was done using the low bid system and the projects have been very successful (Kashiwagi, 2009).

7. **Modification of pips to create a new project management model**

PIPS, as described above, and as test results have shown, has solved many of the construction performance problems. However, to make PIPS easier to use and to understand as a project management model, and to reinforce the dominant concepts that are being proposed, PIPS has been further modified with the following changes:

1. The client no longer needs to legally define the requirement, a general intent of what is required is sufficient.

2. The contract shall be drafted and written by the best value contractor.

3. The project manager no longer needs to be a technical expert, but needs to understand the process of identifying an expert and the best value contractor.

4. This process is being proposed for all types of delivery systems, and because the project manager no longer needs to be a technical expert, the authors propose that this project management model can be used for the delivery of any service.

7.1 **Client requirement**

The client’s project manager no longer needs to know the exact project requirement. The project manager needs to know the client’s intent in as much detail as possible. The intent can be communicated in terms of completed specifications and drawings or a more general document. If a completed design package is used, it will still be recognized as the client’s intent, and not necessarily as the final delivered product. The process of selection and preplanning and risk management will modify and clarify the delivered product. If all contractors propose the same package as the client’s professional has identified as the client’s intent, the project is probably simple, more of a commodity, and will probably be awarded to the lowest price.

7.2 **New procurement model**

The new procurement or source selection philosophy (Figure 5) is compared to the traditional philosophy (Figure 4). The traditional philosophy is a requirement which is identified and communicated to the contractors. The contractors respond at all different levels. Contractors 1 and 2 are above the requirement, and contractors 3 and 4 are below the requirement. Traditionally, the client’s project manager will direct that contractor # 2 be negotiated down, and required to deliver the
higher performance/value at a lower price. Or they will request contractor #3 to increase their performance/value for the lower price that contractor #3 proposed. In both cases, the client’s project manager is attempting to negotiate the performance and price of the contractor and assumes that the contractors can be influenced or controlled to meet the requirements of the client. In both cases, the client’s project manager is directing the contractors to do something that they have not proposed. This increases the risk, as now the client’s PM is directing the contractor to deliver something different than what they have proposed.

The new philosophy is shown in Figure 5. In the new philosophy, the client’s intent is made known to the contractors. The contractors propose their perception of the client’s intent. The client can either buy up or buy down, but in either case, they will buy what the contractor has proposed, and minimize the attempts to modify the contractor’s proposal. If the client does not like what the contractor proposes, the client does not need to buy their service/product. In this new model, the contractor is the expert, and clearly identifies the initial conditions (Figure 6). Because they are the experts, they can more accurately identify the initial conditions, the final conditions, and how to get from one state to the next. Instead of meeting minimum standards, the expert contractor will maximize value by minimizing time and cost deviation (Deming, 1982). The high performing contractor is still required to meet the minimum requirements, but will most likely perform at a much higher level.

The expert contractor will divide the technical requirement from the risk that they cannot control. They will clearly identify how they will manage and minimize the risk that they do not control. They have very little technical risk, so the risk they must manage and minimize is the risk caused by other parties who they cannot control. They will use the risk management plan (RMP) to document all risks and concerns of the client, and how they will manage and minimize the risk. They will ensure that the client clearly understands what is included in the technical scope and what is not. They will then use the weekly risk report (WRR) to manage the risk and deviations throughout the project.

Figure 4: Traditional Procurement Philosophy
Figure 5: New Procurement Philosophy
Because of this new procurement philosophy, the PIPS process and structure defines the product/services the client will receive as the process is being run. Instead of the normal procurement philosophy and actions, the process changes dramatically in the following ways:

1. The client no longer wants to level the playing field.
2. The client minimizes the number of procurement rules.
3. The client minimizes the flow of information to the contractors and tries not to answer questions seeking for direction.
4. The project manager and procurement agent, and selection committee, minimize their decision making.
5. The best value, if there is no dominant information, is the lowest price.
6. Because of the efficiency of the system, the best value may often be the lowest price, because the contractor knows the project the best, and utilizing preplanning, can maximize profit without increasing the cost of the project.

### 7.3 New contract model

The new contract model (Figure 8) is different from the traditional contract model (Figure 7) because of the following:

1. The client’s representatives no longer write the contract. The vendor writes the contract.
2. The contract is no longer used to attempt to control the contractor. The contract is used by the best value vendor to minimize the deviation and risk of the project.
3. The contract still includes the client’s intent, the legal requirements of the client, and any general condition requirements.
The new contract model also includes the WRR and the RMP. Although the contract will not be used to control, direct, or manage the contractor, it can still include liquidation or other damages. However, as seen when PIPS was run correctly, the general conditions of the contract has never been exercised in the 700 cases over 15 years.

The best value contractor puts the contract together. The contract should be as simple as possible and includes the:

1. Client’s intent.
2. Client’s legal requirements.
3. Client’s general conditions requirements.
4. Technical modifications to the client’s intent.
5. The RMP and the WRR.
6. A milestone schedule and payment schedule.

### 7.4 Prototype testing of the new project management delivery model

The new modified PIPS model has been prototyped on the delivery of services outside of construction. It has been tested on:

1. 10 year, $400M food services contract at Arizona State University (ASU)
2. 5 year, $62.5M outsourcing of ASU networking services
4. State of Oklahoma hazardous waste, emergency clean up contract
5. State of Idaho University health care contract

In all cases, the client has been extremely satisfied with the delivered services.
The model is soon to be tested in the General Services Administration (GSA) in the construction services arena. The federal procurement model identified by the FAR, stresses the role of government as quality assurance, and not management, direction, and control (which makes quality control by the contractor and quality assurance a moot issue.)

8. Conclusion

Through the use of deductive logic, the dominant concepts used in leadership and management have been tested for 15 years in the implementation of the Performance Information Procurement System (PIPS.) The concepts have proven to be very effective. They include:

1. Identifies and selects the best value expert based on performance and price.

2. Transfers risk and control to expert vendors, forcing them to manage their own project.

3. Minimizes direction and control from the client.

4. Transforms the client’s project manager’s role to quality assurance (running a process that ensures that the contractor knows how to do their work, and is using a risk management/quality control structure that minimizes risk.)

To assist project managers transform their role from a management, direction, and control role to a leadership role (select the best value contractor and ensure that the best value contractor has a quality control/risk management system that minimizes time and cost deviation,) the following dominant concepts were added to the PIPS process:

1. The client no longer needs to clearly define the requirement in a contract document. Even if the intent is communicated in a detailed document, it will still be recognized as a general intent of what is required.

2. The final delivered service/product will be clearly defined by the best value contractor.

3. The contract shall be drafted and written by the best value contractor.

4. The project manager no longer needs to be the technical expert who makes the technical decisions, but needs to understand the process of identifying the expert and the best value contractor.

5. This process is being proposed for all types of delivery systems, and because the project manager no longer needs to be a technical expert, the authors propose that this project management model can be used for the delivery of any service regardless of industry.

The modified PIPS process has been tested very successfully in case studies at Arizona State University and the State of Oklahoma in non-construction industries. Further testing with the General
Services Administration (GSA) will test the new project management concept in the delivery of
construction. If the processes works in construction, it will transform the project management model
from a management, direction, and control model to a quality assurance model.

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Abstract

Most Department of Defense (DoD) entities consider their contract procurement processes to be tailored towards best value. The Best value process awards contracts to the highest performing contractor. Best value procurement generally leads to a higher reliability of product and execution, including reliable schedules, budgets and ultimately satisfied customers. Despite the professed best value methods, many Government procured jobs continue to have schedule and budget over-runs and displeased customers. Arizona State University’s Performance Based Studies Research Group (PBSRG) is dedicated to the research of Best value contracting practices. PBSRG has developed a procurement and project management system called the Performance Information Risk Management System (PIPS) which weeds out under-qualified bidders and awards contracts to the best performer. PIPS has been proven to significantly improve contractor performance and increase client satisfaction. (Sullivan, 2008) The intent of this paper is to provide an analytical comparison of traditional Department of Defense procurement methods, PIPS, and a hybrid PIPS, capable of operating in compliance with the Department of Defense enforced Federal Acquisition Regulations (FAR). A case study will be presented where the hybrid PIPS is used.

Keywords: DoD, procurement, best value, performance, risk
1. Introduction and Problem Defined

1.1. Problem defined

One of the most significant issues Department of Defense (DoD) facility specialists deal with is the quality of contractors hired to provide facility support to base tenants. The contractors often exceed the budget, finish behind schedule, and deliver poor quality, which lead to clients that are dissatisfied. The procurement process is a major role in the final outcome of a project.

Table 1 shows a portion of the results of a 2006 Naval Facilities Engineering Command (NAVFAC) distributed survey (NAVFAC, 2006). The survey was a NAVFAC wide survey, distributed to 3207 tenant customers. Data is based on 1147 returned surveys. The table specifically shows the five worst rated areas based on a 5-point scale (5 being the best). Three of the five worst responses are related to project delivery. The key to good project delivery is a system that produces a high quality performance-based contractor. From these figures it is clear that an alternate system that provides real “best value” needs to be found.

Table 1: NAVFAC Worst Rated Project Support Areas

<table>
<thead>
<tr>
<th>#</th>
<th>Category</th>
<th>Item</th>
<th>NAVFAC - Wide Mean</th>
<th>Highest Command Mean</th>
<th>Lowest Command Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Delivery System</td>
<td>NAVFAC recommends innovative solutions to satisfy my requirements.</td>
<td>3.4</td>
<td>3.8</td>
<td>2.9</td>
</tr>
<tr>
<td>16</td>
<td>Delivery System</td>
<td>NAVFAC delivers products and services within agreed upon timeframes.</td>
<td>3.4</td>
<td>3.8</td>
<td>2.8</td>
</tr>
<tr>
<td>2</td>
<td>Client Relationships</td>
<td>NAVFAC follows up with me after product and service delivery to ensure no outstanding issues</td>
<td>3.3</td>
<td>3.9</td>
<td>2.8</td>
</tr>
<tr>
<td>4</td>
<td>Client Relationships</td>
<td>If problems occur in the delivery of products and services NAVFAC keeps me informed on</td>
<td>3.3</td>
<td>3.9</td>
<td>2.9</td>
</tr>
<tr>
<td>17</td>
<td>Delivery System</td>
<td>Compared with other providers of similar products and services, I get good value for my</td>
<td>3.3</td>
<td>3.9</td>
<td>2.8</td>
</tr>
</tbody>
</table>

The purpose of this paper is to analyze traditional procurement methods within the Department of Defense and other potential procurement systems. Arizona State University’s (ASU) Performance Based Studies Research Group (PBSRG) has developed a system called the Performance Information Risk Management System (PIPS) that will filter out under-qualified bidders and award contracts to the best performer. (Sullivan, 2008) The paper will provide an analytical comparison of traditional DoD methods, PIPS and a hybrid PIPS capable of operating in compliance with the DoD enforced Federal Acquisition Regulations (FAR).

2. Traditional DoD procurement and delivery process

The procurement process used by most DoD entities is referred to as a best value process. As is shown in the breakdown of traditional DoD procurement processes (below), price is considered at least equal with performance and technical competence and usually is weighed heavier. Therefore, it is questionable that the DoD procurement process is truly producing best value contracts. To
facilitate a review of DoD process, several Request For Proposals (RFPs) from different divisions of the military were obtained and analyzed. The RFPs reviewed include: Army RFP’s, including a solicitation for the construction of the Kayenta Community School in Arizona (Irving, 2006) and for the design and construction of Ojo Encino Day School in New Mexico (Irving, 8FEB2008), and Navy RFP’s reviewed include solicitation for the construction of two enlisted dining facilities in North Carolina (Taylor, 2008) and the design and construction of a joint regional correctional facility in Virginia (Newton, 2008).

Figure 1 shows a graphical representation of the traditional DoD Procurement System. This graphic is specific to the requirements of submittal for the design build joint regional correction facility to be built at Naval Support Activity, Northwest Annex, Virginia (Newton, 2008). Factors, bid evaluation weights and screening levels may vary according to the specific requirements of the project.

The DoD’s traditional procurement process includes an initial analysis of several factors not related with cost. Common factors for construction include; past performance, technical excellence, management capability and personnel qualifications. The RFP specifies the weight of the technical factors in comparison to price. The Solicitation is formatted as a two-phase process. Phase I is a written technical proposal addressing corporate experience, past performance, and safety. Phase II includes a written technical proposal and a price proposal. Separate teams will evaluate the two proposals, without knowledge of each other’s analysis. The Final evaluation includes technical evaluation ratings, the non-cost factor and the price factor. The RFP states, “The Government considers it to be in its best interest to allow consideration of award to other than the lowest priced offeror or other than the highest technically rated offeror.” It also states, “Technical evaluation factors are equally weighted and when combined are approximately equal to price.” Both these statements are consistent for all the referenced RFPs.
3. Performance information procurement system (PIPS)

PIPS is a best value procurement and contract management system developed by ASU’s Performance Based Studies Research Group (PBSRG). This system has been implemented over 600 times for construction projects, A/E services and non-construction type contracts. Evaluation of projects implementing PIPS has shown average ratings of 98% of projects completed on time, 98% projects completed on budget and 100% of customers satisfied. The key factors that make this system work are simplicity, use of logic, reduction of management, making decisions easy, transfer of risk from the client to the contractor and productive measurement. (Sullivan, 2008)

Figure 2 (Kashiwagi, 2008), shown below illustrates the steps and intent of the PIPS process. Within a procurement context, PIPS acts as a filter, eliminating lower quality vendors and producing the true best value vendor. As the process progresses from filter to filter the quality of vendor increases and the number of proposals to be reviewed decrease.

Filter 1 in the PIPS system consists of past performance information. Past performance information (PPI) is submitted on all critical team components for each vendor. Critical team members for a design-build project would include the design firm, the construction contractor, the design build project manager, the construction project manager, the site superintendent and any other key personnel that would support the project.

The second filter in the PIPS process is current project information. The main elements of this filter is a risk assessment and value added plan (RAVA) and cost. The risk assessment section is a short plan that shows the contractors ability to recognize potential risks they do not control associated with the job and methods for minimizing that risk for the duration of the project. The value added section of the proposal shows the vendors ability to stand above the competitors. The RAVA plan typically is restricted to two pages of text. It is meant to hold dominant information, allowing the client to make an assessment of superiority.

The third filter in the PIPS process is interviews. Typically the three to five top qualified bidders, based on the previous filters, move on to this stage. Interviews are held individually with the people specified as members of the critical team in the PPI. Per contract these same people will be assigned to the project. Questions asked in the interviews should be consistent for all interviewed personnel.
and are meant to show in simple fashion if the members of the team are high performers in their areas of expertise.

The fourth filter in this process is prioritization of the final offerors, towards a preliminary final selection. Mathematical models such as a linear relationship model and a displaced ideal model are used to aid in the selection process. The process progresses to the next phase with the identified best value vendor as the preliminary final selection.

3.1 Contract management and delivery portion of PIPS

The pre-award or pre-planning phase is the most critical filter of PIPS. The identified best value bidder is notified, and then required to prepare for and conduct a pre-award meeting. During this phase the contractor develops in more detail the project plan and the risk management plan, laying out all potential risks for the project and plans for mitigation. The offeror coordinates critical elements of the plan with all parties involved. He develops a list of client requirements, key risk events, the program for weekly risk reports, and a finalized schedule. Upon completion of these items the vendor holds the pre-award meeting to summarize their developments and intent to the client. At this point the client still has the option to reject the selected vendor if they are not satisfied. If the client is satisfied, award is made at this time.

The final filter of PIPS is weekly reports and the post-rating. After award the purpose is to implement client management by risk management. This is accomplished through a vendor-maintained weekly risk report. This report documents project risks and performance issues which affect cost or schedule. It allows the contractor to manage the risks associated with the contract, including owner-required actions.

3.2 PIPS/DoD hybrid procurement system

The PIPS/DoD hybrid is a combination of PIPS and the traditional DoD procurement system. This process was developed for the US Air Force and the Army Corps of Engineers (COE) and has seen initial implementation for procurement of a design build contract for the construction of the Battle Space Environment Laboratory at Kirtland Air Force Base in Albuquerque, New Mexico. Procurement of this contract is complete with a notice to proceed given 17 August 2008, with a scheduled contract completion date of 09 May 2010. The PIPS/DoD hybrid description and subsequent cross process analysis will use this project as a reference. (Information is gathered from the project RFP (Irving, 17JAN2008).)

The following table, Table 2, outlines the procurement process for the hybrid projects. The process follows closely the PIPS filter process shown above but with added factors that are necessary for DoD procurement.
Table 2: PIPS/DoD Hybrid Procurement Process

<table>
<thead>
<tr>
<th>Stage</th>
<th>Criteria</th>
<th>Evaluation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Safety EMR less than or equal to 1.0</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td></td>
<td>Small Business Plan</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td></td>
<td>Minimum Bonding</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td></td>
<td>CCAS/ACAS Past Performance Information</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td></td>
<td>Will Run Weekly Risk Report</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td>Qualification Occurs – All qualified Offerors move Forward</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T: Past Performance Information of Critical Components</td>
<td>SSB Rating</td>
</tr>
<tr>
<td></td>
<td>T: Risk Assessment and Value Added Plan</td>
<td>SSB Rating</td>
</tr>
<tr>
<td></td>
<td>T: Schedule</td>
<td>SSB Rating</td>
</tr>
<tr>
<td></td>
<td>T: Small Business Subcontracting Participation</td>
<td>SSB Rating</td>
</tr>
<tr>
<td></td>
<td>P: Price w/ Proposed Scope (beyond minimums)</td>
<td>SSB Rating</td>
</tr>
<tr>
<td></td>
<td>Best Value Selection Occurs – One Offeror moves Forward</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interview of Key Personnel</td>
<td>SSB Rating</td>
</tr>
<tr>
<td></td>
<td>Risk Management Plan</td>
<td>Not Rated</td>
</tr>
<tr>
<td></td>
<td>Offeror Clarification of Requirements of COE and Users</td>
<td>SSB Rating</td>
</tr>
<tr>
<td></td>
<td>Sign Contract – Modify Risk Management Plan (as needed) – Hold Final Risk Presentation – Move into Design and Construction</td>
<td>SSB Rating</td>
</tr>
<tr>
<td></td>
<td>DB Team Submits Weekly Risk Report</td>
<td>USAF PM</td>
</tr>
<tr>
<td>Project Conclusion. Close Out and Performance Database Updated</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The first stage of the evaluation and selection process is qualification. Qualification factors are a simple pass/fail evaluation and will be evaluated prior to the rest of the proposal. The competitive range determination phase reduces the competition down to a predetermined number of competitors as specified in the solicitation. Factors evaluated in this stage have predetermined and RFP specified evaluation criteria. Technical factors (T) evaluated for this solicitation are: PPI of critical components, RAVA, schedule, and small business subcontracting participation, along with the non-technical consideration of price (P) with a proposed scope beyond minimums (bid options beyond the base bid requirement). PPI and the RAVA are collected using the same format and procedures as explained in the standard PIPS process. Similar to the PIPS system a basic milestone schedule showing key items and tasks and total duration of project is submitted.

In order to meet the requirements for small business participation as required by FAR the subcontracting selection plan is more detailed. For this solicitation technical proposals are evaluated with greater priority than price. All evaluations or ratings are conducted by a pre-selected committee, the Source Selection Board, or SSB. Evaluation factors include interviews of key personnel, and submission of a risk management plan. The only difference from the PIPS system is that each of the competitive range vendors are given the other’s risks as specified in their RAVA, minus solutions. During the interview this will allow for a more accurate assessment of the individual’s understanding of the work and how they might manage and minimize risks they don’t control.

After the interviews, each of the competitive range vendors prepares and submits a Risk Management plan. This plan addresses all possible risks, specifically risks the vendor does not control, and
proposes methods of minimizing the effects of each risk. Proposed Risk Management plans must not affect the vendor’s original cost or time schedule. Other key portions of the Risk Management plan include a detailed schedule, key risk points in the schedule, client action items and a plan for methods and management of a weekly risk report through the duration of the project.

Using the submitted data a best value offeror is selected. After award the contractor will make any needed adjustments to the Risk Management plan, present the plan to the client for review and approval. Upon approval the vendor is issued the notice to proceed and for the duration of the project the vendor will submit weekly quality assurance checklists and weekly risk reports.

3.3 DoD, PIPS & PIPS/DoD hybrid procurement comparisons

Table 3 shows some key differences between the three systems.

<table>
<thead>
<tr>
<th>Characteristic of Procurement</th>
<th>PIPS</th>
<th>PIPS/DoD</th>
<th>DoD Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best Value is Intent</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Performance Typically Carries Greater Weight Than Cost</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Evaluation Criteria Established and Included in Solicitation</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Offeror’s Bids Compared to Evaluation Purposes</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Interviews are Performed</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Risks the Contractor Does not Control are Addressed</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Best Value is Clearly Identified</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Award Based on Optimum Performer vs. Qualified at Lowest Price</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Preplanning and Risk Analysis Phase Required</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Preplanning and Risk Analysis Phase Performed Preaward</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Preplanning and Risk After Award and Prior to Notice to Proceed</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Risk is Transferred to the Contractor</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
</tbody>
</table>

3.4 Theoretical differences between traditional DoD & PIPS/DoD hybrid procurement

PIPS is developed around several theories related to decision-making, events, perceived information, and the idea that “we know nothing.” Decisions are made because there is unknown information. If all the information is available then the optimum solution is known and no decision is required. (Kashiwagi, 2009) The traditional DoD procurement method is designed to help the evaluator make a decision. Prior to solicitation, factors of evaluation are determined with specified evaluation methods. The system makes the decision, but there is not dominant information in the end to show that that the decision the system led to is the optimum solution. The PIPS system is designed to provide the evaluator with simple and dominant vendor information with no decision necessary. The PIPS system is designed to filter out all the non-optimums eliminating the need to make a decision, leaving the best value vendor alone on the sieve.
The theory of events is simply that an event has only one possible outcome. The outcome is dependent upon the initial conditions; therefore if all initial conditions are understood and known the outcome can be predicted. (Kashiwagi, 2009) Application to the construction world is that if we know the initial conditions we will know the final product. For instance if you know that the selected contractor traditionally does not finish projects on time or on budget, than the predicted outcome will be that the project will end past schedule and over budget. On the other hand, if a project is awarded to a contractor known to have 100% customer satisfaction, 98% projects completed within budget and 98% projects completed within schedule, than the predicted outcome is your project will be completed on time and on budget. The price given by a contractor tells you nothing of the final product; past performance and job experience tell everything.

A person that quickly processes information is a faster learner and more open to change (Kashiwagi, 2009). One of the purposes of the hybrid interviews is to determine the individual’s ability to identify risks and explain how to mitigate the risks they do not control. The person who is a high performer will be able to quickly process information in the area of their expertise and present potential risks and solution to mitigate the risks. The traditional DoD procurement system pulls risk information in written form. This does not as readily show the professional knowledge, experience and capabilities of the vendor as may be observed through interview.

The last theory is that relative to the knowledge available on this earth, we know nearly nothing. To operate alone and to rely upon our own knowledge results in a high probability of missed expectations (Kashiwagi, 2009). The hybrid best value system acknowledges experts, as the person or company most qualified to do the required task. A visionary is a person that realizes that they know nothing, can relinquish control, responsibility and ownership, leaving the expert to complete the assigned task without interruption or questioning from the client. The traditional DoD procurement system does not allow for full transfer of responsibility and risk ownership to the vendor, therefore holding back the expert from performing to his optimum.

### 3.5 Acquisition results of battle space environmental laboratory at Kirtland AFB

The hybrid was used to procure the construction for the Battle Space Environmental Laboratory at Kirtland AFB. The solicitation resulted in four design-build companies competing for the work. The low bid vendor failed two of the five initial qualification criteria and was eliminated leaving three remaining vendors to proceed. Evaluation of performance showed two of the three with very similar ratings, but with significant price differences. The lower cost offeror was selected. The best value firm was therefore the lowest price within the competitive range. (Irving, 18DEC2008)

One of the concerns about implementation of the PIPS was the legal status in relationship to the FAR and this is the reason for the creation of the hybrid as discussed above. The Albuquerque COE District Legal counsel reviewed the best value PIPS process and concepts in detail and considered the implementation of the concepts of PIPS as a paradigm shift and not as a legal issue. According to the Albuquerque COE District Legal counsel the PIPS/ hybrid process is legal as related to the FAR.
Upon completion of the acquisition process the key Air Force personnel involved presented their assessment of the alternative acquisition process. According to a survey distributed to the five members of the Air Force evaluation committee, there was a 24 percent improvement between traditional DoD procurement and the PIPS/ hybrid, with a 40 percent reduction in time for the selection. The survey consisted of 21 questions, 18 of which compared PIPS directly with the traditional procurement method. Table 4 below shows in summary the five categories with the greatest improvement between the two processes (Irving, 18DEC2008).

Table 4: Acquisition Survey Results - Battle Space Environment Laboratory at Kirtland AFB

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>T</th>
<th>BV</th>
<th>%Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The amount of pre-planning, risk minimizing, and value added by the vendor, before contract award</td>
<td>6</td>
<td>8</td>
<td>40%</td>
</tr>
<tr>
<td>2</td>
<td>The process minimizes unnecessary management and decision making efforts on the part of the client</td>
<td>6</td>
<td>9</td>
<td>42%</td>
</tr>
<tr>
<td>3</td>
<td>The process transfers risk to the most appropriate party</td>
<td>6</td>
<td>9</td>
<td>54%</td>
</tr>
<tr>
<td>4</td>
<td>Your understanding of project risks, before the contract begins</td>
<td>5</td>
<td>9</td>
<td>77%</td>
</tr>
<tr>
<td>5</td>
<td>The process encourages risks to be identified by all parties</td>
<td>5</td>
<td>9</td>
<td>88%</td>
</tr>
</tbody>
</table>

The following are several quotes from DoD personnel directly involved in the procurement of this work:

“I hope I can persuade more COE Districts to give [PIPS] a try. I also have had more experience with design-bid-build acquisition and [PIPS] blows that archaic process out of the water. In our particular project I think we dealt with everything that could go wrong with an execution, but [PIPS] pulled it all together in a quicker, cleaner, and more definitive manner,” quoted by Jeff B Brinkmeier, Program Manager (Irving, 18DEC2008).

“The Best Value Process clearly places the risk where it belongs. Excellent process, a bit bumpy at times, but this was our first one and we should get better at understanding the steps as we get more experience with it,” quoted by Phillip Roybal, Construction Contract Administration (Irving, 18DEC2008).

“The documentation and risk management system was simplistic, dominant (brought consensus), and could minimize the bureaucracy that is inherent in all government agencies,” quoted by Doug Langley, Chief of Construction for Headquarters Air Force Material Command (2008).

3.6 Lessons Learned – Alterations to the Proposed PIPS/DoD Hybrid

The Battlespace Environmental Lab project was the first test of PIPS within the FAR. It was a learning process for both the Air Force and the PBSRG teams. Upon completion of the procurement phase of PIPS several lessons learned were discussed and considered for future efforts. Table 5 shows a revised outline of the PIPS/DoD hybrid. Changes are in italics. (Langley, 2008)
Table 5: Revised PIPS/DoD Hybrid Procurement Process

<table>
<thead>
<tr>
<th>Stage</th>
<th>Criteria</th>
<th>Evaluation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualification</td>
<td>Safety EMR less than or equal to 1.0</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td></td>
<td>Small Business Plan</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td></td>
<td>Minimum Bonding</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td></td>
<td>CCAS/ACAS Past Performance Information</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td></td>
<td>Will Run Weekly Risk Report</td>
<td>Pass/Fail</td>
</tr>
</tbody>
</table>

Qualification Occurs – All qualified Offerors move Forward

<table>
<thead>
<tr>
<th>Competitive Range</th>
<th>Criteria</th>
<th>Evaluation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T: Past Performance Information of Critical Components</td>
<td>SSB Rating</td>
</tr>
<tr>
<td></td>
<td>T: Risk Assessment and Value Added Plan</td>
<td>SSB Rating</td>
</tr>
<tr>
<td></td>
<td>T: Schedule</td>
<td>SSB Rating</td>
</tr>
<tr>
<td></td>
<td>T: Small Business Subcontracting Participation</td>
<td>SSB Rating</td>
</tr>
<tr>
<td></td>
<td>P: Price w/ Proposed Scope (beyond minimums)</td>
<td>SSB Rating</td>
</tr>
</tbody>
</table>

Competitive Range Occurs – 3 Offerors move Forward

<table>
<thead>
<tr>
<th>Best</th>
<th>Criteria</th>
<th>Evaluation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>Interview of Key Personnel</td>
<td>SSB Rating</td>
</tr>
</tbody>
</table>

Best Value Selection Occurs – One Offeror moves Forward

<table>
<thead>
<tr>
<th>Clar</th>
<th>Criteria</th>
<th>Evaluation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Offeror Clarification of Requirements of COE and Users</td>
<td>SSB Rating</td>
</tr>
</tbody>
</table>

Sign Contract

<table>
<thead>
<tr>
<th>Risk Mgmt. Plan</th>
<th>Criteria</th>
<th>Evaluation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Management Plan Kickoff Meeting &amp; Education</td>
<td>Not Rated</td>
<td></td>
</tr>
<tr>
<td>Risk Management Plan Developed by DB</td>
<td>Not Rated</td>
<td></td>
</tr>
<tr>
<td>Final Risk Management Plan Presentation</td>
<td>Not Rated</td>
<td></td>
</tr>
</tbody>
</table>

Issue Notice to Proceed (NTP) once Risk Management Plan is Complete

<table>
<thead>
<tr>
<th></th>
<th>Criteria</th>
<th>Evaluation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DB Team Submits Weekly Risk Report</td>
<td>USAF PM</td>
</tr>
</tbody>
</table>

Project Conclusion: Close Out and Performance Database Updated

The major change in the process was placement of the Risk Management Plan (RMP). The original execution had each of the members of the competitive range (three vendors) providing a RMP after interviews. It was concluded that the RMP should be moved to the post award period to minimize the effort and expended resources of the bidders who are not selected. It was determined that any increase in risk from this change would be minimal as the other elements of PIPS enable selection of best value. (Langley, 2008) The offerors were allowed to submit up to 25 surveys for the organization and 10 for individuals. This was overburdening and it was agreed that the number of surveys should be minimized to 10 for organizations and five for individuals. (Langley, 2008)

Interviews were considered a major value added item by the Air Force team. Two areas of improvement were discussed related to interviews. The first was a consensus that the RFP needed to clearly specify who would be included in the interview process as some of the bidders brought management personnel, who did not have direct knowledge of the project proposal. The solicitation
identified critical personnel by title and the better alternative would be to identify the critical personnel by function (designer, project coordinator, and cost estimator). The desired outcome is to interview those who know the most detail about the project. (Langley, 2008)

The second suggestion was to utilize fewer interview questions. After selection and review, the selection committee agreed that the technical questions and those specific to the project were not necessary and made the rating of interviews more difficult. Questions should focus on vision, accountability, and the vendor’s ability to manage and control risk that is outside their control (Langley, 2008).

One last general lesson learned is the education of the committee members. Implementation of PIPS requires a change of thought process of the core team. It requires the evaluators to set aside bias and to trust the system. Education and buy in by committee members is essential for success.

3.7 Perceived vs. actual compatibility of traditional PIPS with the FAR

The development of the PIPS/DoD hybrid is a dynamic process. PIPS was originally implemented within the civilian sector. PIPS has been altered in order to conform to FAR regulations allowing PIPS to be used in DoD procurement. This section looks at the traditional PIPS and references areas of the FAR that clearly show that maybe DoD could be giving PIPS a try in its pure form. In any organization there is always a resistance to change, especially to dramatic change and sometimes the methods used are so engrained that personnel believe that suggestions for process are actually regulation.

The FAR defines best-value as: “the expected outcome of an acquisition that, in the Government’s estimation, provides the greatest overall benefit in response to the requirement.” (FAR 2.101) The FAR clearly states the type of contractors that should be doing Government work; it is said, “when selecting contractors to provide products or perform services, the Government will use contractors who have a track record of successful past performance or who demonstrate a current SUPERIOR ability to perform” (FAR 1.102-2(a)(3)). The following FAR quote shows that acquisition in the price-based environment is not always preferred by stating, “The less definitive the requirement, the more development work required, or the greater the performance risk, the more technical or past performance considerations may play a dominant role in source selection” (FAR 15.101). Federal acquisition supports a system such as PIPS that promises best value.

The FAR promotes the introduction and testing of innovative acquisition methods. The FAR states, “The development and testing of new techniques and methods of acquisition should not be stifled simply because such action would require a FAR deviation. The fact that deviation authority is required should not, of itself, deter agencies in their development and testing of new techniques and acquisition methods” (FAR 1.402). So there is nothing keeping a DoD entity from developing a PIPS pilot system.

If seeking deviation authority is too much effort, a PIPS pilot system could start with Simplified Acquisition Procedures (SAP). SAP is allowed in contracts less than $100,000. Regarding SAP the
FAR stipulates: “Contracting officers are encouraged to use best value. Solicitations are not required to state the relative importance assigned to each evaluation factor and subfactor, nor are they required to include subfactors.” (FAR 13.106) It further states, “The contracting officer has broad discretion in fashioning suitable evaluation procedures. The procedures prescribed in Parts 14 and 15 are not mandatory....(3) Contracting offices may conduct comparative evaluations of offers.” (FAR 13.106-2(b)(1)) Implementation of PIPS within SAP projects is fully compliant with the FAR.

Research of the FAR and regulations that parallel the various elements of PIPS show little reason why PIPS should be considered illegal. Table 6 shows the six filters of PIPS and FAR references that support these filters. References quoted below are requirements of acquisition that are supported by these elements of PIPS. Referenced below is FAR 1.202-4(e) which states: “If a policy or procedure, or a particular strategy or practice, is in the best interest of the Government and is not specifically addressed in the FAR, nor prohibited by law (statute or case law), Executive order or other regulation, Government members of the Team should not assume it is prohibited. Rather, absence of direction should be interpreted as permitting the Team to innovate and use sound business judgment...” For instance, in absence of reference by FAR, the RAVA, being in the best interest of the Government, should be allowed.

Table 6: PIPS Filters and FAR regulations

<table>
<thead>
<tr>
<th>Filter</th>
<th>FAR References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Past Performance Information</td>
<td>15.305(a)(2)(iii), 53.301-330</td>
</tr>
<tr>
<td>Current Project Information (RAVA)</td>
<td>1.202-4(e)</td>
</tr>
<tr>
<td>Interviews</td>
<td>15.306(c), 15.102(a)</td>
</tr>
<tr>
<td>Identify Potential Best Value</td>
<td>15.305(a), 15.304(b)</td>
</tr>
<tr>
<td>Pre-award Phase</td>
<td>15.506(c), 15.306(d)</td>
</tr>
<tr>
<td>Weekly Report and Post Rating</td>
<td>46.105(b), 36.201(a)</td>
</tr>
</tbody>
</table>

The FAR does require the establishment of evaluation criteria 15.305(a). This would point to a non-comparison type evaluation, if requirements were met, two offerors would get the same rating. This was accounted for in the hybrid. The issue is that the comparative approach is superior. Two vendors may both meet the requirements needed for the highest rating, but one of those vendors may still clearly be the higher performer. He should be rated as such. SAP allows this.

The hybrid eliminated the pre-award phase, allowing all three members of the competitive range to produce some of the elements of the pre-award phase during the interview phase. This should not drastically change the outcome of the acquisition and actually gives a more thorough evaluation of the offerors. The negative side is, this requires additional work for the evaluation team and requires effort and resources of two contractors that ultimately will not get the award. The FAR does allow identification of a competitive range per 15.306(c). The establishment of a second competitive range identifying the single potential best value should be allowed. 15.306(c) says that the number of people in the competitive range may be reduced for efficiency. Progressing only one contractor to the pre-award phase increases efficiency. As long as the process is clearly stated up front in the solicitation it is fair to the contractors.
Each Government entity has its own regulations supplementary to the FAR. Therefore, when initiating PIPS, each Government entity should be evaluated individually to ensure compliance with their regulations. To make the process successful the PIPS pilot procurement team needs to be unresisting to change and be excited about the potential of PIPS. They need to work within the legal limits of the FAR (unless going for deviation authority), but also need to be willing to look more, at how PIPS is permissible while working to recognize ways the FAR allows PIPS, rather than automatically declaring it illegal because it is different.

References


The Design-Construction Industry needs to move to Best Value (A Survey of A/E/C Professionals)

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Abstract

Design professionals’ nonperformance may be a result of the system/environment in which owners/clients operate. The current design-construction environment is often inefficient due to the procurement systems used throughout the industry. A survey was conducted throughout the A/E/C (Architectural, Engineering and Construction) industry to identify issues and concepts within the price based marketplace as well as the Best Value marketplace and to see what kind of agreement exists within the different sectors (private and public) of these markets. The results of the survey suggest that the majority of the industry is in favor of moving towards a Best Value environment.

Keywords: client relationships, QBS (Qualification Based Selection), commodity, best value, design services, designer performance, survey, PIPS
1. Introduction

There is a great deal of inefficiency throughout the A/E/C (Architectural, Engineering and Construction) industry. Many believe the design professional to be the major source of risk and inefficiency, ultimately leading to poor delivery of construction services (Tucker, 2003; FMI / CMAA, 2004). However, there may be multiple issues causing poor performance throughout the design and construction industry (Rubin, 2005). One of these issues may be the procurement system itself (Sullivan, Kashiwagi, & Kashiwagi, 2009). Since the enactment of The Brooks Act (Public Law 92-582 for Federal Procurement) in 1972, the majority of A/E design services, for public projects, have been procured through QBS (Qualification Based Selection). QBS is good in theory but not always the most efficient method and could be better if it were moved into a Best Value environment (Holsinger, 2005). Best Value procurement is a performance based environment, considering qualifications and price (Kashiwagi, 2002). An efficient Best Value system considers many additional important factors such as minimization of risk, added value, and past performance measurement of the firm and its individuals (Kashiwagi, 2002).

2. Problem statement

The delivery of design services through QBS (Qualification Based Selection) does not always procure the most qualified consulting design professionals. The procurement process itself may be the cause of poor designer/professional engineering performance (Sullivan, Kashiwagi, & Kashiwagi, 2009). Design professionals are not being held accountable for delivering designs that meet the expectations (on time, on budget and minimized change orders) of the client (Touran, 2006, Tucker, 2003; FMI / CMAA, 2004).

3. Hypothesis

Owners could maximize design and construction performance by improving the selection and delivery of professional design services. Design professionals need to move to the Best Value environment to increase their professionalism and value added. Design Professionals work in an inefficient, price based, and relationship based environment.

4. Methodology

To validate the hypothesis the following steps will be performed:

1. Research literature to verify inefficiencies of existing conditions and how those inefficiencies hamper the design professional’s performance.

2. Use deductive logic based Construction Industry Structure (CIS) model (Kashiwagi, 2010,) to demonstrate that design professionals currently work in a price based environment and need to move to a Best Value (BV) environment to increase professionalism.
3. Conduct a survey amongst A/E/C Professionals to verify that they are in agreement with these concepts.

4.1 Design professional’s performance hampered by current environment

A good design results in a successful project. Architects, engineers and contractors are now being taken out of their core competencies. In today’s environment architects are performing engineering, engineers are performing architecture, contractors are preparing designs, and some architects are even constructing. Owners hire construction managers to manage the design phase and hire architects to manage the construction phase. Architects and engineers attempt to select the best contractors, while owners are often stuck with the low bidder (Berman, 2003). The low price bidder always brings confusion. Owners try to protect themselves by making lawyers part of the project team. Facilitators, mediators, arbitrators, judges, juries, special masters, and neutral advisors are also often part of a project. Indemnification provisions are often longer than the scope of services in service agreements. The party least likely to control risk is often contracted to do so (Berman, 2003).

Another major problem with today’s professional design environment is that it is relationship based and not performance based. Architects and engineers are often hired based on relationships. In 2007, SMPS conducted a survey where almost 60 percent of the respondents said that key client relationships are in jeopardy if a particular staff member retires or leaves (Schriener, 2007). Relationships are so important to owners and architects that current AIA contracts are set up to protect and preserve relationships during disputes (Berman, 2002).

Owners control the level of performance and quality in the design-construction industry since they are the ones procuring/selecting the designers. Many owners also have the misconception that contract documents are 100 percent perfect, free of any errors or defects and contain everything a contractor needs to do the job, expecting no change orders and believing contingency budgets are unnecessary. They should instead force the contractor use the documents as explanations of intent. Construction industry surveys and studies show that between one-third and one-half of all projects are over budget or behind schedule and that more than one-third of owners, of major new construction projects, are involved in arbitration or litigation of construction claims (Beemer, et al., n.d.).

Another problem in today’s design-construction environment is that architectural, engineering and contracting services are being treated as commodities. For example, Maricopa County (Arizona) has considered changing its procurement code. The proposed amendment of the Maricopa County Procurement Code of September 2009 would consolidate procurement functions into the Department of Materials Management. J. Burnett (2009), Executive Director of ACEC of Arizona, stated, “What this means is, if adopted, ‘procurement’ for engineers, architects and contractors would go through Materials Management … Not Public Works. ACEC of Arizona is adamantly opposed to taking the procurement of professional engineering services from the engineering experts and placing this function in the hands of procurement officers who buy commodities.”
In a 2001 survey of architects, engineers and contractors, 89 percent of the respondents agreed that work should be awarded based on performance history. Another survey in the same year was sent to general contractors. 79 percent of the contractors strongly agreed that contracts should be awarded based on performance rather than low bid, while only three percent strongly disagreed (Erdmann, 2002).

According to a survey, by KPMG in 2005, most (63 percent) of the world’s largest international construction firms believe properly managing and pricing risk is their biggest challenge (Rubin, 2005) (Touran, 2006).

### 4.2 The Construction Industry Structure

The construction industry consists of project owners, contractors and design professionals. The Construction Industry Structure (CIS) (Figure 1) (Kashiwagi, 2009) typifies the construction or any industry based on performance and competition.

![Construction Industry Structure Diagram](image)

Figure 1. Construction Industry Structure (Kashiwagi, 2009)

The price based environment includes the following characteristics (Kashiwagi, 2009):

1. Projects being awarded based on price, using relationships to determine minimum requirements, and the designers/contractors being perceived as commodities.
2. The client’s representative directs through specifications and controls and inspects the contractor’s work for compliance.
3. There is no transfer of control and accountability to contractors. Decision making is done by the design personnel or the client’s representatives.
4. Designers use minimum standards to identify requirements. They also have quantity surveyors, or cost estimators to estimate the scope.

5. The minimum standards are turned to maximums by the vendors due to the price based environment and driven downward by vendors (Figure 2).

6. Contractors who are short on experience, reactive, and only do what they are directed to do become more competitive because they can give a lower initial price, but increase the prices when deviations are identified due to a lack of perception, incomplete directions from the owner, unforeseen events which would normally be identified and handled by the high performance contractors, but unknown to the inexperienced contractor.

7. Contractors who manage and minimize risk and who are the better value when considering total project cost, become less competitive because they do not fully utilize the change order or deviation system, which raises the perceived initial cost of construction, resulting in making their fair price look high due to the incomplete pricing of the low performing competitors (Figure 3).

Relationships, change orders, the reactive nature of all participants, the lack of preplanning, inexperienced vendors, and control oriented client’s representatives (designers, professionals, construction managers, project managers, and quantity surveyors) are all demonstrations of the price based environment (Sullivan, Kashiwagi, & Kashiwagi, 2009). Low performing vendors bring both the vendor and the buyer risk and need to be managed, directed, and controlled by the client (Kashiwagi, 2009).

In the Best Value environment, risk is transferred to the high performance vendor (designer or contractor). Only the experienced, high performing vendors with expertise can reasonably minimize risk. In the Best Value or value based environment, designers and contractors must do the following to be awarded work (Kashiwagi, 2009):

1. Compete based on past performance of the company and key individuals.

2. Quantify the scope of work and the risk that they do not control (not in the scope of the project) and have a plan to manage and minimize the risk.

3. Key personnel must be interviewed to identify if they can predict the project from beginning to end, if they can manage and minimize the risk that they do not control, if they can preplan and be accountable, and to identify if they have the expertise to manage the project.

4. Price is determined by the professional/vendor, and it must be competitive. The low price proposer will be awarded the project, if the value of the different proposers cannot be identified. There is not a client party to double check and assist the proposer, on their price and baseline plan. The professionals/vendors must be accountable and liable for submitting a correct price.
The difference between the two environments is that the price based environment has the following negative and unstable characteristics (Kashiwagi, 2009):

1. No transfer of risk and accountability.

2. The risk and accountability resides with the buyer’s representative instead of the party who is the expert and who is contracted to do the work, resulting in finger pointing and no individuals being accountable.

3. Increased confusion, communications, and higher flow of information.

4. Requires more individuals to do the work.

5. Allows less qualified personnel to do the work due to the lack of accountability.

6. Participants are reactive.

7. Has a management, control, and direction approach and requires more managers; management becomes a more critical position, and decision making is seen as a positive action.

Figure 2. Minimum/Maximum Dilemma (Kashiwagi, 2009)

Figure 3. Price-Based Award (Kashiwagi, 2009)
The price based environment is setup and controlled by the owner/client. Deductive logic shows that the solution might be in changing the system from a price based system to a Best Value system. The participant who can implement system change most efficiently is the owner/client because they have set up and control the current delivery system (Beemer, et al., n.d.).

4.3 Survey of architects, engineering, contracting (A/E/C)

October of 2009, an online (internet based) survey was prepared and invitations were sent via email to over 1,200 professionals (architects, engineers and contractors) and 449 responses were received. The survey was sent out using the survey hosting website www.surveymonkey.com. The survey was sent, by the author, with the objective to identify issues and concepts within the price based marketplace as well as the Best Value marketplace and see what kind of agreement exists within the different sectors of these markets.

4.3.1 Who was polled?

The majority of the survey recipients/participants were design professionals from the Arizona marketplace. They either currently reside and work in Arizona or reside in another state but frequently do work and have projects in the Arizona market.

Responses were received from professionals working for municipalities, engineering consulting firms, architectural consulting firms, contractors, utility providers, etc. The majority of the respondents came from municipalities and consulting firms, representing two distinct sides from within the design-construction market. Municipalities represent the public owner/client while the consulting firms represent the private side of the market sector.

4.3.2 Sample size & confidence Interval

According to the Arizona Board of Technical Registration, there are over 40,000 Licensed Professional Engineers and over 28,000 Licensed Professional Architects in the state of Arizona (Arizona Board of Technical Registration Professional Registrants Listing, 2009). According to the Arizona Registrar of Contractors, there are over 50,000 licensed contractors in Arizona (Arizona Registrar of Contractors License Search, 2009). From a statistical standpoint the A/E/C population size is considerably large. The sample size of the survey was 449. This equates to a greater than 95 percent confidence level with a plus or minus of five percent (± 5%) margin of error, using commonly accepted statistical analysis standards.

4.3.3 The survey

The survey consisted of some identifying questions to determine such things as the respondents’ organization type (private consulting or public agency), title, and whether or not they are a licensed engineer or licensed architect. The next section of the survey then asked the respondents to rate 18 statements on a scale of 1-10 (1 Strongly Disagree, 3 Disagree, 5 Don’t Know, 7 Agree, 10 Strongly Agree). The first 12 statements were related to Quadrant I and the last six statements were related to
Quadrant II of the Construction Industry Structure, as explained in the previous sections. The responses to the survey show the level of agreement and/or disagreement with these concepts. The entire survey is shown in Attachments 1 and 2.

4.3.4 The results

The survey respondent’s organization type had a nearly even split between the public and private sides of the marketplace (see Figures 4 and 5 below). Private consulting services comprised 45 percent of the survey respondents (Engineering 28 percent and Architectural 17 percent). The public owners/clients response made up 41 percent of the survey. The remaining 14 percent of the survey respondents included contractors, developers, private utility owners and others.

In order to simplify the interpretation of the survey results, the survey rating scale of 1-10 (1 Strongly Disagree, 3 Disagree, 5 Don’t Know, 7 Agree, 10 Strongly Agree) can be grouped into three groups: 1-3 Disagree, 4-6 Don’t Know and 7-10 Agree.

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Practice Consulting Engineering (civil, environmental, geotechnical, structural, transportation, etc.)</td>
<td>28.3%</td>
<td>126</td>
</tr>
<tr>
<td>Private Practice Consulting Services (architecture, planning, specialty, etc.)</td>
<td>16.6%</td>
<td>74</td>
</tr>
<tr>
<td>Government/Public Works/Public Agency</td>
<td>40.6%</td>
<td>181</td>
</tr>
<tr>
<td>Construction</td>
<td>6.1%</td>
<td>27</td>
</tr>
<tr>
<td>Land Development</td>
<td>2.7%</td>
<td>12</td>
</tr>
<tr>
<td>General Industry (real estate, commercial, industrial, manufacturing, utility etc.)</td>
<td>3.1%</td>
<td>14</td>
</tr>
<tr>
<td>Academic Institution</td>
<td>0.9%</td>
<td>4</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>1.8%</td>
<td>8</td>
</tr>
<tr>
<td><strong>answered question</strong></td>
<td><strong>446</strong></td>
<td></td>
</tr>
<tr>
<td><strong>skipped question</strong></td>
<td><strong>3</strong></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4. Survey Respondent Organization Type

4.3.5 Agree or disagree

Overall the survey results lean more heavily towards agreement than disagreement of the identified issues within the price based environment and important concepts of the Best Value environment (Attachment 1).

The most frequent rating throughout the entire survey was seven (7). It was chosen 1,457 times. The next highest was eight (8) at 1,317 times. This was followed by nine (9) and ten (10) at 1,017 and 1,011 respectively. After this, five (5) was the next most selected at 825 times.

60 percent of the time “Agree” (7-10) was chosen, 26 percent of the time “Don’t Know” (4-6) was chosen and 14 percent of the time “Disagree” (1-3) was chosen.
There are a few obvious disagreements on some of the issues. Upon analyzing the data it was determined that the major disagreements exist between the public and private sectors.

The disagreeing results between public owners/clients and the private consultant sectors demonstrate the confusion that exists within the existing QBS (Qualification Based System), price based, and commodity environment. This confusion may be one of the major factors contributing to an inefficient environment. The following sections show the differing perceptions between the public and private responses.

Survey questions related to Quadrant I of CIS: Relationships are important. The industry agrees that in the QBS (Qualification Based Selection) process, relationships with public owners/clients are very important in order to get work. Seventy seven percent of the industry agrees with Question 1 “Relationships are important for design firms to get work from project owners in the existing QBS process”. Sixty five percent of the industry agrees with Question 2 “The QBS system results in relationships being very important”. The results of Questions 1 and 2 have an average rating of 7.60 and 7.01 respectively.

Question 3 “Design firms are often hired based on relationships instead of capability and performance” is in the “Don’t Know” range (5.58). There is some disagreement between the public and private sectors. This can easily be seen in the histograms of Figures 6 and 7. Figure 6 shows the perception of the public owners/clients to Question 3. Figure 7 shows the private A&E perception to Question 3 overlaid on the public histogram. Figure 8 shows a normal distribution of the public and private responses.

57 percent of the private A&E respondents agree with Question 3, 29 percent don’t know and 14 percent disagree. To the contrary, 45 percent of the public owners/clients disagree with Question 3, 32 percent don’t know and only 23 percent agree.

In order to verify that there was a significance difference between the public and private ratings (for Question 3) a T-test was performed, which verified that the observation was accurate, showing that the probability of making the wrong assumption was 1.52x10^{-15} percent. The traditional acceptable limits are five percent (5%) error. This level of error is far under 0.01 percent (0.01%).

76 percent of the industry agrees with Question 4 “The major objective of contractors and design consultants at a conference is to network with owners/agencies and form relationships”. The average rating was 7.35. These results are further demonstration of the importance of relationships in the existing QBS, price based, and commodity based market.

4.3.6 Differentiation

Question 5 “Differentiation between qualified firms can be difficult using QBS” only had an average rating of 5.71 throughout the industry. However, 43 percent of the responses fall in the “Agree” group, 31 percent in the “Don’t Know” group, and 26 percent in the “Disagree” group. The results of
this section support the notion that it is difficult to clearly differentiate one qualified firm from another in the QBS process.

4.3.7 Commodity

The overall response to Question 7 “Construction and design services are often perceived as commodities by owners” was interesting. The average rating was 6.51, which is right in between “Don’t Know” and “Agree”. Looking at the responses even further, yields some more interesting information.

65 percent of the private A&E side agree with Question 7 by giving it an average rating of 7.11. However, only 40 percent of the public owners/clients agree and 44 percent don’t know, giving them an average rating of 5.8. Much like Question 3, the difference on commodity perception between private and public supports the theory that the existing QBS, price based, commodity based environment is an inefficient and confusing market where private and public disagree.

4.3.8 Experts

The responses for Question 9, “Designers should be the experts at design and contractors should be the experts at construction”, leaned heavily towards agreement. 63 percent of the industry responded within the “Agree” range, while 19 percent fell within the “Don’t Know” range and only 18 percent were in the “Disagree” range.

4.3.9 Minimum requirements viewed as maximums

The majority of the industry agrees with Question 12 “Minimum requirements by owners/clients are often viewed as maximums by design firms and contractors in order to remain competitive on price, and results in a lowering of quality”. 52 percent of the respondents “Agree”, 33 percent “Don’t Know” and 15 percent “Disagree”.

4.3.10 Survey questions related to quadrant II of CIS

Performance measurements are important. 80 percent of the industry agrees with Question 13 “Measuring the performance of the design firm and their key individuals on a project would increase their accountability and performance”. The average rating was 7.43.

With these kinds of results it is evident that the industry recognizes performance measurement as a critical component to an efficient Best Value environment.

4.3.11 Risk management

Risk management by designers is a characteristic of Quadrant II of the CIS. The industry favors this Best Value attribute.
The majority of the industry agrees with Question 14 “Designers should manage risk and deviation on the project”. 63 percent of all responses fell within the “Agree” range, 28 percent within “Don’t Know” and only 9 percent within the “Disagree” range.

4.3.12 Rely on expertise of design professional

71 percent of the industry “Agree” with the concepts of Question 15 “On design related issues, project owners should rely on the expertise of the design professional to identify the best course of action”. 22 percent of the respondents “Don’t Know” and only 7 percent “Disagree”. The average rating was 7.2.

4.3.13 Design with assistance of experienced contractors

Question 16, “Designers should seek the assistance of experienced contractors to provide accurate cost estimates and scope of projects”, received the second highest rating of all the questions with an 8.04. 87 percent of the industry agrees with this Best Value concept.

4.3.14 Owners control performance and quality

This survey question, Question 17 “Project owners control the level of performance and quality in the design-construction industry since they are the ones procuring/selecting the designers”, produced some interesting results. Both the private sector and the public gave it very similar ratings of 6.16 and 6.06 respectively. The overall industry rating was 6.23 with 53 percent rating it within the “Agree” range.

These results seem to provide more support to the fact that the current design-construction industry is working in Quadrant I of the CIS and that the industry doesn’t know who controls performance and quality on a project.

4.3.15 Qualifications, price, minimization of risk, added value and past performance

Question 18 “Qualifications, competitive price, minimization of risk, added value, and past performance of the firm and its individuals are all important factors an owner should consider when selecting/procuring a design firm”, was the highest rated question in the entire survey. This question contains the majority of the characteristics and attributes of an efficient Best Value procurement system.

89 percent of the industry agrees with its concepts. Only six percent disagree and only five percent don’t know. The average rating was 8.40. The public owners/clients actually gave it a higher rating of 8.61 while the private A&E firms gave it an 8.03 rating.
5. Conclusions and recommendations

The current design-construction environment is often inefficient due to the procurement systems used throughout the industry. The existing design-construction environment, including QBS, is a price based marketplace that inherently brings about nonperformance. Survey results show that relationships are very important in the QBS process. Owners can change the level of performance and quality in the industry through their procurement methods. Survey results suggest that the A/E/C industry is strongly in favor of moving design professionals into a Best Value environment.

References


Berman, G. (2002). The Morphing of the Architect’s Role and How it is Impacting the CM. National Conference and Trade Show (pp. 3-17, 28-29). San Diego: Construction Management Association of America.


### ASU Thesis Research (ALL A/E/C RESPONDENTS)

Please rate the following statements on a scale of 1-10 (1 Strongly Disagree, 3 Disagree, 5 Don't Know, 7 Agree, 10 Strongly Agree).

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>DESAGREE</th>
<th>DON'T KNOW</th>
<th>AGREE</th>
<th>Response Count</th>
<th>Rating Average</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Relationships are important for design firms to get work from project owners in the existing Qualification Based Selection (QBS) process.</td>
<td>2.0% 1.1% 5.1% 3.1% 5.3% 6.0% 16.9% 19.2% 18.3% 22.9%</td>
<td>14 24 27</td>
<td>449</td>
<td>7.60</td>
<td>2.24</td>
<td></td>
</tr>
<tr>
<td>2. The QBS system results in relationships being very important.</td>
<td>2.2% 1.3% 7.0% 4.3% 11.0% 9.2% 16.0% 18.9% 15.2% 14.0%</td>
<td>19 49 41</td>
<td>446</td>
<td>7.01</td>
<td>2.30</td>
<td></td>
</tr>
<tr>
<td>3. Design firms are often hired based on relationships instead of capability and performance.</td>
<td>7.4% 5.1% 15.2% 8.9% 10.7% 11.9% 15.4% 11.6% 6.0% 8.1%</td>
<td>38 48 53</td>
<td>447</td>
<td>5.98</td>
<td>2.60</td>
<td></td>
</tr>
<tr>
<td>4. The major objective of contractors and design consultants at a conference is to network with owners/agents and form relationships.</td>
<td>0.9% 1.6% 3.1% 4.9% 6.1% 8.1% 26.3% 18.0% 18.2% 13.3%</td>
<td>20 27 36</td>
<td>445</td>
<td>7.35</td>
<td>1.98</td>
<td></td>
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<tr>
<td>5. Differentiation between qualified firms can be difficult using Qualification Based Selection.</td>
<td>4.3% 5.4% 16.0% 7.4% 14.2% 9.0% 15.7% 12.1% 8.8% 6.5%</td>
<td>33 63 40</td>
<td>445</td>
<td>5.71</td>
<td>2.50</td>
<td></td>
</tr>
<tr>
<td>6. Design firms spend more money on marketing/sales than they do on training, analyzing and improving their own performance.</td>
<td>3.2% 4.5% 13.4% 6.3% 31.7% 7.5% 13.2% 6.8% 7.9% 5.4%</td>
<td>28 140 53</td>
<td>444</td>
<td>5.54</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td>7. Construction and design services are often perceived as commodities by owners.</td>
<td>1.8% 2.2% 6.5% 5.8% 17.8% 12.4% 18.0% 14.0% 13.0% 7.9%</td>
<td>26 79 55</td>
<td>445</td>
<td>6.51</td>
<td>2.18</td>
<td></td>
</tr>
<tr>
<td>8. Throughout the industry designers are often taken out of their core expertise of adding value by design and are instead spending more and more time directing, managing and inspecting contractors.</td>
<td>2.2% 3.7% 18.4% 13.7% 18.2% 13.0% 13.7% 10.3% 4.9% 2.9%</td>
<td>61 61 58</td>
<td>446</td>
<td>5.35</td>
<td>2.11</td>
<td></td>
</tr>
<tr>
<td>9. Designers should be the experts at design and contractors should be the experts at construction.</td>
<td>2.9% 4.9% 10.9% 7.8% 4.0% 7.1% 19.6% 16.1% 10.9% 16.1%</td>
<td>35 18 32</td>
<td>448</td>
<td>6.64</td>
<td>2.60</td>
<td></td>
</tr>
<tr>
<td>10. Design services are inefficient but would be more efficient if designers were given total control of the project, and all participants including the designer, the client's representatives, the contractor and manufacturer representatives, and regulatory agencies were held more accountable.</td>
<td>8.3% 7.0% 19.6% 15.1% 15.1% 9.0% 10.3% 8.1% 2.9% 4.9%</td>
<td>67 67 40</td>
<td>445</td>
<td>4.79</td>
<td>2.39</td>
<td></td>
</tr>
<tr>
<td>11. Errors in the design documents are motivation for contractor requested change orders.</td>
<td>1.3% 0.9% 6.1% 4.5% 7.0% 9.2% 20.0% 17.9% 16.1% 17.0%</td>
<td>20 31 41</td>
<td>446</td>
<td>7.28</td>
<td>2.18</td>
<td></td>
</tr>
<tr>
<td>12. Minimum requirements by owners/clients are often viewed as maximums by design firms and contractors in order to remain competitive on price, and results in a lowering of quality.</td>
<td>1.6% 1.6% 11.0% 8.1% 11.4% 13.4% 19.0% 14.8% 9.4% 9.2%</td>
<td>36 51 60</td>
<td>447</td>
<td>6.37</td>
<td>2.26</td>
<td></td>
</tr>
<tr>
<td>13. Measuring the performance of the design firm and their key individuals on a project would increase their accountability and performance.</td>
<td>0.9% 0.9% 3.1% 2.7% 4.3% 8.3% 26.8% 26.0% 17.0% 10.1%</td>
<td>12 19 37</td>
<td>447</td>
<td>7.43</td>
<td>1.79</td>
<td></td>
</tr>
<tr>
<td>14. Designers should manage risk and deviation on the project.</td>
<td>2.0% 1.6% 5.4% 5.0% 10.8% 12.4% 21.8% 23.4% 10.8% 7.0%</td>
<td>22 47 55</td>
<td>444</td>
<td>6.76</td>
<td>2.06</td>
<td></td>
</tr>
<tr>
<td>15. On design-related issues, project owners should rely on the expertise of the design professional to identify the best course of action.</td>
<td>1.5% 0.0% 5.8% 5.6% 4.9% 11.2% 20.6% 22.6% 17.2% 10.7%</td>
<td>25 22 50</td>
<td>447</td>
<td>7.20</td>
<td>2.02</td>
<td></td>
</tr>
<tr>
<td>16. Designers should seek the assistance of experienced contractors to provide accurate cost estimates and scope of projects.</td>
<td>0.2% 0.2% 2.2% 2.2% 2.9% 4.9% 20.8% 22.8% 21.4% 22.3%</td>
<td>10 13 22</td>
<td>448</td>
<td>8.04</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>17. Project owners control the level of performance and quality in the construction design industry since they are the ones procuring/selecting the designers.</td>
<td>2.7% 2.7% 12.6% 8.7% 9.0% 11.7% 21.7% 14.1% 9.6% 7.6%</td>
<td>39 40 52</td>
<td>446</td>
<td>6.23</td>
<td>2.33</td>
<td></td>
</tr>
<tr>
<td>18. Qualifications, competitive price, minimization of risk, added value, and past performance of the firm and its individuals are all important factors an owner should consider when selecting/procuring a design firm.</td>
<td>2.2% 1.3% 2.2% 1.8% 1.3% 2.2% 10.1% 18.1% 20.4% 40.3%</td>
<td>8 6 10</td>
<td>447</td>
<td>8.40</td>
<td>2.10</td>
<td></td>
</tr>
</tbody>
</table>

**Vertical Summation (most frequently chosen rating 1-10 in entire survey)**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 213 | 199 | 735 | 513 | 625 | 742 | 1,497 | 1,137 | 1,017 | 1,011 |

---

1. Relationships are important for design firms to get work from project owners in the existing Qualification Based Selection (QBS) process.
2. The QBS system results in relationships being very important.
3. Design firms are often hired based on relationships instead of capability and performance.
4. The major objective of contractors and design consultants at a conference is to network with owners/agents and form relationships.
5. Differentiation between qualified firms can be difficult using Qualification Based Selection.
6. Design firms spend more money on marketing/sales than they do on training, analyzing and improving their own performance.
7. Construction and design services are often perceived as commodities by owners.
8. Throughout the industry designers are often taken out of their core expertise of adding value by design and are instead spending more and more time directing, managing and inspecting contractors.
9. Designers should be the experts at design and contractors should be the experts at construction.
10. Design services are inefficient but would be more efficient if designers were given total control of the project, and all participants including the designer, the client's representatives, the contractor and manufacturer representatives, and regulatory agencies were held more accountable.
11. Errors in the design documents are motivation for contractor requested change orders.
12. Minimum requirements by owners/clients are often viewed as maximums by design firms and contractors in order to remain competitive on price, and results in a lowering of quality.
13. Measuring the performance of the design firm and their key individuals on a project would increase their accountability and performance.
14. Designers should manage risk and deviation on the project.
15. On design-related issues, project owners should rely on the expertise of the design professional to identify the best course of action.
16. Designers should seek the assistance of experienced contractors to provide accurate cost estimates and scope of projects.
17. Project owners control the level of performance and quality in the construction design industry since they are the ones procuring/selecting the designers.
18. Qualifications, competitive price, minimization of risk, added value, and past performance of the firm and its individuals are all important factors an owner should consider when selecting/procuring a design firm.

**Response Options**

1. Strongly Disagree
2. Disagree
3. Don't Know
4. Agree
5. Strongly Agree

**Count**

1. 2.2%
2. 1.3%
3. 7.0%
4. 4.3%
5. 11.0%
6. 2.9%
7. 9.2%
8. 16.0%
9. 18.9%
10. 15.2%
11. 14.0%

**Average**

1. 16.9%
2. 19.2%
3. 18.3%
4. 22.9%
5. 76%
6. 86%
7. 82%
8. 103%

**Standard Deviation**

1. 2.24
Abstract

Best Value Procurement, using the Performance Information Procurement System (PIPS), also works outside the US. Rijkswaterstaat, part of the Dutch Ministry of Transport, Public Works and Water Management, is using the philosophy to procure infrastructure projects worth circa $1200 mln. This paper reflects on the use of PIPS within this project, the world’s biggest PIPS pilot. Eleven adaptations (mostly minor) to the original methodology are outlined, including the reasons why.

Keywords: best value procurement, the Netherlands, PIPS, Rijkswaterstaat
1 Introduction

Best Value Procurement, using the Performance Information Procurement System (PIPS), also works outside the US. PIPS has recently been implemented in The Netherlands at private companies such as the construction companies Ballast Nedam (a.o. procurement of acoustic fencing along railway track) and Heijmans (a.o: bitumen emulsion). Currently, Rijkswaterstaat (the government agency whose role is the practical execution of the public works and water management, including the construction and maintenance of waterways and roads) is implementing the methodology. Rijkswaterstaat is a part of the Dutch Ministry of Transport, Public Works and Water Management. It is using the philosophy to procure infrastructure projects worth circa $ 1200 mln. This paper will reflect on the use of PIPS within this project, the world’s biggest PIPS pilot. The structure of the paper is as follows. First, we provide a background of the program. Next, we will describe the set up of the process. We will focus on the differences of the application of the philosophy (in comparison to the “pure” PIPS process as developed by Dean Kashiwagi; (Kashiwagi, 2009)). We will then outline the results of the first projects. We finish with a summary and conclusions.

2 Background of the program

The road network in the Netherlands (specifically the Randstad area\(^1\)) is heavily congested, with unreliable journey times of one in five during the rush hour. Most of the traffic jams in the Netherlands (81% in 2005) are concentrated in The Randstad (source: OECD). In the Netherlands there are extensive procedures preceding road construction. The average lead-time from idea to new road is over 20 years (!). A law was passed called ‘Besluitvorming Versnelling Wegprojecten” (translated: “Decision for Accelerated Road projects”). This law simplifies some public procedures concerning environmental issues for 30 specific road bottlenecks starting January 1\(^{st}\), 2009. This enables Rijkswaterstaat to take some quick measures to enlarge highway capacity and reduce congestion on several locations on the Dutch road network. The Dutch Ministry of Transport, Public Works and Water Management has identified 30 major bottlenecks, which need to be (partly) resolved by May 1, 2011.

The main reason for using the Best Value Process is that the procurement of DB-contracts usually leads to high transaction costs (efforts of all possible suppliers) and long tender procedures. At this moment the tender capacity in the Dutch market is limited. Therefore suppliers have asked Rijkswaterstaat to develop a procurement strategy heavily based on quality (most economically advantageous tender (MEAT)) to lower the transaction costs and shorten the tender procedure. As a government agency Rijkswaterstaat has to follow the European legislation on public works. Rijkswaterstaat has adopted Best Value Procurement for 16 of the 30 bottleneck projects to tackle this issue.

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\(^1\) The **Randstad** (a city at the edge of a circle, with empty space in the centre) is a conurbation in the Netherlands. It consists of the four largest Dutch cities (Amsterdam, Rotterdam, The Hague and Utrecht), and the surrounding areas. Its 7.5 million inhabitants make up almost half of the population of the Netherlands. source: Wikipedia
In order to resolve the congestion on the highways as soon as possible, the tender process starts before the right-of-way plans (spatial planning) are final. When a draft right-of-way plan is published, stakeholders have a say whether it is legally right. In case of environmental issues (noise or pollution) neighbours can object (appeal) to the road widening. This means that the exact moment that the contractor can start the actual execution of the project is unsure. Appeals may delay the start for half a year or more. Nevertheless the parallel procedures of spatial planning and procurement will contribute to acceleration of a majority of these ‘fast track’ projects.

As speed and quality is of the utmost importance, the best value methodology is / will be used to select the best suppliers who will do the infrastructural work for 16 selected projects (typical work: asphalting, making acoustic screens, road signs and signals, lighting, adding extra lanes next to existing lanes, renovating bridges, gantry sign / overhead traffic sign, etc). The 16 projects have been divided into 6 clusters (see table 1). For each of these clusters the Best Value Procurement process is /will be used.

Table 1: 16 projects / 6 clusters

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Projects</th>
<th>Size in €</th>
</tr>
</thead>
</table>
| A       | A9 Velsen - Raasdorp  
          A9 Raasdorp - Badhoevedorp  
          A4 Badhoevedorp - Nieuwe meer  
          A10 Nieuwe Meer - Amstel      | 20 - 40 mln  |
| B       | N50 Ramspol - Ens      | 70 - 90 mln  |
| C       | A9 Alkmaar - Uitgeest  | 10 - 20 mln  |
| D       | A1 't Gooi  
          A1/A6 Diemen - Muiderberg - Almere Stad West  
          A1 Watergraafsmeer - Diemen | 190 - 250 mln |
| E       | A2 Maasbracht - Geleen  
          A2 's-Hertogenbosch - Eindhoven  
          A2 Leenderheide - Valkenswaard  
          A58 Eindhoven - Oirschot | 185 - 275 mln  |
| F       | A12 Gouda - Woerden  
          A12 Woerden - Oudenaarden  
          A2 Oudenaarden - Everdingen | 125 - 220 mln |

The precise scope of the clusters is not yet defined. Because of the importance of speed, Rijkswaterstaat first will award the project to the supplier that best understands the project and the proposal from beginning to end. Rijkswaterstaat will work out all further details with that supplier (the actual design & realization). This methodology has some advantages; it turns up the speed and it minimizes transaction costs for all suppliers. Only one supplier does all the work (technical aspects).

Rijkswaterstaat has set up 6 project teams that will use the Best Value Procurement process for “their” cluster. Next to the six project teams there is an overall procurement team (a central “core group”) that monitors and coaches the individual teams.²

² The authors work for this central core group
At the moment of this writing, the first three clusters have been awarded (cluster B & D to Volker Infra, cluster E to Heijmans). The proposals on cluster A are currently under review, the formal tender process on cluster C and F are in progress.

3 Set up of the process

While designing the process, the goal was to stay as close to the original PIPS methodology (as developed by Dean Kashiwagi) as possible, with a few adaptations. In this section we will describe the differences between the methodology used in the fast-track project and the "pure"/original PIPS methodology. We will outline what the differences are and why changes were made. We will guide you through the following points:

- Preparation phase
- Procurement phase
  - Past Performance Information
  - RAVA plan (Risk Assessment / Value Added plan)
  - Planning
  - Interview
  - Ranking
- Pre-award phase
- Execution phase

3.1 Preparation phase

As normal in Best Value Procurement, the client and the vendors were extensively educated in the paradigms of the philosophy. A difference during the preparation phase with the "pure methodology" was setting up so called “consultation sessions” or “Intelligence meetings” with each of the individual companies during the tender. In these sessions (2 sessions of 4 hours for each of the companies) the companies had the opportunity to ask questions to the client. The use of “consultation sessions” is standard procedure in The Netherlands when dealing with projects of this size. It gives the vendors an opportunity to find out the risks and concerns of the client (amongst other things). Of course, with the use of BVP it did not seem very logical to talk about risks and concerns of the client (that would be dealt with in the RAVA plan!). Still, it seemed a good idea to have these individual sessions (certainly from an “involvement” point of view; if there were no consultation sessions, the vendors would not know what to expect). The consultation sessions were also used to, once again, delve further into the philosophy.
3.2 **Procurement phase**

The intention was to copy the procurement phase as much as possible from the pure PIPS methodology. Award criteria were pricing RAVA plans, schedule (planning) and interviews. Still, some changes were made. Below we highlight the most important differences.

*Past Performance*

First of all Past Performance Information (PPI) was not used. Although the use of PPI has been discussed in The Netherlands for numerous years, no system is “in place” to use PPI. There have been supporters and opponents of PPI. Given the ongoing discussion, it did not seem “wise” to use PPI in this important program of fast-track projects. Instead of using PPI, pre-qualification was used. All interested parties could express an interest in tendering for the contract but only those meeting the selection criteria of Rijkswaterstaat were actually invited to do so. This is the so-called “Restricted Procedure” within European tender regulations. Under the Restricted Procedure any supplier may request to participate (stage 1) in an advertised tender. However only those invited/short listed (stage 2) by the client (in this case Rijkswaterstaat) may actually submit a tender. New suppliers cannot be introduced at stage 2.

This restricted procedure led to the following results

- Project B: 3 bids
- Project D: 5 bids
- Project E: 5 bids

The consequence of using pre-qualification is that vendors are either “in” or “out”. There is no differentiation between the vendors in the final ranking (like with PPI, which usually counts for 5% in the final ranking). Under European law, award criteria cannot include selection criteria (i.e. financial standing, technical or professional ability).

*Difference # 2: pre-qualification instead of Past Performance Information. This rules out using PPI as an award criterion. PPI can only be used as a qualification criterion.*

*RAVA plan*

The use of the Risk Assessment / Value Added plan led to some differences compared with the original methodology of Dean Kashiwagi. The first difference is that Value Adds were only allowed as long as the contractors price (including value adds) was below the pre-defined budget ceiling. The rationale behind this was a strict judicial one. Lawyers from the Ministry argued that you cannot allow
“options” in a bid: the proposed options needed to be part of the contract. The argument is that once you select a vendor and do not make use of the proposed options (e.g.: in hindsight these options are of “no value”), it could have made a difference in the ranking/ the ranking might have been different in hindsight. The second-ranked vendor could have won the bid.

It remains the question whether this argument really holds, but it was decided not to take any chances/risks (these fast-track projects could not be delayed because of legal problems…..)

**Difference # 3: only no-cost Value Adds were allowed in the RAVA plan**

A slight modification in the use of the RAVA plan was made to assess the Risk Assessment independently from the Value Added plan. In the original methodology each team member gives one overall grade to a RAVA plan.

**Difference # 4: assessing the Risk Assessment independently from the Value Added plan**

**Schedule / Planning**

The second criterion to rank the pre-qualified vendors was “scheduling” or “planning”. Because of the uncertainties surrounding the “road studies”, it seemed impossible to ask the vendors in days / weeks when they would be finished. If vendors could finish the project earlier than the required date, the vendors could write this in the Value Added plan. “Planning” as a criterion focused only on the logical sequence between the activities and the RAVA plan.

**Difference # 5: “planning” (scheduling) was the coherence between milestones and the RAVA plan (instead of the number of days/weeks)**

**Interviews**

In April 2009, before the set-up of the tender procedure was finalised, the principles of BVP (including the way of ranking) were “tested” with the vendors in a so-called “market consultation” (before the start of the tender). One of the findings of the market consultation was that all vendors were (very) satisfied with placing emphasis on quality instead of price. However the findings on the use of the interviews as a ranking mechanism were diverse. Some companies were very comfortable with it, while others displayed hesitation. The core group of Rijkswaterstaat was convinced of the usefulness of interviews as a ranking mechanism. However, from the perspective of involvement of the vendors, the weight of the interviews in the final ranking had to be lowered. Interviews were counted for 20% of the ranking (instead of the proposed 25%).

**Difference # 6: less weight to the interviews in the ranking (20% instead of 25%)**

The market consultation also showed a need from the side of the vendors to explain the way they saw the project by having the option to choose which key persons they would like to send to the
interviews. The argument of the vendors was that the choice of the position of the interviewees would also be a way to illustrate how they see the project. In this case the freedom to choose the position of the interviewees was a way to further explain their vision on the project. This might provide an extra degree of difficulty for the project teams of Rijkswaterstaat, who needed to assess the interviewees: it might be easier to compare two key persons who have the same role/position than to compare two key persons who have different positions. Because the core group of Rijkswaterstaat understood (and agreed to) the arguments of the market, the vendors were allowed to choose 3 key positions (and the corresponding key person) themselves. The vendors could not choose the 4th key person: each vendor needed to send their Project Manager to the interviews.

**Difference # 7: vendors can choose themselves which 3 roles (and corresponding key persons) to send to the interviews**

**Ranking**

Ranking the suppliers was, just like in the original BVP methodology, aimed at finding the best possible vendor (within the given budget). However the ranking method was done in a different way from the “pure” process.

The first difference with regard to ranking was that an extra “safeguard” was built into the process. Like in the BVP process, each team member rated the Risk Assessment plans, the Value Added plans, the schedules and the interviews individually and independently, after which all individual scores were discussed in the team. This team needed to come to a consensus score. The extra “safeguard” was that for the Risk Assessment plans, Value Added plans and scheduling two teams were installed. This way the process consisted of the following 3 steps:

- Each team member rated the vendors individually
- Coming to a consensus score in a team:
  - The 5 team members of team A came to a consensus score for each of the vendors
  - The 5 team members of team B came to a consensus score for each of the vendors (parallel to team A)
- Using the consensus scores of team A and of team B a “final” score for each of the vendors (for each criterion) was reached

**Difference # 8: making use of two teams who each come to a consensus score, after which the final score for each vendor (on each criterion) is determined (again in consensus)**

A more significant difference regarding ranking was the way the actual ranking took place. In the original methodology each vendor scores a percentage of the highest performing vendor (on each criterion). This relative scoring is not allowed in The Netherlands: the rule of independence of
irrelevant alternatives says that the relative ranking of two alternatives A and B must not be affected by a third alternative C.

Within European law, contracts can be awarded either on the basis of lowest price or most economically advantageous tender (MEAT). Logically, the system of MEAT was chosen for the fast track program. When an award is going to be based on MEAT the suppliers must be reasonably informed on the criteria and relative weighting, that will be applied to each criteria, to identify the most economically advantageous tender. Award criteria must be objective criteria to ensure compliance with the principles of transparency, non-discrimination, equal treatment and which guarantee tenders are assessed in conditions of effective competition. As mentioned before, award criteria were pricing, RAVA plans, schedule (planning) and interviews. Logically, these criteria were disclosed prior to the tender process.

In the Dutch infrastructure sector bigger public clients have adapted a specific way to combine price and quality into best value (PSI Bouw, 2007). All “quality” criteria are “transformed” into “fictitious” Euros. To calculate which vendor has the most economically advantageous tender, the amount of “fictitious” Euros scored on quality is deducted from the vendor’s budget. E.g. : for a € 100 mln project, the maximum (fictitious) deduction is € 70 mln (=70%). This would lead to a fictitious price for this vendor of € 30 mln. For each criterion, a vendor could get a deduction on its price (when the grade on the quality criterion is more than a “6”) or there could be an addition to the price (when the grade on the quality criterion is lower than a “6”). See table 2.

Table 2: The grading system

<table>
<thead>
<tr>
<th>Grade</th>
<th>% of maximum value</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>9</td>
<td>75</td>
</tr>
<tr>
<td>8</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>25</td>
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<td>6</td>
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<td>5</td>
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<tr>
<td>4</td>
<td>-50</td>
</tr>
<tr>
<td>3</td>
<td>-75</td>
</tr>
<tr>
<td>2</td>
<td>-100</td>
</tr>
</tbody>
</table>

E.g.: if RAVA plans counts for 20% in the ranking of a € 100 mln project, the maximum deduction (resulting from interviews) would be € 20 mln. A score of “7” on interviews would lead to a deduction of € 5 mln.

Difference # 9: ranking the vendors based on their absolute scores (instead of the relative scores), and based on price +/- “deductions from quality scores”
3.3 Pre-award phase

The pre-award phase was done after the award. European legislation prohibits public clients to negotiate with contractors before the award. For this reason Rijkswaterstaat used the phase directly after the award as an “introduction phase”. This phase is set up exactly like the pre-award phase. At the end of this phase the contractor has a project management plan, a risk management plan which includes all the risks and concerns of the client and an overall schedule. Also the weekly risk report has been brought into place.

Difference # 10: the pre-award phase is carried out after the award.

3.4 Execution phase

A question Rijkswaterstaat had to face in the absence of a past performance system, was how the best value contractor could be incentivised to control risk he did not control after contract award. The solution was a so-called “risk fund”. This fund is filled with the predicted amount of € for the risks that are the responsibility of Rijkswaterstaat. During the execution of the project the contractor can propose measures for risk minimization. The money for these measures are paid out of the risk fund. Also risks that actually occur are paid from the risk fund. The contractor receives 25% of the remaining euros in the risk fund at the end of the project. This risk fund, combined with the weekly risk report, ensures that the contractor works in the best interest of the client.

Difference # 11: working with a risk fund

4 Results of the first 3 projects

The first 3 projects that have been tendered, show that quality goes hand in hand with a sharp price. The first tender in the fast track project was cluster D (see figure on next page). In cluster D traffic congestion during the execution of the project is a major issue. Rijkswaterstaat gave the contractors a reference staging for the work with matching traffic congestion. During the tender phase contractors had to design a better staging with less traffic congestion: the less congestion, the more value (expressed in euros). The traffic congestion could be considered a predefined value add. For cluster D the highest performing contractor (C) bid was € 137,9M, This led to an overall third place ranking for contractor C. Contractor A was the second highest performer and had a bid of € 107,2 M (the second lowest price). This contractor had the best score on traffic congestion and the best schedule. The interviews of contractor A were average, but because of the traffic congestion and the price contractor A won the bid. See figure 1.
For cluster B the highest performer (contractor A) was also the lowest bidder. The financial bid of contractor A however did not comply and the bid had to be eliminated from the tender process. The contract was awarded to contractor B, whose bid was just below the budget of € 78 M. Contractor C scored negative value on all quality aspects.

Cluster E also showed a correlation between the lowest bid and the highest quality. Contractor A offered the lowest price and ranked best on quality. Especially the interviews dominantly showed the quality of contractor A. As in the other two tenders the overall score shows a large spread (€75M). The conclusion is that the quality aspects highly differentiate between the contractors.
One observation during the tender process of the first three clusters was that the interviews are differentiating. There were no problems in scoring different key persons. The free choice of the key persons by the contractors did not raise any problems. Another observation is that the individual consultation sessions during the tender sometimes led to attempts to verify chances of risks minimizing measures by the contractors. Not answering these questions was sometimes misunderstood by the contractors and led to allegations of non-transparency.

5 Summary and conclusions

Over the last years, PIPS tests have not only been done within the US, but also outside the US. Recently a number of (successful) tests have been done in the Netherlands. Now, Rijkswaterstaat is using PIPS in its Fast Track project, making it the world’s largest PIPS pilot, worth circa $1200 mln. In designing the tender process Rijkswaterstaat’s goal was to stay as close to the original PIPS methodology as possible. A few adaptations had to be made. In this paper we have outlined 11 adaptations (mostly minor) to the original methodology. The philosophy when applying the adapted methodology however was still completely intact: it was aimed at finding the highest quality vendor within the budget (like in the original methodology as developed by Dean Kashiwagi).

The results of the first three clusters have been promising: when setting up a tender process using Best Value Procurement high quality and a sharp price tend to go hand-in-hand. Next, the three other clusters will be awarded and all projects will go into the realization phase. We will follow-up with a paper on the realization phase.

The outlook is bright; Rijkswaterstaat is currently contemplating applying the principles in new projects (outside the fast track projects).
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Barriers of TQM Implementation in Libyan Industries

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Abstract

In today’s competitive market there are many challenges facing Libyan construction industries. The ability of Libyan companies to effectively introduce quality management system QMS such as ISO and Total Quality Management (TQM) is one of the main challenges to Libyan industries. TQM can empower employees and develop the organizations ability of responding to international competition. The main purposes of this study were to identifying the barriers to TQM implementation in Libyan industries. The research investigates the quality management systems which are currently being Implemented in the Libyan construction industry (LCI). A number of senior managers of construction companies in Libya were interviewed to identify barriers, drivers and benefits of QMS. Initial results suggest that LCI has suffered from; employee resistance to change and over emphasis on production quantity to the detrimental of quality, lack of skilled labour. The research aims to help address some of the problems by developing a generic company-wide framework to facilitate the adoption of quality management principles which consider local culture, organisational readiness and maturity.

Keywords: Total Quality Management (TQM), Libyan construction industry, Quality Management System (QMS)
1. Introduction

Currently, for a company to be successful and have steady organisational growth, the most important cause is quality management. This works for both national and international markets. Construction companies must provide high quality products consistently and must use added value to appeal to their customers and clients and also to remain in the highly competitive business climate. Any countries economy relies on their construction industry to be their backbone and it is also vital to a countries infrastructure. However the construction industry faces a lot of problems. Some examples include: economic, high fragmentation, low productivity, lack of standards, poor quality and instability. McCaffer (1998) states that most countries are faced with similar problems in their construction industry even though the economy of each country is different. The requirements stated in Kometa & Olomolaiye (1997) about the quality standards are often not fulfilled by construction clients. Kometa & Olomolaiye (1997) also states that clients are still displeased and many other problems are still arising in the construction industry, however efforts have been made and timing and cost overruns have been improved. However this still means that the construction industry in Libya is still not up to its fullest potential and is not at its best therefore it will have problems meeting the competitive challenges that arise in the modern fast changing market that we have now. The findings of Torbica & Stroh (1999) were that competitive edge is with those who manage their resources most effectively and offer a timely response to the demands of the market.

For the recent years, the Libyan construction sector has been going through a radical change driven by the (ISO) quality policy of the Libyan government. Recently, the number of contractors obtaining certification of ISO 9000 Quality Management System (QMS) is ever increasing. However, with insufficient experience on ISO quality implementation within the Libyan environment, the construction participants are staggered with several performance-related problems. Sayah,(2006) A number of quality managers and senior managers of construction companies in Libya were interviewed to identify barriers, drivers and benefits of quality management system (QMS) initial results suggest that (LCI) has suffered from; employee resistance to change and over emphasis on production quantity to the detrimental of quality lack of skilled labour and the research aims to help address some of the problems by developing a generic company-wide framework to facilitate the adoption of quality management principles which consider local culture, organisational readiness and maturity.

2. Overview

Libya is an African country that spans over 1,759,540 square kilometres (679,182 sq. miles), making it the 17th largest nation in the world by size. It is linked to the North by the Mediterranean Sea, and bordered in the West by Tunisia and Algeria, the southwest by Niger, the South by Chad and Sudan and to the East by Egypt. Libya has the longest coast amongst all African countries bordering the Mediterranean which stands at 1770 kilometres (1100 miles), The portion of the Mediterranean Sea in the North of Libya is often referred to as the Libyan Sea. The construction industry in Libyan is consequence of interaction of geographical, historical, social, political, and economic and technology factors. The Libyan industry operates in difficult geographical social and economic circumstances.
The operations are concentrated in four separate regions influenced by social tribalism and nepotism, fluctuation in oil revenue and foreign workers.


The effectiveness of an organisation and its people depends on the extent to which each person and department perform their role and move toward the common goal and objectives.

The traditional, post-operation inspection process, which was used during the early part of the last century, was largely replaced by techniques of quality control (QC) and quality assurance (QA). Then, the approach of the total quality management (TQM) was then developed and applied by leading companies. An organisation that continues to use traditional methods, because it is the way they have always done it, will not resolve their quality problems effectively. Such methods add cost and delay by employing more inspectors and this approach does not promote quality because it involves expensive repair and rework. TQM is an approach eliminates the costs and time delays, improving the competitiveness and flexibility of whole organisation.

The figure shows the relation between the four stages of control (Dale and Plunkett).

Figure 1: Relationship between the four stages of quality management

- **INSPECTION**: activity such as measuring, examining, testing or gauging of one or more characteristics of all entities and comparing the result with specified requirement in order to establish whether conformity is achieved for each characteristics

- **QUALITY CONTROL (QC)**: operational techniques and activities that are used to fulfil requirements for quality

- **QUALITY ASSURANCE (QA)**: all the planned and systematic activities implemented within the quality system and demonstrated as needed to provide adequate confidence that an entity will fulfils requirement for quality.

- **TOTAL QUALITY MANAGEMENT (TQM)**: management approach of an organisation centred on quality based on the participation of all its members and aiming at long-term
success through customer satisfaction, and benefit to all member of the organisation and to society.

4. Research methodology

The objective of this paper is to assess TQM in number of Libyan contracting organisation to explain and identifying barriers, drivers, and the benefits of implementing (QMS) therefore 10 interviewing was arranged with the quality managers and senior managers to discuss the research and objectives.

So the research made 10 interviews conducted at the preliminary literature review stage to support the preliminary review where the interviews helps in identifying the major problems in the Libyan construction industry and formulated the objectives of the research. The preliminary stage of this research focused on the observation and analysis of the construction industry in Libya at this stage of identifying the problems this approach also used to collect data of TQM in Libyan construction industry.

However, according to Oppenheim (1996) “interviews often have a higher response rate they offer the opportunity to correct misunderstanding and to carry out observation and rating while controlling for incompleteness and for answering sequence and the interviewers can often succeed with respondent who have reading or language difficulties but the interviews are expensive and time consuming to conduct and to process”.

At the beginning of each interviews the research asked for permission to use a tape recorder to record the interview for future reference and data analysis but the interviewees refused permission to tape so after each interviews the researcher wrote script of the interviews in the Arabic language then researcher translated to English language.

The data required for the implementing QM in the LCI were collected through the personal interviews and questionnaires, the interviews took place before to development of the questionnaires. The data extracted from the interviews with the Libyan contractors and the literature reviews were used to develop the questionnaires. As apart of the data collection the research conduct personal interviews with number of contactors, about the implementing the QM in the Libyan construction industry and the problems of the Libyan industry. And also the interviews emphasis the effectiveness of the quality management as the solution to problems in the construction industry (to identify the construction industry problems) the interviews consists of number of managers such as quality managers and senior managers the emphasis in these interviews was on the implementing of TQM as a solution for the LCI in general, also the interviews discussed the challenge and the problems of the (LCI) where the nature of the CI in general and in Libya particular makes the TQM unrealistic according to the interview one of the quality managers who had attempted to implement TQM.
5. Contractor interviews result

The data required for the implementing quality management (QM) in the Libyan construction industry (LCI) were collected through twenty five personal interviews; the interviews took place before to development of the questionnaires. The data extracted from the interviews with the Libyan contractors and the literature reviews were used to develop the questionnaires.

The interviews emphasised the effectiveness of the quality management as the solution to problems in the construction industry (to identify the construction industry problems). The survey includes interviews with managers such as quality managers and general managers. The emphasis in these interviews was on the implementing of TQM as a solution for the LCI in general.

In the interviews the challenge and the problems of the LCI were also discussed. The nature of the (CI) in general and in Libya particular makes the TQM unrealistic according to the interview with one of the quality managers who had attempted to implement TQM.

The objectives of these interviews were to identify the critical success factors of implementing total quality management in the Libyan construction industries; two contractors interviewed were relatively large and had an average of 25 years in business experience.

The quality and senior managers were asked about the critical success factors of implementation of quality management, and how these factors affected to these companies.

In advance of the interviews, the author sent a letter to all potential interviewees, describing the purpose and the background of the research work. Each of the quality and senior managers was given a set of questions to answer. At the beginning of each interviews the research asked for permission to use a tape recorder to record the interview for future reference and data analysis but the interviewees refused permission to be taped so after each interviews the author transcribed in Arabic language and then translated to English language.

5.1 Management commitment obstacle

The major obstacle to quality initiative in Libyan construction companies is the lack of management commitment such as the lack of employee’s involvement, lack of incentives, lack of motivation inadequate recourses employees resistance to change lack of customer care, and lack of continues improvement

Managers in Libyan companies have to be more active and involved with the business; in particularly they need to focus on customer’s needs and wants. They must show further commitment to the quality policy and as they are the managers they must deal with the quality arrangement of the business. Managers must be an example to other employees and demonstrate the dedication needed.

The quality council is set up to manage the arrangement of the quality journey. The quality council are set up to identify any problems or hiccups along the way; they then find a solution to overcome
the problem. The general manager should lead the quality council along with a full time quality related manager; this ensures the quality council is well supported. An external consultant can be hired if extra help is needed to assist in the implementation process. The comprehensive quality policy must be based on the company’s targets, the mission statement and a clear plan on what should be accomplished, including quality goals of all levels of the organization. The quality council’s senior management has the duty to create this policy. The policy will join and focus the efforts of all employees, and set a clear plan on the organizations aims and expectations. This policy should be visible and available for all employees to see so they can learn the organizations expectations and they can refer to it for help, they can also see what tasks need to be done to help accomplish the expectations. The policy should be easy to read so there is a common understanding and can be communicated successfully. Every department should be allocated with a quality committee, this should be directed by the department head. The committee can hold discussions to track how much progress has been made and make sure all employees are aware of the quality policy’s goals. The committee’s set up at each department should be directly linked with the quality council. The mission statement should also be communicated from the top managers to the employees; this should be done frequently to make sure all workers are aware of the mission statement. The mission statement concentrates on the employees; to make sure they are aware of the objectives defining the quality values and expectations from the quality values. Face to face communication should be used to communicate the mission statement at meetings, this is a early implementation step. Top managers should also make sure employees are committed and they participate fully within the organization. To be certain all workers are fully notified top managers must make them aware of the following; preparation, implementation and evaluation of any improvement activities. Assistance, training, acknowledgment and a chance to contribute should be given to employees, this will guarantee all employees achieve the quality goals of the organization. It will also give employees experience and they would have learned and gained knowledge.

5.2 Culture obstacle

The other obstacle organization bureaucracy where the bureaucracy is the greatest day to day problem and major challenge for all Libyan companies Libyan authoritarian and bureaucratic management style have been impeding more participatory and conscious organization culture. The effect of this obstacle was clear from the feedback of all the interviewees in the Libyan

5.3 Orgainsation

The management styles in Libyan companies must be changed. A new approach is required, to create a new approach data must be collected on the current management style and the disadvantages it has, this will help the managers focus on what specifically they need to change with the management style. It will be the first stepping stone for some improvement in the work environment.

Currently, as were revealed by the quantitative and qualitative data analysis, due to the poor management in Libyan companies employees were not working to their full potential, this led to employees feeling de-motivated and boredom. Management should change the organization’s culture and environment and compare their working culture to the culture TQM brings about; this will help
discover the problems which exist. Managers can then begin putting a plan in place to help resolve the problems and help move the organization towards a TQM culture.

5.4 Training and education obstacle

The other obstacle to cause the effect TQM implementation is training and education as I was mentioned by most of the Libyan interviews (quality managers and general managers) have not receive formal quality management courses where the training for all levels of the organization is the fundamental importance and must be provided continuously.

A vital first step is awareness training; this is where employees learn how to adjust, or what to do differently for quality improvement to take place. Problem identification and solving skills must be learnt, training will also be provided on how to communicate effectively and it can also encourage teamwork and decision making to occur, and employees can improve at a faster, continuous rate. Middle managers must also be well trained and know how to establish quality principles and tools, they must also be trained to teach and be able to help their subordinates. This involvement in training will help make the transition to quality more smooth and successful.

5.5 Empowerment

The other obstacle is lack of Employee empowerment, is the latest way of overseeing organizations towards a more intricate, economical and competitive future. If empowerment of employees is missing then a TQM strategy is deemed as failing. To be a successful organization, employees should be given more authority, control, independence, information and acquaintance. The organization must also have a rewards and recognition system in place relevant to business performance to motivate the workers.

5.6 Salary and incentives obstacle

Every Libyan organization has to operate is the low of salaries for all levels of employees, all employees in the public sectors are state employees and government fixes their salaries as well as yearly increased in their salaries under rigid low called (low 15/1983) this low did not changed from 25 year the consequently it is difficult to motivate employees to work harder or to be more efficient or more effective.

6. Interviewer’s findings

1. Poor internal communication between departments and offices are as follows:

   • The lack of scheduling or a clear mechanism for holding the meetings at the level of departments and offices.

   • The absence of direct contacts through all level of departments and offices to resolve any problems that may occur. It is through the guidance of internal communications to address
any topic or any work-related departments and offices. Departments and sections all need better communication between each other.

- Prepare scheduled periodic meetings for all level of departments and offices. This applies for all the senior management of the company.

- Increase communication through daily meetings between the directors straight to the departments and offices, departments and sections should be encouraged to discuss the progress of work and overcome any problems or obstacles in a timely manner.

- Reduction of direct internal memos and correspondence with a view to reduce and minimize costs. Direct contact is made to resolve any problems that may occur in the time and this should be done as soon as possible.

2. The employees are not adequately trained about the company’s business operations.

3. The management and the leadership in the Libyan construction companies have inadequate education to understand the quality approach

As will be seen in the literature review, communication systems are a vital component of TQM. However the researcher focused on the internal communication problems encountered by the case study, particularly contractors B and C. The researcher has been asked to address and improve the communication as it is one of the crucial problems that the Libyan companies are facing. In this case these companies had inadequate communication systems. So the researcher will introduce a roadmap or a protocol to all departments which will encourage the Libyan companies to maximize profit and promote TQM principles.

We can also see that there is lack of effective communication systems between the top management and its employees.

As we know the communication gives the employees the knowledge about what is going on in the organization and keeps them updated.

Therefore the most common barriers of effective communication are: difference in meaning, lack of trust, information overload, poor listening skills etc (Goetsch and Davis 2006).

7. Conclusion

- Creating effective communication networks in any company is vital for a successful company; the company has to improve communication. By improving these channels, they must also implement a clear and open structure where the communication flows openly and doesn’t get distorted.
• Creating an atmosphere of trust and mutual respect where communication is improved. Information can be accurately delivered and received as a way of solving and overcoming barriers to communication.

• From the interviews the researcher found that there was a clear lack of implementation of the critical success factors (CSFs) of TQM demonstrated through features such as; lack of knowledge of QM and lack of commitment from the management.

• In my view the Libyan organisation are still in the early stages. Most of the Libyan companies introduced ISO 9000 for the reputation it would bring to the company because some of the local companies had been certified ISO 9000 and it was a success.

• There are weaknesses in communication and information systems in the LCI. Currently the present communication system in the LCI is based on paper and verbal formats; this results in low quality and a low flow of information.

• Libya is not yet ready to accept and adopt TQM because the lack of infrastructure, top management are not keen to be involved in adopting TQM due to lack of education and skills. For these reasons the implementing of the quality management in Libyan construction industry is difficult and it will take a long time to understand the exact meaning of quality management systems and how to implement them.

• Unfortunately some managers working in companies mentioned the policy of their company, they also said that the government does not allow them to delegate some tasks to the employees and give them some authority; in this case the employees could not make a decision until the management (leadership, supervisors) said so.

8. Summary of findings

It is extremely important for Libyan construction companies to have a clear communication system linking all company departments and management as well as outside parties.

It is obvious that the LCC should have an efficient communication system between top management and employees.

A proper chain and efficient information will channels link all parties. This should be instituted so that there is proper information flowing through all departments.

It is apparent that the Libyan construction companies should enhance their effort to understand the opinions and thoughts of employees which will clearly help on achieving the company’s goal and objectives.
It is imperative for managers to encourage their employees more and more towards teamwork as it helps solve problems between employees.

It is very clear that the Libyan managers should set up a training program for their employees; it should particularly focus on quality management systems.

As we know Training is the main target to any organizations to increase the ability of their managers and employees.

From the finding when the author asked general managers in the interviews about if the company “B” provides Training courses, “the managers said

Managers should not have such training and developing courses, because they are full of knowledge.

9. Limitation of the study

There are some shortcomings that will restrict the scope of this research are mentioned as follows The research in this study suffers from number of limitation every effort has been made to overcome these limitations the first limitation which is the most important was a general shortage of data, and information regarding to the quality management in the Libyan construction industry. The limitation was related to the cultural and social elements of the context of the study, whereby Libyan people are very sensitive about providing information about their work such as income company turnover, and so forth so friendships and social and tribal relationships were significant in influencing access to data.  Other point that should be mentioned is that the majority of roads and streets and building are not named or numbered in the Tripoli and as a result the research could not make contact easily with the personnel of the construction companies We chose quality managers and general managers because they are involved in the implementation of total quality management.

In addition, this research concentrates only on one of the Arab countries namely Libya which is a part of the Arab countries. The findings of this study and the proposed roadmap could be implemented to some Arab and Islamic countries that have similar cultural background such as Egypt, Tunisia, Algeria where the dominant workforces are local people. However, it may be hard to be implemented in most of the other Arab countries because the workforce in these countries is mix of many nationalities. Therefore, further studies should be conducted to compare the findings in other countries where there is a mix nationality in their management and workforce with this study which is totally about Libya and Arab managers and workers.

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Post Occupancy Evaluation Practices: A Procedural Model for a Successful Feedback

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Abstract

Post occupancy evaluation (POE) refers to a systematic building performance feedback procedure conducted on occupied buildings. POE is invaluable for existing as well as future projects – it ensures that completed buildings operate efficiently throughout its expected life span, and serves as a crucial lessons learned feedback cycle for future buildings. The effectiveness of POE feedback cycle depends on its key procedural components namely the processes, the participants, and the documentation and dissemination instruments and technology. This paper reviews established POE practices to derive a POE procedural model. This procedural model is then used as the basis to assess the current POE practices in Malaysia through a case study. The paper concludes with observations on the current state of POE practices in Malaysia and recommendations for improvements.

Keywords: post occupancy evaluation, procedural model, procedural component
1. Introduction

Globally there are growing efforts to undertake performance studies of occupied buildings in response to the quest for more efficient buildings to meet sustainability challenges. The potential of building performance studies extend beyond the benefits for improvement to a specific building under investigation. It probe outcomes and make recommendations that open up opportunities to enable transfer of knowledge in future projects (Lackney, 2001; Zimring, 2002; Lu Aye et al., 2004). An effective building performance study requires adoption of a systematic procedures and techniques, whereby the most commonly known is Post-Occupancy Evaluation (POE). POE is different from other evaluation methods in that it emphasises on the needs of building occupants (Preiser, 2005). The strength of POE therefore lies on its capacity to promote the carrying forward of knowledge through lessons learned and feedback. Past studies have established the importance of POEs as determinants to crucial performance factors relating to sustainability such as resource consumption, environmental conditions, and the occupant satisfaction and operator experiences. As a result there are firm calls to make POE a mandatory step in the design and commissioning of buildings (Preiser 2005; Isaac et al. 2009),

Malaysia is a developing country with a vision to be a fully developed nation by the year 2020. In its pursuit to be a developed nation, Malaysia has undergone unprecedented change in the last five decades in terms of economic, social and environment. The drive towards socio-economic progress has results in rapid change in the natural environment which if remain uncontrolled is likely to pose severe impact in the long run. Aware of this potential consequence, Malaysia has made its commitment towards sustainable development clear since 1996 in the 7th Malaysia Plan (Government of Malaysia 1996). Several efforts have been initiated to drive further the sustainable development agenda, with the most recent move is the introduction of the Green Building Index (GBI) - the country’s own rating system for green building.

This paper seeks to establish the current state and future directions of POE in Malaysia. It reviews literature on POE practices adopted by pioneers of POE and building performance studies, namely from the USA, Canada, UK, New Zealand and Australia, focusing on identifying the people-process-tools aspects of POE.

1.1 Aspects of post occupancy evaluation

There are various approaches to POE studies, which have been classified according to the intensity of the investigation (Presier, et. al., 1988), the targeted time frame of the benefits to be gained (Isaac et. al., 2009) and the study’s emphasis (Vischer, 2001).

The degree and extend of POE studies primarily depends on the necessity and purpose of the POE to meet either the short, medium or long term benefits, and the availability of fund. (Refer to Figure 1).
1.2 People aspect: initiators, commissioners, consultants and the respondents

The formulation and implementation of POE programmes require strong support from various groups. They comprise the project initiator, client, commissioner, the experts / consultants and industry consultants.

The initiator

Based on interviews conducted with key market actors Hewitt et al. (2005) concluded that the primary initiator of POE are the owners who are in the best position to motive and drive the POE agenda.

Involvement of universities, professional bodies and the industry

POE studies have mainly been supported by scholarly research activities conducted by academicians and their institutions. For example in the case of the development of the Association of University Directors of Estates (AUDE) Guide to Post Occupancy Evaluation 2005, the key parties involved are the University of Lincoln, University of Westminster, Higher Education Funding Council for England (HEFCE) and professional bodies namely Royal Institute of British Architects (RIBA) and Royal Institutions of Chartered Surveyors (RICS).

Government-related bodies as commissioners

Significant POE programmes are usually associated with and commissioned by large, government organizations and public property owners. For example the Department of General Services (State of California, USA), the General Service Administration and Public Works Canada and the New South Wales Health Department.
1.3 Process / protocols

POE process is often referred to in the literature as ‘protocol’. POE protocols are developed through a rigorous process of consultation with various groups of people. As explained by Carthey (2006) who developed the generic POE for healthcare buildings for Australia and New Zealand, involvement of representative cross-section of industry professionals and the building operation team is crucial. Documented protocols are in the form of POE Guidelines, while the main bulk is in the form of POE reports and published past POE experiences. Most of these are from the UK, Canada and the USA. Some of the prime protocols that have evolved are as follows:

1. The protocol that was an outcome from the PROBE (Post-Occupancy Review of Buildings and their Engineering) project that started in 1995 in the UK. The protocol was developed particular to examine workplaces.

2. The protocol developed by the Center for the Built Environment (CBE), University of California, Berkeley, USA used primarily in the Federal Facilities Council funded programmes, as well as for projects funded by the Cascadia Region Green Building Council.

3. The protocol used in the Post Occupancy Evaluation Project Phase 1 prepared by Keen Engineering, Canada


5. The protocol developed for the New South Wales Health Facility, 2006.

1.4 Technologies and tools

A good performance study uses commonly agreed set of data collection and performance assessment tools. As argued by Carthey (2006), standardization in the data collection, data analysis and in the reporting is necessary to ensure the result is consistent.

Initially researches on the subject of building performance primarily focused on the socio-environmental discipline that includes the gathering of environmental data, resources consumption and occupants’ feedback. The evaluation tools combine multiple data sources that include occupant feedback, energy usage data and actual data measurements. Key environmental criteria used in POE studies include thermal comfort, visual comfort, daylight availability, air quality and operational energy index. Nowadays the concern for building performance studies are shared by researchers from the field of facilities management – a major discipline in the procurement and management of buildings that has emerged in the last decade. It can be observed that the POE goals and approach from this view point can be different. This suggests that while it is important for POE tools to be...
consistent, it is also crucial that the generic POE programme is kept flexible to be adapted for varying project nature.

The main tools used for POE can be grouped according to its purpose, as discussed in the following paragraphs:

1.4.1 Occupant survey

Occupant survey is the essence of POE. There are several occupant survey instruments that have evolved through time. Example of established POE survey instruments are:

**Outcome from the PROBE project**

Since its introduction, the developer of the PROBE questionnaire has simplified the questions so as to make the exercise less taxing and could be carried out in a period of 4 to 10 minutes (20 questions, in 2-page length). Respondents are required to answer according to a 7 point scale.

**Survey developed by the Center for Built Environment at UC-Berkeley (CBE)**

The survey seeks for information on topics that cover on – general respondent’s profile, their satisfaction on specific building features, the workstation layout, visual condition, privacy, office furnishings, thermal comfort, air quality, lighting, acoustic, cleanliness and maintenance and cleaning services. This survey form is used in Canada and for projects funded by the Cascadia Region Green Building Council.

1.4.2 Tools for benchmarking and measurement of performance

BREEAM (BRE’s Environmental Assessment Method) is an environmental assessment tool for buildings. BREEAM has been used as the benchmarking tool for recent POE studies conducted in the UK. The tool covers a wide range of environmental issues namely the management, health and well being, energy, transport, water, materials, land use and ecology, and pollution.

Another instrument introduced in POE studies in the UK is the Design Quality Method (DQM). In the past, this method has been adopted for assessment of educational buildings and is familiar amongst the auditing bodies in the UK. The results of the evaluation are produced in the form of a ‘balanced scorecard’ that measures the whole performance of building. The method combines expert opinion, professional judgement, user opinion, and scientific measurement (e.g. lighting levels, air quality and acoustics etc).
2. POE practices in Malaysia: case study the ministry of health (MOH)

Initial governmental effort to implement POE programme in Malaysia can be traced back to the Ministry of Health (MOH), and this will serve as a case study in this paper.

Published literature on Malaysian based building performance studies that meets the merits of a POE programme as described earlier are few. Research by Natasha Khalil and Abdul Hadi Nawawi (2008) focuses on office buildings that observe the functional and technical aspects of the facilities, and did not cover the environmental baseline information.

2.1 Malaysian healthcare industry

The Malaysian healthcare industry has been growing at a pace comparable with the Malaysian sunrise industries such as telecommunication, biotechnology and Information Technology (IT). It also has been characterized as a strong public sector component (Barrowclough, 2000). A research report by Frost & Sullivan (2009) observed: “Malaysia healthcare industry in 2009 is expected to grow at 8 percent and is being supported by 13.7 billion budgets (RM 13 billion in 2008). There is a continuous challenge for the sector to provide better service to the public. As articulated in Thrust Four of the Ninth Malaysian Plan, the Malaysian Government maintains adopts a policy that supports continuous improvement of standard, quality and sustainability of life. Healthcare is seen as a main vehicle to achieve this objective, through provision of good service quality and facilities for the public.

Post Occupancy Evaluation in the Ministry of Health was initiated in 1997, developed in collaboration with the Medical and Health Branch of the Public Work Department (PWD). This collaboration team, called the Evaluation Unit has so far conducted 9 structured POE of MOH hospitals, one POE of rural health clinic and 3 private hospitals. The results of the evaluation were used in the mid-term review of the Seventh Malaysia Plan (1997) and preparation of the Eight Malaysia Plan (2001-2005). The last POE conducted was in 2002. The main objectives of the POE conducted by MOH then are as follows (Malaysia Health, 2002):-

(1) To evaluate the capacity of the completed project to meet “project specifications” with regard to scope, quality, cost and time. The specifications are described in the project brief and master plan, and include situational analysis, development control plan and design brief.
(2) To evaluate the performance of the “as-built” facility in meeting current requirements
(3) To establish the changes (if any) that would need to be made to the original assumptions and requirements, to meet current needs.
(4) To prepare recommendations for modification, guidance in planning and developing new medical facilities and for future development of the medical facility that has been evaluated.
2.2 Methodology of MOH's post occupancy evaluation

The methodology of POE conducted by MOH was adapted from various sources namely, the Medical Architecture Research Unit (MARU) UK, POE of Frankston Hospital, Australia, the University of New South Wales, Australia, Public Work Department (PWD) Australia and Malaysia and previous POE conducted by MOH. Most POEs conducted by MOH were at indicative and investigative levels, as both approaches are comparatively inexpensive, less complicated and time consuming.

Figure 2: Stages of POE process for MOH, Malaysia (Malaysia Health, 2002)

3. Discussion

3.1 The state of POE practices in Malaysia

Evaluation on occupants’ satisfaction and perception on how their building performs are regarded as the cornerstones for the continuous improvement in building procurement (Baird, 2003). Performance evaluation is aimed at gaining knowledge about buildings as to whether people are satisfied with the building, and the manners that people actually respond and use them. The benefits are to those who use the buildings as well as those involved in their creation and operation. Lessons learned from these studies could be fed back to the designers.

In Malaysia POE programme initiated at MOH have not evolved since its introduction in 1997, not evolved as tin the comprehensive sense can be considered as a relatively new area that have not been significantly explored. The available programmes focus on specific area of interest that incline to
towards generating measured environmental and services performance data, or occupant responses and satisfaction.

### 3.2 Feedback elements of POE

POE offers what Bordass et al. (2006) termed as hindsight feedback, whereby a completed project is assessed in terms of how well it performs in meeting its intended purpose and objectives. However, many have observed that detailed information on building performance rarely comes back to the design and development teams (Keen Engineering, 2006) remain a theory. There are salient practices that could be learned from the literature in terms of approaches to exploit the full potential of POE implementation and feedback as follows:

#### People issue

POE development requires strong backup in terms of expertise, commitment as well as funding. The process warrants participation and feedback from members of the building industry.

#### Process issue

Ideally we should target POE to become routine for buildings of certain scale and innovative nature in the near future. It is therefore important that it is incorporated as part of the building delivery procedure – identifying who to be responsible to perform the assessment, and fund allocated for.

#### Technological and Tools issue

POE tools need to be carefully developed. At the moment there are a few occupant survey forms suggested by individual researchers. The robustness of these tools need to be tested and enhanced if need be. At the moment there is no locally derived environmental assessment method to enable a consistent benchmarking process to take place. There is therefore a need for such research. Past POEs have mainly been conducted overseas, and the tools developed are based on foreign experiences. As aspects of human satisfaction for different countries are likely to vary due to the varying cultures and people’s attitude to the various aspect of the environment (Humphrey, 2005), the POE instruments developed in a particularly country, may not apply equally well for other countries.

In the case of the MOH’s POE procedures, the following practices that are not in line with practices suggested in the literature were observed:

#### People issue

The purpose of POE needs to be clearly made known to the people who administer and manage the process for it to be effective. Based on the study interviews, there appears to be unfamiliarity amongst the core participating parties on the feedback potential of POE programmes and its mechanisms.
Protocol issue

The MOH POE protocol suggests that the baseline data were collected at the last stage rather than upfront. POE protocol needs to be established at the start of the programme which would allow adjustment of instrumentations according to each project. In the case of the MOH, its POE protocol has not been reviewed since its introduction in 1997.

Technological/tools issue

Information gathered regarding occupant satisfaction appears to be randomly captured, mainly relying on informal feedback and complaints. In addition, no database system were created and made available to maintain and disseminate the information and findings from past POE studies.

4. Conclusion

In short, several MOH’s POE practices do not correspond with procedures suggested in the literature to ensure effective flow of feedback. Review on foreign experiences indicate that implementation of an effective POE that optimizes its feedback potential requires deployment of a systematic procedure and involvement of various organizations to initiate, commission and ensure the sustenance of an effective knowledge transfer. Currently POE appears to be a relatively new subject in Malaysia, familiar only to a limited group of researchers and practitioners. This paper highlights the need to introduce POE and familiarise key stakeholders on its feedback benefits and objectives. It also reveals the need for a concerted effort and support from commissioning bodies, research expertise and communities from the building industry to device a consistent and effective POE programme for various projects implemented in the country. POE efforts for varying building type and design approaches are most desired to materialize the Malaysian Government’s sustainable development agenda. Besides MOH’s POE programme, on the local scene documented POEs are few, covering only parts of the core assessment criteria. Also, in light of the recently introduced Malaysian GBI rating system, it is suggested that the POE procedure adopts this assessment tool which would make benchmarking of building performances in the country possible.

References


Simplified Indices Assessing Building Envelope's Dynamic Thermal Performance: A Survey

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Abstract

In the last years, great attention was reserved to the global energy consumption and the related CO$_2$ emissions, and in this framework a lot has been done in the construction world, introducing different kinds of building regulations and assessment methods (i.e. in Europe the EPBD "Energy Performance of Buildings Directive" was adopted) in order to improve the general quality of buildings. Thermal behaviour of the building envelope is maybe the element which most strongly influences the energy consumption during building service life, affecting climatization needs. Most of the simplified procedures used to estimate the building energy consumption are based on steady-state indicators, which cannot fully reflect the real building behaviour. This is true in particular during the warm season, when it is more difficult to simplify the envelope performance without taking into account the hourly variability of the indoor and outdoor climatic conditions. This work surveys the existing indicators which represent the dynamic thermal envelope performance in a simplified manner, in order to understand the possible benefits and limits connected to their application.

Keywords: building performance, building envelope, thermal characteristics, dynamic behaviour
1. Introduction

In the last decades the worries about energy resources availability and \( \text{CO}_2 \) emissions brought to the spread of a lot of regulations regarding a variety of fields. One of the main source of energy consumption (equal to 1/3 of the total amount) and of greenhouse gases emission in the developed countries is the building stock, mainly because of climatization: because of this, new codes related to building energy performance were published (i.e. EPBD) aiming at a general increase in the building stock quality. Considering the heating and cooling demand in buildings, the main element involved is the envelope, which exchanges heat with the outdoor environment. Most of the currently available building performance assessment methods evaluate the heat exchange through the envelope by the means of a steady-state analysis, bringing to the diffusion of strict regulations regarding the heat transmittance of the envelope elements.

This approach is surely simple to use and has been very effective in improving the quality of the building stock. On the other hand it does not take into account the unsteady state behaviour of the construction materials, which tend to store heat and release it after a certain amount of time: this phenomenon is usually referred to as thermal inertia or thermal mass effect. It is more evident when considering the average heating or cooling demand, since the usual exercise conditions for buildings are highly unsteady, in both the daily and the yearly interval, and considering the summer peak load, since it is more strongly influenced by transient elements such as the external climate and internal heat loads variability.

Now that the steady-state analysis of building envelope performance is part of the common practice and is fully understood by the construction sector and a lot of building codes have set higher standards regarding the steady-state parameters, new attention is given to the transient behaviour of the construction materials and its effect on the heat exchanges.

2. Heat transfer

Heat transfer calculation is based on the law of heat conduction, the Fourier’s law, which states that heat transfer through a building element is directly connected to the temperature distribution inside the same element. This law takes the form of Eq. 1.

\[
\bar{q} = -\lambda \nabla T
\]  

Where:
- \( \bar{q} \) density of heat flow rate [W/m\(^2\)]
- \( \lambda \) thermal conductivity [W/(m K)]
- \( -\nabla T \) temperature gradient [K/m]
2.1 Steady-state analysis

Regarding the calculation of the heating peak load, which can ignore the heating effect of unsteady elements such as the solar radiation and the internal heat loads, a steady-state and one-dimensional analysis is considered accurate enough, and so the heat transfer by conduction takes a simplified form.

Integrating along a path of constant heat flow rate and considering its mean length $L$ (which is equal to the wall thickness in case of a plane wall), it is possible to define the $L/\lambda$ value, which is called thermal resistance $R$ [(m$^2$ K)/W] and which allowed to create a model for the heat transfer with analogies to the electrical connections. From this concept an overall heat transfer coefficient was developed, to represent both the heat conduction through single- or multi-layer structures and the heat transfer due to convection and radiation on the two external sides of them: it is the reciprocal of the overall thermal resistance of the envelope element and is called thermal transmittance [W/(m$^2$ K)].

Equation 2, then, is the most common way used to calculate the part of the building energy balance which represents the heat exchange by transmission through the envelope.

$$\Phi = U \cdot S \cdot \Delta T$$  \hfill (2)

Where:

- $\Phi$: heat flow rate [W]
- $U$: thermal transmittance [W/(m$^2$ K)]
- $S$: surface area [m$^2$]
- $\Delta T$: temperature difference between the indoor and outdoor environment [K]

2.2 Transient analysis

Under transient conditions, and by combining Eq. 1 with the energy conservation principle, the general heat conduction equation for the one-dimensional heat flows takes the form of Eq. 3, which is a partial differential equation (PDE) and cannot be simply solved analytically if not for specific and rigid boundary condition (i.e. periodic analysis).

$$\rho c \frac{\partial T}{\partial t} = \lambda \frac{\partial^2 T}{\partial x^2}$$  \hfill (3)

Where:

- $\rho$: density [kg/m$^3$]
- $c$: specific heat [J/(kg K)]
- $T$: temperature [K]
- $t$: time [s]
- $\lambda$: thermal conductivity [W/(m K)]
- $x$: heat flow direction
This equation is usually solved by the means of numerical methods, which simplify the calculation but are usually complicated to use. The most common of these methods are: conduction transfer function (CTF), which approximate the heat transfer to an impulse-result scheme, or finite difference and finite element analysis, which simplify the reference domain.

3. Simplified methods

The diffuse practice for the assessment of the energy performance of buildings is generally based on the steady-state calculation of the transmission heat transfer, but the attention given to the transient state is increasing as the general performance of the building envelopes becomes better and as the energy analysis of buildings is becoming a standard procedure. The use of numerical methods to solve PDEs, on the other hand, needs a lot of resources in terms of time and knowledge, and seems to be a big obstacle to the adoption of the transient analysis.

This is one of the reasons that brought to the development of simplified methods which introduce simple parameters modifications to approximate the dynamic effects of the building envelopes’ characteristics. According to Barnaby (1982) these can be divided into two groups: those analysing or simulating an isolated building element, and those considering the mass effect in the context of a typical whole building or building zone.

CEN (European Committee for Standardization), in collaboration with ISO (International Standard Organization), has already addressed the problem of approximating the transient behaviour of the building elements in the climatization demand calculation procedure and proposes a correction value, which belongs to Barnaby’s second category and has to be added to the zone steady-state heat balance equation. Because of this approach, the CEN method is commonly defined “quasi-steady-state”. The previously mentioned correction value is the utilization factor, which represents the amount of internal and solar heat gains (for the heating season) or of the transmission and ventilation heat losses (for the cooling season) actually capitalised by the effective mass of the zone. This parameter can be easily calculated and is specific for the characteristics of the analysed building: it depends on the heat gains on heat losses ratio and on the building or zone time constant. The time constant is a measure of the total building thermal inertia, and is calculated essentially by the means of the effective heat capacity of both the envelope and the internal elements, derived according to EN ISO 13786 (2007).

Internationally, several alternative approaches have been developed to approximate the dynamic behaviour of buildings regarding both the peak load and the energy demand calculation. In these work, some of the international simplified methods analysing isolated building elements are surveyed, even acknowledging the limit of them not considering the coupled effects of the thermal mass contained in other room and building elements.
3.1 Heat transmittance correction values

Some simplified methods apply a correction to the U-value of the considered element, and are usually referred to the heating season.

The first of these methods is the mass factor, developed by Hankins and Anderson (1976), which applies to the heating season calculations. The adjustment factor was defined as the ratio of the heat exchange through a given wall calculated by the means of a dynamic simulation and the one calculated by the means of the steady-state method applied on hourly interval. Several reference values were calculated and proposed by Hankins and Anderson in relation to the heating degree-days of the building location and the element frontal mass, which have been translated in graphs to enlarge the possible use of the method. The main problem of this method is that these values are reliable when dealing with the winter peak load calculation, but their use for the seasonal energy calculation does not allow an accurate prediction of the savings due to the envelope mass.

Another method is the effective U-value, developed by Van der Meer (1978). This parameter is defined as the ratio of the seasonal average density of heat flow rate and the seasonal average temperature difference between the indoor and the outdoor environments. By the means of an ad hoc developed software, Van der Meer performed series of dynamic energy simulations for a whole set of construction technologies in relation to the New Mexico climatic conditions, and derived reference values for the most common wall constructions. The aim of this parameter is not to determine a comparison between different construction, but to make a correction of the traditional U-value and to determine how the element behaviour changes as its orientation or its surface colour are modified. Later on values of this parameter have been calculated for a wider range of construction and they have been implemented in the New Mexico Building Code. As for other simplified methods, the effective U-value is not universally applicable, since it is based on a list of reference values, which were calculated by the means of detailed dynamic simulations for specific kinds of envelope technologies and specific climatic conditions.

3.2 Temperature difference correction values

Some other methods apply a correction value to the temperature difference needed to calculate the heat exchange by transmission, and are usually referred to the cooling season.

Since 1940s, ASHRAE started developing a method to calculate the thermal gains for the peak cooling load estimation through the opaque envelope based on an alternative value of temperature difference, which could take into account the combined effects of solar radiation and envelope thermal inertia. Starting from experimental data and calculation using the periodic analysis, some default data regarding specific envelope technologies were derived as the ratio of the calculated heat flow and the nominal U-value and were collected into reference tables. In 1972 the total equivalent temperature differential (TETD) was introduced in ASHRAE Handbook of Fundamentals (1972) to determine the cooling peak load. The method can be applied both choosing pre-calculated values from the reference tables, which were derived for specific constructions and for mild climates, and
calculating directly the specific value by the means of a general equation which depends mostly on
the decrement factor and on the time lag of the analysed building envelope, which respectively
represent the attenuation of the heat wave when going through it and the connected delay in the heat
transmission (Eq.4).

\[
TETD_t = T_{as,e,t} - T_{a,i,t} + f(T_{as,e,t-\delta} - T_{a,i,t})
\] (4)

Where:
- \( T_{as,e} \): outdoor sun-air temperature [K]
- \( T_{a,i} \): indoor air temperature [K]
- \( f \): decrement factor
- \( \delta \): time lag [h]

Because of this last option, this method can be considered simple and at the same time accurate in
calculating the cooling load, and related researches are still going on, even if adopting more
sophisticate calculations of the time lag and decrement factor values (Yumrutaş et al., 2006, Kaşka et
al., 2009).

In order to further simplify the CTF and the TETD methods, ASHRAE developed also the cooling
load temperature difference (CLTD), which allows to directly obtain the peak load value and is still
adopted as a simplified method for residential buildings (ASHRAE, 2001). The standard values were
derived as the ratio of the dynamic heat flow, calculated by the means of the CTF method, and the
nominal U-value of some typical envelope constructions. As for other methods considered, the
accuracy of these adjusted values strongly depends on the similarities between the actual building and
the simulation conditions used by ASHRAE, regarding the envelope characteristics, the internal heat
sources and occupancy schedules, and the climatic condition, which are typical for the United States.
To address this limit, ASHRAE (1989) proposed some possible corrections regarding latitude, indoor
design temperature (the standard value is 25.5°C), outdoor design temperature (the standard value is
29.4°C), presence of additional insulation and the envelope finishing in terms of colour. Some
researches still propose the use of this method, with a wider range of boundary conditions. In
particular, Bansal et al. (2008) adopted the finite difference method to solve the Fourier’s equation
and calculated reference CLTD values for typical constructions and climate of India.

As a representation of the energy consumption due to the building envelope, always in summer,
ASHRAE developed, then, the overall thermal transfer value (OTTV), which tries to combine the
effect of the envelope elements exposed to different orientations and of both the opaque and
transparent parts of these elements.

\[
OTTV = \left( A_{op} \cdot U \cdot \alpha \cdot TD_{EQ} \right) + \left( A_{win} \cdot SC \cdot ESM \cdot SF \right) \div A
\] (5)

Where:
- \( A \): envelope surface [m²]
- \( A_{op} \): surface of the opaque part of the envelope [m²]
Considering a single opaque element, the characteristics taken into account by this index are the U-value, the thermal absorptance and an adjusted value of temperature difference: the reference values of equivalent temperature difference were listed according to the surface orientation and to the element weight, after being calculated by the means of dynamic simulations. Even if since 1989 this index is not part of the ASHRAE Standard 90.1 anymore, the building codes in some eastern countries (i.e. Hong Kong, 1995) still use it to evaluate the cooling load in case of commercial buildings.

More recently, Nilsson (1994 and 1997), developed a whole method for assessing the energy demand of buildings based on the construction of duration diagrams for the variable elements of the building energy balance equation. Within this method, the heat exchange by transmission through the envelope is calculated by the means of the steady-state equation. In order to include the envelope dynamic behaviour in his method, Nilsson derived the fictitious ambient temperature value, which is supposed to be used instead of the outdoor air temperature in the temperature difference calculation. The principle, similarly to what implied by the TETD but originally applied to complete envelopes rather than to isolated elements, is that massive constructions are more influenced by the outdoor temperature history than by the instantaneous outdoor temperature (Eq. 6-7).

\[ T_{a,t}^* = T_{a,t} - \left( T_{a,t} - T_{a,t,0} \right) e^{-\frac{t}{\tau^*}} \]  
(6)

or:

\[ T_{a,N}^* = T_{a,N} - \left( T_{a,N} - T_{a,N-1} \right) e^{-\frac{\Delta t}{\tau^*}} \]  
(7)

Where:
- \( T_{a,t}^* \) fictitious ambient temperature [K]
- \( T_{a,t} \) outdoor air temperature [K]
- \( \tau^* \) time coefficient [s]
- \( \Delta t \) time interval [s]
- \( t,N \) current time
- \( 0 \) initial time

Starting from the lumped heat capacity of the envelope elements, a characteristic time coefficient can be calculated and used to represent the time lag. Since the lumped heat capacity value does not
change depending on the insulation position in the structure cross-section, an adjustment value can be used to distinguish between specific layers layouts with the same lumped mass value (Eq. 8).

\[ \tau^* = \xi \frac{\sum cm}{\sum UA} \]  

(8)

Where:
- \( \xi \): correction coefficient due to the layers layout
- \( c \): specific heat [J/(kg K)]
- \( m \): mass [kg]
- \( U \): heat transmittance [W/(m\(^2\) K)]
- \( A \): surface [m\(^2\)]

Standard reference values of the correction coefficient were calculated for different standard layouts (such as massive layers both on the inside and on the outside, only on the inside, only on the outside, and insulation layers both on the inside and on the outside) comparing the fictitious ambient temperature method results and the ones from dynamic building simulations: the results were later listed in reference tables.

## 4. Conclusion

The currently available simplified methods to adjust the steady-state heat transmission calculation are only few and usually developed on the basis of a limited number of case studies (considering constructions and climatic conditions), which is a strong limit to their possible use. Most of them are also old, and were therefore developed using very different constructions compared to the ones currently adopted, especially considering the starting U-value. It would be interesting to develop new reference tables of the same correction values using a wider range of wall samples and boundary conditions, in order to fully understand their reliability as the simulation conditions change.

Most of these methods are then related to the peak load calculation more than to the general demand assessment: this is easy to understand, since the thermal mass effect on the peak loads (attenuation) is considerably more evident and is commonly represented by the decrement factor.

Moreover, limiting the analysis to the heat exchange through a single envelope element causes a lack of consideration of other unsteady parameters of the room heat balance equation, such as the thermal mass effect due to the other building elements (walls, slab, ceiling and internal mass), the internal heat sources and the ventilation heat losses. These parameters strongly influence the boundary conditions of a single wall behaviour, but their effect can be surely better calculated when considering a whole room analysis.

This is the reason why some of the previously described simplified methods, in particular the ones not specifically addressing the peak load calculation (i.e. effective U-value, OTTV, fictitious ambient temperature), refer to values derived by several simulations of case-study buildings. Also the CEN
method, which regards the whole zone heat balance calculation, takes into account all the above mentioned unsteady parameters.

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The Relationship between Human Resource Practices and Organizational Performance in Chinese Construction Enterprises

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Abstract

Construction comprises a multitude of knowledge-driven activities within and amongst participating organizations. Given the dynamic environment and multi-project operations, construction organizations need to develop well-structured human resource practices to manage employees as well as to learn, innovate and change creative directions which are vital for organizational continuous improvement. Chinese construction enterprises have gained experience in various types of projects within the competitive environment over the 30 years of economic transformation to a market-based, socialist economy. This paper develops a framework to investigate the effects of human resource practices and organisational learning on the performance of Chinese construction enterprises. It is postulated that organizational learning exerts a mediating effect on the relationship of human resource practices and performance. This paper proposes a mixed method approach in which the qualitative study will contribute to the understanding of the current human resource practices and the barriers (if any) in implementing organizational learning practices in the Chinese construction state-owned enterprises; the quantitative analysis will examine the mediating effect of organizational learning on the relationship between human resource practices and organizational performance.

Keywords: human resource practices, organizational learning, performance.

1. Introduction

Throughout China’s thirty years of economic reform, construction is one of the underpinning industries and Chinese construction companies have improved their performance and competence in terms of technology, financial ability, procurement management, project management, etc. There are 50 Chinese construction companies in the list of the top 225 international contractors (Engineering News Record 2009). However, according to their interview investigation with 12 high level managers from Chinese state-owned construction enterprises (Zhou, Fang and Chen 2009), a significant gap between Chinese construction companies and international counterparts still exists. Zhao and Shen (2008) recognize ‘lack of well-trained human resources’ as one of the weaknesses when Chinese
contractors compete in the international market. As previous studies have found a positive relationship between human resource practices and organisational performance (Wright, Gardner and Moynihan 2003), the human resource (HR) practices in the context of Chinese construction companies, including recruitment, training, rewards and appraisal plan and employees’ participation, need to be investigated and addressed to enhance continuous improvement.

HR management is defined as “a managerial perspective, with theoretical and prescriptive dimensions, which argues for the need to establish an integrated series of personnel policies consistent with organization strategy, thus ensuring quality of working life, high commitment and performance from employees, and organizational effectiveness and competitive advantage” (Huczynski and Buchanan, 2001: 673). The positive effects of HR practices on organisational performance have been investigated in various sectors, such as manufacturing, services and information technology, and construction (Loosemore, Dainty and Lingard 2003). According to knowledge-based theories, the employment of HR practices improves organizational learning, which increases organisational capability and, in turn, improves organisational performance. Thus, it is postulated in this paper that there is a mediating effect of organizational learning on the relationship between HR practices and organizational performance in the context of Chinese construction enterprises.

2. Literature

A conceptual model, underpinned by general systems theory and resource-based theory, is proposed. General systems theory (Cleland and King 1983) explains an organisation (the construction enterprise) as a complex system of interdependent parts, including organizational strategy, structure, technology, HR management and decision-making within the environment of the Chinese construction industry. Resource-based theory, which focuses on the link between organizational strategy and the internal environment, analyzes the strategy formulation concerning the organization’s resources. There are mainly three categories of resources, physical capital, human capital and organizational capital (Barney 1991), with characteristics of value, rarity, imperfect imitability and a lack of substitutes to achieve sustained competitive advantage. The conceptual model in this paper is discussed in its elements of ‘human resource practices’, ‘organisational learning’ and ‘organisational performance’.

**Human resource practices**

Given the dynamic environment in a multi-project based culture, construction organizations need to develop well-structured HR practices to align management of employees with organizational strategy (Loosemore et al. 2003). HR practice is “the implementation and experience of an organization’s HR programs by lower-level managers and employees” (Arthur and Boyles 2007) and HR practices can be classified into the four concepts of information sharing, knowledge/skill, power (decision making), and rewards (Lawler 1986).
Notions of HR management differ significantly between countries. Arthur (1994) argues that HR management has adopted either a resource-based or a control-based approach to the measurement of high-performance HR practices, and the adoption of HR management vary most from countries such as the USA and UK to others such as Iran, with an array between those extremes (Tayeb 2001).

Before the 1990s, HR management in China lacked emphasis/focus and, often, was no more than personnel management and administration (Ahlstrom et al. 2005). Usually, graduates were assigned to the enterprises which provided secured lifelong jobs. The task of each enterprise was to help solve social issues, e.g. housing, child education, and retirement. Following the economic transformation and foreign firms’ investment in China, especially after entry to the World Trade Organization (WTO) in 2001, Chinese enterprises recognize the requirement to modernise their HR policies and practices to support the development of organizational strategy in a more competitive and dynamic environment. Current HR practices in China contribute an input to strategic decisions and include employee selection, staff training, job mobility, job security, employees’ appraisal of their performance, rewards, clear and up-to-date job description, and employees’ participation in decision making (Sun, et al. 2007; Warner 2008). Chinese enterprises now embrace the idea that HR practices can facilitate the development of competency, generate tacit organizational knowledge, and may contribute to the capacity of the organization to learn (Soliman and Spooner 2000).

Organisational learning

Organisational learning relates to the changes in organisational knowledge that are induced by information processing to enable the organisation to succeed and is defined as “a dynamic process of creation, acquisition and integration of knowledge aimed at developing the resources and capabilities that allow the organization to achieve better performance” (Lopez, et al. 2006: 217). There are two types of organization learning, single-loop and double-loop learning (Argyris 1977).

However, the terms knowledge and learning are often used interchangeably, which may lead to conceptual confusion (Bontis, et al. 2002; Spender 2008) and problems in measuring the concepts. Knowledge management is mainly used in the field of strategic management whereas organizational learning is investigated within the area of human resources (Chiva and Alegre 2005). Organizational knowledge can be considered as the key component of organizational learning, which is a process associated with the growth of and changes in knowledge (Chiva and Alegre 2005). Critically, Wang and Ahmed (2003) identify five foci of organizational learning as individual learning, process or system, culture or metaphor, knowledge management, and continuous improvement. Chinowsky and Carrillo (2007) bridge the link between knowledge management and learning organization based on the knowledge management steps and learning organization maturity models. The aim of organization learning is to improve performance through the development of organisational knowledge and capability. This paper adopts the above approach and focuses on the mediating role of organisational learning in influencing the effects of HR practices on organisational performance.
Organisational performance

Organizational performance is a complex and multi-dimensional construct; there is little agreement on how organizational performance should be measured (Neely, et al. 1995; Henri 2004). The main metrics to measure organizational performance include: Balanced Scorecard (Kaplan and Norton 1996), key performance indicators (KPIs), and the Excellence Model (EFQM 1999). Performance is defined by Mitchell (1983) as an aggregate of behaviour over time, tasks or people. According to Henri (2004), organizational performance reflects “a construct perspective in which the focus is on the definition of the concept in terms of assessment and conceptualization”. For example, Chakravarthy (1986) identifies the conceptions of assessment including profitability, financial-market, multi-stakeholder satisfaction, and quality of firm’s transformations.

Previous researches have studied the relationship between HR practices and organizational performance in the past 15 years (Huselid 1995). The process by which HR practices affect performance has not been answered (Becker and Gerhart 1996). In accordance with the resource-based view, Wright, Dunford and Snell (2001) propose that HR practices can improve the human capital pool (knowledge, skill and ability), employee relationships and behaviours (psychological contracts, job related/required behaviour, discretionary organisation citizenship behaviour). Integrating strategy and HR practices within the resource-based view, Wright, et al. (2001) explore the linkage between HR practices and a firm’s core competencies through the management of the firm’s knowledge stock (human, social and organization capital), knowledge flow (knowledge creation, transfer and integration), and dynamic capability.

3. Model development

From the resource-based view, human resource is a value-added source of sustainable competitive advantage, which will improve organizational performance (Wright et al. 2001; Huselid 1995). Among the studies on the relationship between HR practices and organizational performance, some attempt to demonstrate that a particular practice has effect on organizational performance (Shaw, Gupta and Delery 2001) while others focus on sets of HR practices (Huselid 1995; Delery and Doty 1996; Wright, et al. 2003;). The multiple HR practices as a system is also called a high performance work system (Huselid 1995) or HR practice configuration (Delery and Doty 1996).

According to Becker and Huselid (2000), seven elements can improve a firm’s performance: employability, selective recruitment, teamwork and decentralization, high remuneration, intensive training, eliminating inequalities and boosting team spirit, and extensive information sharing. For instance, performance is positively related to the HRM systems of recruitment and selection, manpower planning, job design, training and development, quality circles, and pay systems in the context of the Indian hotel industry (Chand and Katou 2007). Li, Zhao and Liu (2006) find that the positive relationship between employee training, motivation and technological innovation, is positively related with organizational performance in the context of China’s high-tech firms. Following Liu and Fang’s (2006) findings in the Chinese construction industry, it is postulated in this paper that motivation, in the context of Chinese construction employees, comprises mainly of
intrinsic rewards. Since HR practices help organization attract and retain human resource, which is essential to improve organizational performance, hypothesis 1 is thus:

**H1: HR practices, especially with regard to training and intrinsic rewards, relate positively to organizational performance.**

HR practices play a significant role to achieve organizational learning (Soliman, and Spooner 2000) and organisational learning has a positive effect on performance (Bontis et al. 2002; Lopez et al. 2005). Minbaeva (2005) finds that the employment of HRM practices (staffing, training, promotion, compensation and appraisal) affect knowledge receivers’ ability and motivation which, then, positively relate to the degree of knowledge transfer but the effect of corporate socialization mechanisms and flexible working practices is insignificant. Similarly, Lopez, et al. (2006) find positive relationships between selective hiring, training, employee participation and organization learning but, organizational learning is not influenced by reward systems.

Bontis et al. (2002) find a positive relationship between the stocks of learning at all levels and business performance, and the misalignment of stocks and flows in an overall organizational learning system is negatively associated with business performance. There is also a positive relationship between organizational learning and both innovation and competitiveness and economic/financial results (Lopez, et al. 2005). In the construction sector, Styhre, et al. (2004) examine six Swedish construction projects and find that learning capabilities in construction projects rely on informal and personal contacts rather than technical and formal systems.

HR configurations and organizational performance is mediated by human capital (employee’s knowledge, skills and experience), organizational capital (institutionalized knowledge and codified experience) and social capital (knowledge resources embedded within, available through, and derived from networks of relationships) (Youndt and Snell 2004). This is supported by Collins and Smith’s (2006) findings from 136 high-technology companies that HR practices affect social climate (trust, cooperation, shared codes and languages) which facilitate knowledge exchange and combination, and then enhance firm performance. Similarly, Liu, Hall and Ketchen (2006) perform meta-analysis to investigate how HR practices affect organizational performance and find that the relationship is mediated by employee’s knowledge, skill and abilities, empowerment, motivation and social structure. According to Chen and Huang’s (2009) investigation of 146 Chinese firms in Taiwan, strategic HR practices are positively related to knowledge management capacity which, in turn, has a positive effect on innovation performance. Hence, hypothesis 2 is:

**H2: Organisational learning mediates the relationship between HR practices and organizational performance.**

Figure 1 depicts the conceptual model for testing the mediating effect of organisational learning on the relationship of HR practices and organisational performance in Chinese construction enterprises.
4. Method

It is suggested that mixed methods (Quan - Qual) approach is to be adopted (e.g., see Creswell 2003). Generally, the quantitative approach typically uses random sampling, structured interviews to collect data, and analyzes data using statistical techniques; by contrast, the qualitative approach typically uses purposive sampling, semi-structured or interactive interviews to collect data, mainly relating to people’s judgment, preferences, priorities, and/or perceptions about a subject, and analyzes data through sociological or anthropological techniques.

The methodological debate between qualitative and quantitative researchers in construction management proposes the possibility of methodological pluralism and paradigm diversity. The mixed method exploits the strengths and minimize the weaknesses of both in single research studies. Chau, et al. (1998, p.102) state that “the interpretative approaches used to investigate construction management provide useful information for identification and conceptualization of the problem, which subsequently may be theorized and subject to further investigation”.

In this proposed model, the HR practices in China’s construction enterprises can be analysed based on measurement constructs developed in previous research studies. Pilot study (using telephone interviews) will investigate the current HR practices and organizational learning practices in the Chinese construction state-owned enterprises (SOEs) to substantiate the question items in the quantitative stage. The interview questions will be developed from HR literature (e.g. Sun, et al. 2007; Loosemore, Dainty and Lingard 2003) and organizational leaning literature (e.g. Lopez, et al. 2006; Kululanga et al. 2002; Tan, et al. 2006) in consultation with Chinese academic researchers and industry experts.
Since the study seeks to investigate the relationships between the constructs, and representative information of HR practices in the context of Chinese construction enterprises is needed. A quantitative approach will be adopted to test the relationships between variables from a large population using a questionnaire sent to construction SOEs sampled from the Ministry of Housing and Urban Rural Development’s (MOHURD) registered firms. According to ‘Provisions on administration of qualification of construction enterprises (No.87)’ issued by MOHURD, there are three categories of ‘general contractors’ which may construct the whole range of projects itself, ‘specialized contractors’ which may sign subcontracts with the general contractors to undertake the specialized project (e.g. electronic subcontractor), and ‘labour subcontractors’ which can provide labour service to the main contractor. General contractors, according to their personnel, total assets, equipment capacity, finance capacity, experience, etc., are classified into four groups of premier grade, 1st grade, 2nd grade, 3rd grade or under. Because the majority of premier and first grade of general contractors are SOEs, the population will comprise these two grades (in which some are international contractors). According to National Bureau of Statistics of China (2006), there are 174 general contractors in premier grade and 2445 in 1st grade. 20% of each group will be selected as the sample using the snowball method.

The measured items in HR practices shall include staffing, training, individual performance measurement, appraisal, participation, job description, job mobility and security. The organizational learning items include continuous individual learning, use of team learning, internal sharing of knowledge, lessons learnt from past experiences, integrating learning with collaborative work schemes, internal improvement schemes, learning from others, continuous renewal of business processes, seeking new developments in the business environment, and developing capability to respond to future business processes (Kululanga, Price and McCaffer 2002). Self-reported measurement of organizational performance is to be used (perceived organizational performance) based on variables adopted in Katou and Budhwar’s (2008) study, e.g. effectiveness, efficiency, development, satisfaction, innovation and quality.

Structural equation modelling (SEM) which represents the hybrid of factor analysis and path analysis (Kaplan 2000) will be used to analyse the data by linking observed variables to latent variables via a confirmatory factor model and the latent variables to each other via systems of simultaneous equations. First, confirmatory factor analysis will develop a measurement model with an acceptable fit to the data. The second step in the analytical process is to form the structural model by specifying the causal relations in accordance with the hypotheses.

After the quantitative study, the general relationships among the main constructs can be established. Then, the qualitative method shall be adopted to capture the complexity and dynamism of the context of organisational settings to understand the complex situation between HR practices, organisational learning and organisational performance in the Chinese construction SOEs. System dynamic modelling methods will be applied in the qualitative study to capture the causal loops.


5. Conclusion

Previous research has suggested links between HR practices and organisational performance. The present study is aimed at extending this research by exploring a possible mediator between the links. Wright, Dunford and Snell (2001) develop a conceptual framework that people management practices (i.e. staffing, training, work design, participation, rewards and appraisal) create value to impact creation, transfer and integration of knowledge that form the basis of firm’s core competencies (i.e. collective learning in the organisation to coordinate and integrate diverse skills and technologies). In order to maintain continuous improvement and to develop organisational performance, the construction firms need to emphasise learning from individual, team and organisation levels (Bontis, Crossan and Hulland 2002). Based on previous research (Soliman and Spooner 2000; Wright, et al. 2001), HR practices contribute to an organisation’s learning and facilitate organisational knowledge development.

It is believed that construction companies need to have a system of committed HR practices to improve the individual’s knowledge, skills and ability, stimulate knowledge sharing within projects and the company, learned from the external environment to facilitate the capture of organisational knowledge and learning. Hence, this paper proposes a positive relationship between HR practices (especially training and rewards) and organisational performance (financial indicators, effectiveness, efficiency, development, satisfaction of employees and client, innovation, and quality) in the context of Chinese construction SOEs. Thus, according to resource-based theories, the mediating effect of organisational learning on the relation of HR practices and organisational performance is postulated.

Although the quantitative (SEM) model may provide the general relationships among the main constructs, the model will not be able to adequately capture the complexity and dynamism of the context of organisational settings. In order to understand the complex situation between HR practices, organisational learning and organisational performance in the Chinese construction SOEs, inductive research needs to be investigated in a mixed method approach to unearth the details.

References


Evaluation of the Thermal Behaviour of Dwellings: 
U-Values Comparison

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Abstract

Work has been developed by the “Observatório da Construção da Universidade de Trás-os-Montes e Alto Douro” (Construction Observatory of the University of Trás-os-Montes e Alto Douro) in order to create a system to evaluate and certificate the quality of dwellings, in different project stages (e.g. design, construction, use), contributing to the sustainability of the building sector of the Northeaster region of Portugal, Trás-os-Montes e Alto Douro (TMAD). Surveys were conducted in order to choose the main aspects to be evaluated. The thermal behaviour of dwellings was considered one of the main aspects that influence the decision of acquiring a dwelling. Moreover, frequent pathologies identified by the users are related with the thermal behaviour of the buildings. With the publication of the Directive EU 2002/91/EC in 16th of December of 2002, the EPBD (Energy Performance of Building Directive), Portuguese regulations had to be changed, in order to comply with the new Directive. So, the Portuguese Energetic Certification System (SCE) and other two complementary regulations, the Regulation of the energetic systems for building climatisation (RSECE) and the Regulation of the thermal behaviour characteristics of buildings (RCCTE), were created. The new RCCTE (the first publication of the RCCTE was in 1990) has been published in July of 2006 and the SCE in July of 2007. In order for this new legislation to be effective it is necessary to guarantee that the constructed solutions are in accordance with the ones defined in the design phase. In this paper, we present experimental work that has been developed combining the use of thermography and a thermal flow meter with the objective of verifying the similarity (or discrepancy) between the U-values obtained with “in situ” tests and the U-values calculated in the design phase. Experimental results indicate that measurements of U-values obtained in situ and the ones calculated in the design stage are usually similar. Deviations should not exceed 30%. This work aims at contributing to the increment of energetic efficiency of dwellings and to the sustainability of the constructed environment in TMAD.

Keywords: quality, dwellings, thermal behaviour, sustainability, “in situ” measurements
1. Introduction

One of the main objectives of the “Observatório da Construção” (OC) is the development of a system to evaluate and certificate the quality of dwellings in the region of Trás-os-Montes e Alto Douro (TMAD). It is hoped that the implementation of this system will increase the quality of the dwellings, in a sustainable way, in all the stages of their construction (design, construction and after construction).

The buildings, in Portugal (including, the residential buildings), are responsible for a significant portion of the CO₂ emissions. Consequently the national regulations were adapted and improved in order to face this reality. The entities related to the building construction sector are taking acknowledgement to the need of decreasing energy and fuel consumption. The quality of the dwellings is becoming more relevant to the users, so it is necessary to give them proofs that work has been done in this direction. The development of a process that enables the evaluation and certification of the quality of dwellings will increase the trust of the users and will improve the relationships between the users, builders/promoters, estate agents and designers. Pereira S (2004) and Paiva A (1995) already developed some work in this area. A survey has been conducted to the builders/promoters, estate agents and users in order to characterise the main aspects that influence the decision of acquiring a dwelling in this region. Another survey has been conducted to the users, to determine the more frequent and relevant pathologies in the housing real estate of TMAD. The results of both surveys helped in the decision of the main aspects to be evaluated, at this stage of development of the system. The results showed that the entities involved consider that thermal insulation, noise transmission and dampness are the main aspects that should be evaluated. It is clear that appropriate design is a key aspect of sustainability in the building sector, namely in what concerns the thermal behaviour of dwellings. Work has been developed in this context by Briga-Sá A (2006). However, in order to promote higher levels of quality, it is mandatory to define a process to measure the thermal characteristics of the constructed dwellings. In this way, all the actors involved in the construction of dwellings will have to pay more attention to thermal quality aspects.

Having this in mind, work is in progress, following the methodology proposed by Pereira S (2004), in order to develop a process to evaluate the thermal behaviour of dwellings, “in situ”. The process which is being studied will contribute to:

(1) the verification of the conformity of the thermal solutions adopted in the design phase, with the implemented construction solutions;

(2) the identification of adequate construction solutions for the dwellings to be in accordance with the thermal standards;

(3) the comparative study of the thermal performance of different construction solutions;

(4) the promotion of energy consumption savings.
The work carried out may also constitute a mean to complement the process of the SCE, in what concerns to residential buildings, as a way to support the independent qualified experts in the verification of the conformity between the design and the constructed, preventing this way eventual inspections during the construction (that implies always more costs). This system should motivate the promoters/builders to do a better work, in order to get an energetic certification of the constructed product. In order to verify the energy consumption and CO$_2$ emissions of a residential building, will be necessary the calculation of the U-values of the different construction elements. In order to apply the RCCTE, for example, these values are necessary for all the building external and internal construction elements and glazed surfaces. The U-values will be then one of the variables that permit the determination of the energetic category of the building (grade A+, A, B, B-, C, D, E, F, G) in ADENE (2009). That way it is important that the calculated values will be as close as possible to the measured ones. This will be a way to guarantee that the construction solutions are identical to the ones used in the design phase.

In that perspective experimental work has been carried out by the OC, with the objective of determining the U-values of the most common construction solutions in this region.

2. In situ tests for the determination of the U-values

2.1 Methodology

The adopted methodology for the persecution of the experimental work was the following:

1. Selection of the construction element(s) to be analyzed;

2. Selection of the most homogeneous place of the construction element to place the heat flow meter (flux sensors), with the help of the thermography;

3. “In situ” measurements consisting of continue data gathering (10 minutes intervals) during at least 14 days;

4. Data analyzes using the average method to determine the U-values (U);

5. Comparison between the U-values determined in situ and the U-values calculated in the design phase;

6. Conclusions.

2.2 Analysed construction solutions

The elements that were tested were the external walls (façades) of residential buildings in Vila Real. Work developed in the OC between 2003 and 2006 by Briga-Sá A (2006) and Costa A (2006), revealed that the more often constructed external walls are the cavity walls, with the external panel made of hollow brick (15cm) and the internal panel made of hollow brick (11cm), with the cavity...
partially filled with insulation (with 3/4cm of thickness) fixed to the external face of the internal panel of the wall. Based in this results this type of external walls were the preferential target to the tests, however, other types of walls were tested, in order to verify the acquirability of the method to different types of walls.

For the realization of the tests was elaborated a survey file, were all important data was registered for the later analysis. This file includes the following elements:

1. Data related with the location of the buildings (dwellings) including its localisation. Date and time - beginning and finishing of measurements. Total number of hours of the test, number of 24 hours periods (integer number) and number of measures for hour;

2. Type of constructed elements tested (walls, ceiling, floors or others);

3. Solar orientation;

4. Data concern with the climate of the place, namely: RCCTE climatic zone; season(s) of the year when the tests were done; weather forecast during the tests (cloudiness, precipitation, velocity and wind direction); temperature and relative humidity) internal and external temperature and humidity, 24 hours before the tests and at the beginning and finishing of the tests; and the existence or not of direct solar radiation;

5. Thermographic data: distance to the element tested, superficial emissivity, other important data related with the thermographic analysis;

6. Position of the heat flux sensors and the surface temperature sensors in the element;

7. Description of the type of fixation, of the heat flux sensors and surface temperatures sensors, to the element;

8. Construction solution data for each layer (materials, description, thickness, thermal properties); table for the calculation of the expected U-Values; and design detail;

9. Schematic plans of the room where the measured element is;

10. Perspective of the element tested where can be drawn the sensors and the areas that were analysed using the thermography;

11. Registration of important aspects observed during the tests that were not in the survey file e.g. data concern with the ageing of the materials, the existence of cooling or heating systems and if they were turned on during the test and how was obtained the information related the construction solution.
2.3 Experimental proceeding

In order to measure the U-values, “in situ”, two heat flux sensors, two thermal-hygrometers and four superficial temperature sensors were used, Figure 1. A heat flow meter is a transducer giving an electrical signal which is a direct function of the heat flow transmitted through it. Most heat flow meters are thin, thermally resistive plates. More detailed information of the structure of heat flow meters can be found in ISO 8301 (1991). These heat flow meters are used combined with temperature sensors that are transducers giving an electrical sign which is a monotonic function of its temperature. The electrical signal transmitted will be directly related with the heat flux transmitted through the plate.

To determine the U-value of a construction element the measurements of heat flux and temperature take place during several days. The measurement period, depends on the type of construction, and it has to be sufficient to minimize the influence of the storage energy capacity of the element. A measurement period of 14 days is normally considered suitable for construction solutions with average and high thermal inertia and with the cavity partially filled with insulation as it has been demonstrated by Doran S (2000). The heat flux sensors and the superficial temperature sensors had been placed in the tested element during at least 14 days. For each case several parameters were registered and saved continuously during the test period for posterior analyses.

Figure 1 – Equipment used in the measures

Using thermography, the location of the sensors was defined, in order to place them where the distribution of temperatures is more homogeneous, and in a representative way, Figure 2.

Figure 2 – Example of a thermogram for helping in the positioning of the sensors

The U-values can be obtained by measuring the heat flow rate through an element, using a heat flow meter, and the temperature on both sides of the element under steady state conditions. However, since steady state conditions are never encountered “in situ”, in practice, such a simple measurement is not possible. It is necessary to consider the temperatures and heat flux variations, in order to calculate the U-values with accuracy. As the more common building construction elements. in Portugal, have
significant thermal mass, internal and external temperature variations induce great fluctuations of the heat flux and change of direction.

### 2.4 Data analysis

Accordingly with the ISO 9869 (1994), can be used two data analysis methods: the average method, or the dynamic method. In this work, the average method was used, because is more simple and the results are similar to the ones obtained using the dynamic method as demonstrated by Laurenti L et al (2004). This method assumes that the thermal transmission coefficient can be obtained by dividing the mean density of heat flow rate by the mean temperature difference, the average being taken over a long enough period of time. If the index \( j \) enumerates the individual measurements, then an estimate of the U-value is obtained by:

\[
U = \frac{\sum_{j=1}^{n} q_j}{\sum_{j=1}^{n} (T_{ij} - T_{ej})}
\]

Where \( q_j \) is the heat flux at moment \( j \), \( T_{ij} \) is the internal temperature at moment \( j \), and \( T_{ej} \) is the external temperature at moment \( j \).

When the estimate value is calculated after each measurement, a convergence to an asymptotical value is observed. This asymptotical value is close to the real value.

If \( n \) measurements are carried out over uniform time intervals then a good approximation is the following formula:

\[
U = \frac{\sum_{j=1}^{n} q_j}{\sum_{j=1}^{n} (T_i - T_e)}
\]

This approximation, however, only provides real values when the summative is taken over a sufficient period of time and provided that thermal storage effects are not too large.

The data which is measured in order to determine each U-value, \( T_i \) and \( T_e \) are respectively the daily mean internal and external temperatures, while \( q \) is the daily mean heat flux, expressed in w/m\(^2\). Each day measures were made each 10 minutes what corresponds to 6 x 24 measures per day. Generally data has been collected during more than 14 days, however in table 1 only 5 days of data are presented, as an example.

Table 1 illustrates how the calculations were performed.

**Table 1: Calculation structure**

<table>
<thead>
<tr>
<th>Day</th>
<th>( T_i )</th>
<th>( T_e )</th>
<th>( q )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( T_i1 )</td>
<td>( T_e1 )</td>
<td>( q1 )</td>
</tr>
<tr>
<td>2</td>
<td>( T_i1 + T_i2 )</td>
<td>( T_e1 + T_e2 )</td>
<td>( q1 + q2 )</td>
</tr>
<tr>
<td>3</td>
<td>( T_i1 + ... + T_i3 )</td>
<td>( T_e1 + ... + T_e3 )</td>
<td>( q1 + ... + q3 )</td>
</tr>
<tr>
<td>4</td>
<td>( T_i1 + ... + T_i4 )</td>
<td>( T_e1 + ... + T_e4 )</td>
<td>( q1 + ... + q4 )</td>
</tr>
<tr>
<td>5</td>
<td>( T_i1 + ... + T_i5 )</td>
<td>( T_e1 + ... + T_e5 )</td>
<td>( q1 + ... + q5 )</td>
</tr>
</tbody>
</table>
The calculations shown above are reproduced several times, using different time data intervals. The U-value derived from each successive period of data is plotted against the start time of the data.

In the tests, two heat flux meters were used, originating two sets of data. So, two U-values were calculated, U1 and U2.

**Comparison of calculated and measured values**

The calculated U-value, based on the structure of the element, may be compared with the ones measured using the proposed methodology. For that purpose, the structure of the element may be examined.

According to the EN ISO 6946 (1996) the U-value of an opaque building element (excluding metallic cladding) can be obtained using the proportional area method (series elements) or by using the combined method (parallel elements).

Both methods use information related to the thermal conductivities and thickness of the materials, as well as information about thermal bridges.

The calculation procedure is largely based on “ideal” constructions, although limited provision is made for imperfections in the structure, such as small air gaps around the insulation.

The ISO standard also allows for the thermal conductivities of construction materials, geometrical effects and air voids, but does not deal with ageing of materials, moisture related phenomena, adventitious air movement or with factors that may be influenced by workmanship. Furthermore, certain types of construction are more vulnerable to these processes than others, and there are a number of factors, such a cavity width, and robustness of insulation materials, the use of air/vapour barriers, and the use of rendering or moisture control layers which could potentially affect the U-value of a building element over time.

Significant differences (till 20-30%) between the calculated value and the U-value measured may be caused by a combination of any of the above factor, or others related with the measurement itself.

### 2.5 Case studied

In this work, 12 tests in external walls of residential buildings in the city of Vila Real, with the duration of more than 14 days, were carried out.

Measurements were taken over a larger period of time, in order to verify the tendency of the U-values, and reveal the accuracy of those values. The characteristics of the studied construction solutions are described in the Table 3.
### Table 3: Construction solutions analyzed

<table>
<thead>
<tr>
<th>Case</th>
<th>Year</th>
<th>Season</th>
<th>Type of Wall</th>
<th>Wall Material</th>
<th>Insulation Type</th>
<th>Insulation localisation</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1985</td>
<td>Winter/Spring</td>
<td>Cavity</td>
<td>Hollow Brick</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>1985</td>
<td>Spring</td>
<td>Cavity</td>
<td>Hollow Brick</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>1985</td>
<td>Spring/Summer</td>
<td>Cavity</td>
<td>Hollow Brick</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>2002</td>
<td>Autumn</td>
<td>Cavity</td>
<td>Hollow Brick</td>
<td>XPS</td>
<td>PFC</td>
<td>40</td>
</tr>
<tr>
<td>5</td>
<td>2005</td>
<td>Winter</td>
<td>Cavity</td>
<td>Hollow Brick</td>
<td>EPS</td>
<td>ETICS+PFC</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>2005</td>
<td>Winter</td>
<td>Cavity</td>
<td>Hollow Brick</td>
<td>EPS+ICB</td>
<td>ETICS+PFC</td>
<td>50+30</td>
</tr>
<tr>
<td>7</td>
<td>1979</td>
<td>Winter</td>
<td>Simple</td>
<td>Hollow Brick</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>1992</td>
<td>Winter</td>
<td>Cavity</td>
<td>Hollow Brick</td>
<td>EPS</td>
<td>PFC</td>
<td>40</td>
</tr>
<tr>
<td>9</td>
<td>1987</td>
<td>Winter</td>
<td>Simple</td>
<td>Concrete Block</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>1997</td>
<td>Spring</td>
<td>Cavity</td>
<td>Hollow Brick</td>
<td>XPS</td>
<td>PFC</td>
<td>30</td>
</tr>
<tr>
<td>11</td>
<td>2004</td>
<td>Spring</td>
<td>Cavity</td>
<td>Hollow Brick</td>
<td>PUR</td>
<td>PFC</td>
<td>30</td>
</tr>
<tr>
<td>12</td>
<td>1987</td>
<td>Summer</td>
<td>Cavity</td>
<td>Hollow Brick</td>
<td>EPS</td>
<td>PFC</td>
<td>30</td>
</tr>
</tbody>
</table>

PFC – Partially filled cavity

#### 2.6 Results analysis

Tests 1, 5, 6, 7, 8 and 9, have been realized in the winter. It is important to notice that during five of these six tests, outdoor temperatures were always below indoor temperatures.

The walls construction solutions used on tests 5 and 6 have external insulation and belong to the same building (although having different orientations). The first was north oriented and the second south oriented. The second wall has also one layer of cork board insulation (ICB), 3 cm thick. It has been noticed that, in all the tests referred to here, the heat flux always follows the external temperature trend.

In the second test, as expected, the U-value result (average of the measured U-values) was lower than in the first test, due to the presence of the ICB layer.

The construction solution in test 8 is identical to those of the first tests, but in this case the insulation is in the interior of the cavity wall. The U-value is similar to the ones obtained in the other tests.

The constructive solutions in tests 7 and 9 are simple brick and concrete walls, respectively. The wall of test 9 was thicker than the wall of test 7. The measured U-value was higher in test 9 that in test 7.

During the tests, indoor temperature was higher than outdoor temperature, exceptions made to sometime intervals during the day, in test 9. This did not affect the results of the test, as can be observed in Figure 3.
In tests number 10 and 11 walls have identical construction solutions: cavity wall, with the internal and external panels made of hollow brick, with the cavity partially filled with insulation fixed to the external face of the internal panel of the wall (XPS in test 10 and PUR in test 11).

The tests were performed in Spring, when sometimes outdoor temperature was higher than indoor temperature. In both cases, no coherent results for the U-values could be obtained.

The evolution of the temperatures and fluxes were very heterogeneous, and the calculations of the proposed method did not converge (Figure 4).

Test number 12 was performed in a cavity wall of hollow brick, partially filled with EPS insulation. This test has been performed in Summer, and air conditioning has been used to control indoor temperature.

In this case, the values of the fluxes are negative, most of the time, while the temperature differential is also negative. The results for the U-value are in accordance with calculated ones.

### 2.7 Comparison of U-calculated and U-measured

Table 4 contains a summary of calculated and measured results. It also shows the deviation between calculated and measured results.
Table 4: U-measured and U-calculated values

<table>
<thead>
<tr>
<th>Case</th>
<th>Season</th>
<th>U-calculated</th>
<th>U-measured</th>
<th>Deviation - ∆</th>
<th>Deviation - %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Winter/Spring</td>
<td>1.09</td>
<td>1.65</td>
<td>0.56</td>
<td>34</td>
</tr>
<tr>
<td>2</td>
<td>Spring</td>
<td>1.09</td>
<td>±∞</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Spring/Summer</td>
<td>1.09</td>
<td>±∞</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Autumn</td>
<td>0.45</td>
<td>0.56</td>
<td>0.09</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Winter</td>
<td>0.45</td>
<td>0.55</td>
<td>0.10</td>
<td>18</td>
</tr>
<tr>
<td>6</td>
<td>Winter</td>
<td>0.34</td>
<td>0.34</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Winter</td>
<td>1.37</td>
<td>1.49</td>
<td>0.12</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>Winter</td>
<td>0.46</td>
<td>0.29</td>
<td>-0.17</td>
<td>-36</td>
</tr>
<tr>
<td>9</td>
<td>Winter</td>
<td>1.85</td>
<td>1.39</td>
<td>-0.46</td>
<td>-24</td>
</tr>
<tr>
<td>10</td>
<td>Spring</td>
<td>0.53</td>
<td>±∞</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>Spring</td>
<td>0.55</td>
<td>±∞</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>Summer</td>
<td>0.45</td>
<td>0.39</td>
<td>-0.06</td>
<td>-13</td>
</tr>
</tbody>
</table>

In 4 of 12 tests (tests number 2, 3, 10 and 11) valid results were not obtained. In the other 6 cases, the U-values measured deviate from the calculated ones, no more than 20% to 30%, as referred to by Doran S (2000).

Tests 5 to 9 were performed in Winter with controlled indoor temperatures. The results of these tests show the convergence between the measured and calculated U-values. In tests 5, 6, 7 and 12 the deviations are inferior to 20%. In tests 5 and 6 this can be justified by the fact that, during the construction, design directives were closely followed. Also in these two tests, the internal temperature was carefully controlled.

3. Conclusions

In this paper, a methodology to verify the similarity or discrepancy between the U-values measured “in situ” and the U-values calculated in design phase, for different construction solutions, has been presented.

The fulfillment of the procedure given by the standards and some care with the control of the internal temperature and with the positioning of the external temperature sensor, result in measured U-values that are equivalent to the U-values calculated in the design phase. However deviations in the range of [0%, 30%] should be expected.

The methodology has been used in a set of tests carried out in residential buildings in the city of Vila Real. The following conclusions were drawn:
• The time needed to obtain results using the heat flux meter method is around 14 days, for buildings with a strong thermal inertia (the most common situation in our region), which indicates that it is necessary to carefully plan the work;

• In order to obtain good results, it necessary that the internal temperature is stable (which means it needs to be adequately controlled);

• In a market scenario, economical costs need to be taken into account.

This leads to the conclusion that this process can be used in the determination of U-values of constructive elements that separate heated spaces from non heated ones (a very common situation). This will help to better implement existing Portuguese regulations.

As expected, in periods when the internal temperature is close to the external temperature, or when great oscillations in temperature occur, the proposed methodology cannot be used, because of the influence of the thermal storage effect in construction elements with high thermal mass. The response of the constructive elements with high thermal mass to the abrupt variation of the external temperature is very slow and difficult to interpret.

In addition to this effect, when the internal and external temperatures are close, the heat flux decreases leading to very low flux values (to a mathematical indetermination, in the formulas). This can be observed in the results of tests 6 and 7.

Traditionally, tests were conducted in winter, keeping the internal temperature constant, at a higher value than the external temperature. The tests we performed show that an identical procedure may be used in Summer, now keeping the internal temperature constant at a lower level that the external temperature. The flux in this situation takes the direction form the outside to the inside of the building, but adequate measures of the U-values may be obtained (as test 8 shows).

This method may be used as a complement to the visual data obtained by the qualified experts, when inspecting the building. This will lead to a more accurate evaluation of the thermal performance of the building, and enables the promoters to provide more information to the users.

With the work presented in this paper, we aim at increasing the quality of the thermal behavior of dwellings. This will contribute to decrease the needs of heating and cooling (increasing energy efficiency), and, as a consequence, to decrease pollution (e.g. CO2 emissions to the atmosphere).

References


ISO 9869 (1994) “Thermal insulation - Building elements - In-situ measurement of thermal resistance and thermal transmittance”.

Developing a Conceptual Model for Measuring the Satisfaction Levels of Malaysian Contractors

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Abstract

The evaluation of satisfaction levels related to performance is an important aspect in increasing market share, improving profitability and enlarging opportunities for repeat business and can lead to the determination of areas to be improved, improving harmonious working relationships and conflict avoidance. In the construction industry, this can also result in improved project quality, enhanced reputation and increased competitiveness. Many conceptual models have been developed to measure satisfaction levels - typically to gauge client satisfaction, customer satisfaction and home buyer satisfaction - but limited empirical research has been carried out, especially in investigating the satisfaction of construction contractors. In addressing this, this paper provides a unique conceptual model or framework for contractor satisfaction based on attributes identified by interviews with practitioners in Malaysia. In addition to progressing research in this topic and being of potential benefit to Malaysian contractors, it is anticipated that the framework will also be useful for other parties - clients, designers, subcontractors and suppliers - in enhancing the quality of products and/or services generally.

Keyword: satisfaction measurement, contractor, attributes, Malaysia.
1. Introduction

The construction industry is a dynamic entity due to the level of uncertainties involved in technologies, budgets and development processes (Chan and Chan, 2004). Identifying the appropriate means of construction project delivery has also provided an ongoing debate among researchers as the scope of the projects is quite diverse and their construction involves multiple stages and processes. This has been said to make the industry unique as it is fragmented and involves a diverse group of participants (Walker and Hampson, 2003), with each having different objectives but also contractually bound to the same construction project.

Over recent decades, construction performance has been broadly criticised due to increasing problems in many areas. Naoum (1995), for example, has highlighted the problems related to the separation of design from construction, lack of integration and effective communication, high levels of uncertainty, changing environments and increases in project complexity. In Malaysia, the inefficiency and ineffectiveness of project teams has been highlighted as the main challenge in obtaining a high quality construction performance. However, according to the Construction Industry Malaysian Planning Report (CIMP) produced by Construction Industry Development Board (CIDB, 2007) project failures are not solely caused by their contractors. Architects and engineers also contribute to the failure of overall project performance, with 50 percent of failures attributed to design faults, with 40 percent being caused by construction faults and 10 percent from material faults.

Currently, several studies address issues of performance by developing performance measurement approaches. Cheng et al. (2006) use two measures, namely objective (time and cost) and subjective (quality and satisfactory). However, performance measurement based on objective measures, also known as the iron triangle (time, cost, quality) has been criticised as ineffective in measuring the performance of large development projects (Toor and Ogunlana, 2009). Other performance indicators, such as the satisfaction level of those involved, are thought to be more useful in improving current performance measurement and project outcomes.

Contractor satisfaction (Co-S) has been recognised one of the best indicators of construction project performance (Soetanto and Proverbs, 2002) but it is seldom, if ever, used in practice. Even in academic terms, there has been very limited study of the attributes of Co-S for construction projects. In developing effective Co-S measurement for construction work, therefore, there is a need to start from basics and identify the major influencing attributes involved and their interrelationships. Accordingly, the research described in this paper aimed to determine the potential attributes of Co-S and develop a contractor satisfaction (Co-S) conceptual model or framework appropriate for construction projects.
2. Literature review

Studies of performance measurement have been rapidly progressing in the recent years, with many performance studies being conducted throughout the world. These are based on different perspectives. For instance, an increasing body of literature is primarily concerned with subjective measures.

2.1 Performance measurement

The early literature of performance measurement is mostly related to marketing or business, with very little concerning the construction industry. Recently, it begins to progressively being employed into the construction industry. This has changed more recently, with several studies conducted in construction over a spectrum of areas. A common belief is that improvements in the satisfaction levels for construction projects will promote a performance-enhancing environment.

Many efforts have been carried out to enhance construction performance. Despite the effective evaluation of the overall project outcomes being seen as fundamental, a single most effective approach has not yet been discovered. The evaluation of the performance is commonly made on the basis of three main dimensions, namely cost, time and quality (Chan and Chan, 2004). As pointed out in recent literature, the traditional measures of the iron triangle (time, cost and quality) have limited application in measuring performance due to economics changes, the large scale of projects, rapid changes in technologies and the variety of participants in a project (Toor and Ogunalana, 2009; Chan and Chan, 2004; Ling et al., 2008 and Bryde and Robinson, 2005). Instead, soft measurements, that consider participants’ satisfaction, have been more frequently used as an improvement on existing methods (Karna, 2004).

2.2 Satisfaction measurement in the construction industry

Previous work on the performance of construction projects based on satisfaction measures are variously concerned with client satisfaction (Cl-S), customer satisfaction (Cu-S), home-buyer satisfaction (Ho-S), occupant satisfaction (Oc-S) and contractor satisfaction (Co-S). Their concepts, differences and relative advantages are discussed in the following sections.

2.2.1 Construction Client satisfaction (Cl-S)

Construction clients play an important role in the construction project and clients perceive service in their own unique way and use a gauge based on their cumulative memory of many positive experiences. Cl-S measurement has been identified as a function not only of output but also of the perceptions and expectations of the clients. Lim and Ling (2002), for example, assert that client expectations can be met by the fulfilment of seven criteria comprising flexibility, function, time, maintenance costs, safety, economy and quality while Tang et al (2003) hold that Cl-S measurement is a function of quality of
service, quality of product and quality of manner to customers. However, Cheng et al., (2006) argue that client characteristics including sector, size or location may have a significant impact on CI-S levels.

2.2.2 Customer satisfaction in construction (Cu-S)

Customer satisfaction (Cu-S) has become a critical issue in recent years (Karna, 2004). In order to meet customer’s needs and requirements, the contractor is required to provide a service of three elements including: service product, service environment and service delivery (Maloney, 2002). Commonly, completion of a project in accordance with its plans and specifications within budget and on time will meet customer needs and allow contractors to make profits. Karna (2004) notes that Cu-S can be used to evaluate quality and ultimately assess the success of a company’s quality improvement programme. This means that a quality improvement effort is important in the construction project as it leads to a higher product and service quality. However, Al-Momani (2000) found that the contractors pay very little attention to the Cu-S and thus, it is thought, resulting in poor performance.

2.2.3 Home buyer satisfaction (Ho-S)

The study of satisfaction in the construction industry has evolved by investigating home buyer satisfaction (Ho-S). Ho-S measurement is important as an indicator of a project team’s performance level. According to Torbica and Ricoh (2001), the quality of the product and service is the main antecedent determining Ho-S. Their study highlighted Ho-S as not only influenced by product design or product quality, but other home buyer characteristics such as experience, income, age, knowledge and location. Furthermore, an instrument to investigate Ho-S, HOMBSAT, was introduced in the same study and comprises the three dimensions of house design, house quality and service. The model developed shows that improved product and service quality results in a positive Ho-S.

2.2.4 Occupant satisfaction (Oc-S)

Determining the occupant level of satisfaction should help identify inappropriate design and performance of the building. Additionally, this method potentially provides a major benefit to the client and designer in the form of a Post Occupant evaluation (POE). As Liu (1999) points out, several approaches can be applied for the building performance appraisal process namely: i) to identify factors, on both physical and social levels, which affect housing residents’ satisfaction, ii) develop performance criteria and grading tools, iii) identify the relationship between residential satisfaction and children’s accident risk, spatial density, crowding and neighbourhood characteristics and iv) provide a quality appraisal of the building design in terms of both function and cost. This method can be conducted during the design stage in the form of value engineering as well as after completion of the building.
2.2.5 Contractor satisfaction measurement (Co-S)

The contractor provides the overall organization of the physical resources needed to realize the design and also needs to perform efficiently in order to survive in the market place. As noted above, there is a lack of agreement on the most appropriate approach to Co-S measurement. Soetanto and Proverbs (2002) address the satisfactory performance of participants, as a pre-requisite to maintaining and improving harmonious working relationships but this is not clearly defined. Generally, Co-S is influenced by other key participant performances in a project including the client, consultant and subcontractor. The Co-S also has a great potential as a tool to enhancing performance of the project. However, the degree of Co-S cannot be determined as clear as satisfaction levels of other participants due to a lack of understanding of influencing attributes. Therefore, to alleviate this problem Co-S attributes need to be further investigated. The following discussion focuses on the development of Co-S framework by considering other significant elements that are not fully explained in previous research.

3. Research methodology

The research aims to identify the key attributes of Co-S and other causes necessary to overcome the issues discussed earlier. Additionally, the research intended to examine other potential key attributes of Co-S not yet identified, for incorporation into a preliminary conceptual framework. The potential attributes of Co-S were obtained through an extensive review of the literature and preliminary interviews. Each attribute was allocated to one of two groups, i) contractor satisfaction attributes (direct attributors) and ii) contractor characteristics (indirect attributors) for further examination. Due to the lack of consensus concerning Co-S, many studies concerning problems in the construction industry and its failures have been examined to develop a basic understanding of Co-S.

Face-to-face preliminary interviews were conducted of contractor personnel registered under the Malaysian Construction Industry Development Board (CIDB). The interviews were conducted to identify additional information and specify problems not identified in previous empirical studies. Six different grades of Malaysian contractors were selected at random for participation through open-ended interviews. This was to identify ideas, and a feel for the practical issues involved. As Cavana et al. (2000) explains, preliminary information gathering involves the search for in-depth information concerning the observed problem. As a result, valuable information was obtained from the contractors, which was then used to develop a preliminary conceptual Co-S framework.

4. Discussion and findings

As highlighted in the earlier discussion, subjective measurement based on satisfaction has been applied in the construction industry to evaluate project performance levels and identify outcomes of a product or
service. To understand the results of the research, the potential attributes of Co-S are discussed in the next section.

4.1 Potential attributes of contractor satisfaction (Co-S) measurement

This section discusses the development of the Co-S framework by using attributes potentially influencing Co-S levels namely: performance attributes (direct attributor) and contractor characteristics (indirect attributor). The performance attributes are a key element in the Co-S conceptual framework. The element directly influencing Co-S consists of three dimensions namely participants’ performance (service quality), project performance and business performance. Co-S levels are not only influenced by these three attributes, but external factors such as project related factors, project procedures and the external environment also play their own role. Another element of the Co-S framework comprises the contractor characteristics. This element indirectly influences Co-S levels. In this study, the indirect attributes were taken to include the experience of the contractor, with knowledge, size and culture of organization also being recognised. These attributes are appropriate for use in developing the new Co-S conceptual framework.

4.1.1 Performance attributes

Previous satisfaction studies have all been different in terms of objectives, perspectives, methodologies and scope. Every attribute has a different effect on Co-S levels and several methods have been used to determine levels of satisfaction on construction projects. In this study, three attributes of service quality were defined as depending on the participants’ performance; project performance; and business performance. Three additional elements are external factors that encompass project related factors, project procedures and external environment. The following section provides a detailed discussion of the attributes namely participant performance, project performance and business performance.

4.1.1.1 Service quality of participant performance

The existing framework of Co-S levels is limited and relates only to client performance. This paper proposes an enhancement by integrating three elements namely service delivery, relationships of people/participants and communications. Other potential attributes discussed in this paper were mainly highlighted in the interviews. Service delivery consists of items gauged on product and/or service performed by the participants (such as client, consultants (architect and engineer), subcontractors and suppliers). Several studies (Yasamis et al., 2002; Leung et al. 2004) confirm that an effective performance evaluation of the service or product leads to the enhancement of project quality. In addition, relationship management in terms of enhancement of harmonious relationships, co-operation, trust, commitment and participation among project team also help deliver projects efficiently (Karslen et al., 2008). One of the interviewees also emphasized communication as another item for evaluating the service quality of participants. Effective communication is needed to improve project team relationships as it influences
participant satisfaction (Leung et al. 2004). This means that service quality is not only based on service
delivery but relationships of participants and communications between project team also need to be taken
into account in developing a Co-S framework.

4.1.1.2 Project performance

In construction projects, the contractor is responsible for converting designs into practical and well
performing facilities. Improvements in contractor performance leads to increase client satisfaction (Cl-S),
improvements in the reputation of contractors and hence their competitiveness in the market.
Additionally, the performance of the project can be achieved through the high quality of performance of
each participant. Several previous studies have examined project performance in different ways. For
example, several project performance measurements have been investigated - mainly concerned with
construction cost, time speed and quality (Al-Momani, 2000; Liu et al. 1998). However, five additional
performance measures have been identified as applicable to contractors: cost performance; time
performance; quality performance; owner satisfaction; and profit margin (Ling et al., 2008). These
attributes are important for contractors in order to maintain the performance of the project as they also
have been emphasized by the interviewees. For example, one contractor highlighted that he was satisfied
when the project was completed as stated in the contract in terms of time, cost and quality. As expected,
differences in project profit margins are also seen as important contributions to Co-S.

4.1.1.3 Business performance

Business performance is another important element to measure Co-S levels. Commonly, contractor
performance is gauged on cost, time and quality alone. However, a previous study (Xio and Proverbs,
2003) argues that contractor performance is extended to include the continued activity of contractors, as
measured by their profitability, investment in research and development, harmonious working relations
throughout projects, environmental protection and safety. Additionally, the same study asserts that
business performance based on profitability is often influenced by the market conditions. In general,
project success has been defined differently by owner or client, designers, general contractors and
subcontractors (Bryde and Robinson, 2005). Here, the top definitions of successful performance include:
profitable projects, on time or early completion, within budget, good working relationships and good
communication. Furthermore, business performance also depends on other aspects such as the resources
and capabilities of the construction company, its project management competencies, the strengths of its
relationships between project team and strategies of the company.

4.1.1.4 External factors

Another attribute that influences Co-S levels is project characteristics. This element is important for
consideration, but is rarely examined for Co-S levels as it is indirectly influenced by the participants’
performance and project performance. On another perspective, the transparency of the government’s
procedure on contractor selection is considered to be one of the main attributes influencing Co-S. Having good connections (guanxi) between the contractor and the client are still essential for the successful procurement of projects in many countries (Ling et al., 2005). Furthermore, issues such as cronyism can be seen as critical problems in the construction industry when a large project is awarded to a contractor organisation regardless of its ability (Sohail and Cavill, 2008). In addition, the environmental issues of: economic environment; social environment; political environment; physical environment; industrial relationships environment; technology advance have a potential influences on Co-S levels.

4.2.1 Contractor characteristics

The impact of indirect attributes or contractor characteristics are discussed here as it is important to examine the degree of Co-S levels. Informed by the literature and the results from the preliminary interviews, four indirect attributes of contractor’s experience, knowledge, size and culture, were found to be necessary to taken into consideration.

4.2.1.1 Experience

The contractor’s experience is an important criterion for evaluating the performance of the contractor. However, the study also found that the level of experience may influence Co-S levels. The contractor’s experience is commonly determined by the number of years working in construction. Experience also influences the contractor in evaluating Co-S levels. Ismail et al. (2006) assert that previous experience influences the expectation of the final outcome. Direct attributes possibly influence satisfaction levels, however the contractor’s expectations affect the decision as they are based on perceived service performance. The expectation or standard of experience of a contractor could be determined by its familiarity with the market, understanding of regulations and technical and management skills. The result indicates that to evaluate Co-S levels, it is important to consider experience in terms of the total work volume on similar projects, the average work volume on similar projects, experience with contract types and teams, working in similar geographical conditions and working in similar weather conditions on similar projects.

4.2.1.2 Knowledge

Another characteristic that impacts on Co-S is knowledge. Currently, most projects require a high level of skills in terms of technology, material and safety, thus the contractor’s personnel need to have sufficient basic knowledge in these areas. Interviews results indicate that an effective and knowledgeable contractor is necessary to ensure the work is delivered according to the work programme, standards of requirements and specified level of quality. This suggests that problems such as delays, cost overruns, poor quality and loss of profits can be rectified if contractors improve their current knowledge of technology, finance and management. The relationship between this knowledge and Co-S can be derived as the contractor has different level of expectation from which judge performance.
4.2.1.3 Size of the organization

In construction, contractors can be distinguished according to the size of their organization and the size of Malaysian contractors is determined by many categorizes and grades. These are identified as small, medium and large and based on their capital and financial capabilities. Additionally, this includes organizational structure, current workload, technical personnel and management capability (Watt et al., 2008). Larger contractors have different expectations than small or medium size contractors. The interviews showed that larger contractors mostly have different workloads or capacities, financial positions, equipment resources, available manpower and other safety measures that can influence Co-S levels. Although performance measurement based on Co-S levels is influenced by several direct attributors, the literature and the results of the interviews show that characteristics such as the size of the contractor indirectly impact on the degree of Co-S. For example, larger size contractors have different needs as they are as concerned as much with their reputation as with profit.

4.2.1.4 Culture

Culture is a significant issue particularly in the construction industry. Locke and Latham (1990) suggest that every organization has a culture which is determined by its history, size, corporate goals and objectives, technology of production, market and operating environment. In construction, culture is concerned with the impact of a nation’s culture on construction activity, the culture of the construction project, the culture of the construction firm and the culture of the construction site. Every organization practices different systems, arrangements and procedures. Co-S levels could be affected by culture as it relates to motivation, efforts to innovate, incentives offered and implementation of new technology. Additionally, the construction industry currently emphasizes environmental issues and innovation as there are several important requirements that need to be fulfilled. In addition, performance measurement based on Co-S levels becomes more challenging as the construction industries of developing countries penetrate into the international arena. It is therefore necessary to consider the different organizational cultures of contractors in determining Co-S levels. This aspect is absent from all related previous studies.

4.2 A preliminary of contractor satisfaction (Co-S) conceptual model

Figure 1 contains the proposed conceptual model developed from the literature review and interviews. It depicts the two key elements to accessing Co-S level of performance attributes and contractor characteristics. Performance attributes have a direct impact and contractor characteristics have an indirect impact on Co-S levels. Both influence Co-S levels and can be gauged as either positive or negative depending on the gaps in Co-S levels.
5. Conclusions

An integrated framework of Co-S levels is proposed in this paper as shown in Figure 1. This integrates the two main attributes (direct attributes and indirect attributes) that have been discussed in the previous section. The paper investigates these two highlighted components to measure performance, namely: (1) direct attributes also known as performance attributes that consist of several elements such as participants’ performance (service quality), project performance, and business performance and external factors; (2) indirect attributes also known as contractor characteristics that comprises several elements including knowledge, size of the organization, experience and culture. Focus is given on this two main attributes only because of the resource limits imposed on the research and the assumption that the chosen areas have potentially more significant outcomes. The model developed is likely to be useful for contractors in enhancing and maintaining their level of business in addition to project performance. Additionally, the proposed Co-S framework may be able to motivate clients, consultants and other participants to enhance their service and product quality, and increase their levels of trust of contractor capability.

References


Building Project Performance Evaluation Model

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Abstract

Building project performance evaluation is a novel research interest in performance measurement (PM) and it is the process of quantifying the efficiency and effectiveness of construction activities. The traditional view of PM highly relies on financial and accounting data, which gives only the past performance. Moreover, the construction industry has been always criticized for its underperformance due to its uniqueness in nature. According to past researchers, there is lack of an appropriate PM system to improve construction performance. There is therefore a necessity for multi-dimensional approach to measure the building construction project performance. Past literature reveals that both balanced scorecard (BSC) and analytic hierarchy process (AHP) tools have been used in manufacturing industry for performance evaluation. This study therefore developed a multi-dimensional performance measurement model for building construction project performance evaluation by integrating BSC and AHP tools. Comprehensive literature review and preliminary survey approach were used to develop a novel extended BSC model, which comprises with six perspectives namely, Client, Financial, Internal business processes, Project team, Health, safety and socio-environmental, and Innovation, learning and growth. Extended BSC model further comprises with key building project performance indicators (KBPPIs) in each perspective. Structured questionnaire survey was then conducted to collect data and AHP tool was used to analyze and prioritize BSC perspectives and KBPPIs. Survey findings revealed that client and financial perspectives have relatively two times higher important level than other perspectives in the model while, three times important than innovation, learning and growth perspective. In conclusion, this novel multi-dimensional performance measurement model can be duly applied by construction industry practitioners to optimize building performance.

Keywords: performance measurement (PM), extended balanced scorecard (BSC), analytic hierarchy process (AHP), key building project performance indicators (KBPPIs)
1. Performance Measurement in Construction Industry

Construction project performance evaluation continues to be one of the primary competitive issues of the new millennium. Performance measurement (PM) is an integral part of management and defined as a process of quantifying both the efficiency and effectiveness of an action (Neely et al., 2005). Some of the major concerns of performance measurement include “What to measure?”, “Which measures are used?”, “How to measure?” and “How to interpret results?” (Sandanayake and Oduoza, 2007). Traditionally, performance has mainly been measured from the financial perspective. Therefore, traditional management accounting systems were highly criticized due to their dysfunctional behaviour (Ridgway, 1956). This dissatisfaction led to the development of “balanced” or “multi-dimensional” PM frameworks in the late 1970s (Bourne et al., 2000). Kagioglou et al. (2001) stated organizations that rely on financial measures alone, can identify their past performance but not what contributed to achieve that performance. Further, Kagioglou et al. (2001, pp 86) emphasised “in addition to measuring ‘what’ the performance of an organization was, ‘how’ that performance was achieved should also be identified on an on-going basis”. This made aligning the leading indicators for PM concurrently with the lagging indicators.

Cain (2004) identified PM as the first stage in any improvement process that benefits the end users as well as the organisations. Therefore, Kulatunga et al. (2007) emphasised that PM is important for organisations to evaluate its actual objectives against the predefined goals and to make certain that they are doing well in the competitive environment. Traditionally, PM in construction is approached in two ways: in relation to the product as a facility and in relation to the creation of the product as a process (Kagioglou et al., 2001). Although a similar set of process stages is involved in every project, the construction industry is a project-oriented industry where each project is unique and can be considered as a prototype (Wegelius-Lehtonen, 2001). Therefore, measuring construction performance focuses more on projects rather than the construction organisations (Kagioglou et al., 2001). The researchers and the industrial experts agree that the lack of appropriate performance measurements have become one of the principle barricades to promote improvements in the construction industry (Alarcon and Serpell, 2001).

Kagioglou et al. (2001) argued that traditional indicators such as cost, time and quality do not in isolation, provide a balance view of the projects’ performance. Researchers further stated that implementation of three traditional indicators in construction projects is apparent at the end of the project and therefore they can be classified as ‘lagging’ indicators of performance. Salminen (2005) developed a system for measuring construction site performance. The researcher analysed the measurement results to determine the success factors for a construction site. Kagioglou et al. (2001) mentioned that the project performance would be addressed on an induction basis by all companies involved in the project. The measures will therefore include both company and project performance issues. It was noted that there are different applications of key performance indicators (KPIs) in construction (Luu et al., 2008). Chan and Chan (2004) developed a set of KPIs to measure success of construction projects. The researchers used three cases to test the validity of the proposed KPIs.
According to the past literature, it is obvious that performance measurement systems such as performance prism, SMART system, performance measurement questionnaire, integrated performance measurement system, EFQM framework and balanced scorecard (BSC), and multi-criteria decision making tools such as value engineering and analytic hierarchy process (AHP) have been used in manufacturing industry for performance evaluation. However, few aforementioned tools such as BSC and AHP have been adapted to performance evaluation in construction industry, individually. It has also been identified that the performance has not been measured quantitatively and qualitatively in the construction industry. There is therefore a lack of a multi-dimensional approach to quantify construction project performance and hence, there is a need to develop a multi-dimensional approach for construction project performance evaluation. Thus, the main objective of this paper is to introduce a multi-dimensional performance measurement model with prioritised BSC perspectives and Key Building Project Performance Indicators (KBPPIs) for construction project performance evaluation, using multi-criteria decision making tool such as AHP.

The paper structure begins with an introduction to PM and reviews PM in construction industry. Sections two and three, review BSC and AHP tools respectively and their applications in construction industry. Fourth section develops a conceptual model and introduces a methodological framework. Section five presents building project performance evaluation model and final section summarizes conclusions derived from the overall research finding and recommendations to improve construction project performance.

2. Balanced Scorecard approach

The Balanced Scorecard (BSC) is a performance measurement system developed in early 1990s’ by Professor Robert S. Kaplan and David P. Norton. The BSC has been described as a set of measures that gives top managers a fast but comprehensive view of the business (Kaplan and Norton, 1996). Hence, it translates an organisations’ mission and strategy into a comprehensive set of performance measures and provides a framework for strategic performance management (Kaplan and Norton, 1996). Traditional BSC was consisting with four perspectives. It includes financial measures that emphasis the results of actions already taken and it complements with operational measures on customer satisfaction, internal business processes and the organisations’ innovation and improvement activities. Kaplan and Norton (1993) emphasised that BSC is not a template that can be applied to businesses in general or even industry wide. Researchers further added the view that different market situations, product strategies, and competitive environments require different scorecards while business units devise customized scorecards to fit their mission, strategy, technology and culture. Hepworth (1998) and Ahn (2005) suggested that additional perspectives should be included if applicable and necessary. Lee et al (2008) also mentioned “depending on the sector in which a business operates and on the strategy chosen, the number of perspectives can be enlarged or new perspectives can be replaced by the other”.

The use of BSC tool can be identified through lot of researches. According to Stewart and Mohamed (2001), BSC has been used extensively in the manufacturing, government, banking, retail, insurance and financial services sectors. ‘Apple computer’ developed a BSC with the use of five performance
indicators; Customer Satisfaction, Core Competencies, Employee Commitment and Alignment, Market Share and Shareholder Value (Kaplan and Norton, 1993). Letza (1996) analysed three companies; construction supply, specialist coatings, telecommunications, which have implemented BSC tool in their organisation.

Implementation of BSC for PM in construction sector can be identified from early 1990s. Construction industry also has come forward to implement BSC approach and lot of researches have been conducted during last two decades (Kagioglou et al., 2001). Kaplan and Norton (1993) described the implementation of BSC tool thorough three case studies. One of them was under water engineering and construction company named Rockwater, which has implemented BSC successfully. Stewart and Mohamed (2001) developed the BSC framework allowing for the measurement of IT/IS performance in construction. Mohamed (2003) adopted the BSC tool to benchmark organisational safety culture in construction. Kagiouglou et al. (2001) developed a PM process (conceptual) framework based on the BSC with the addition of ‘project’ and ‘supplier’ perspectives, which can be tailored to construction industry needs.

3. Analytic hierarchy process tool

The AHP was first introduced by Saaty in 1971 to solve the scarce resources allocation and planning needs for the military (Saaty, 1980). AHP is about breaking a problem down and then aggregating the solutions of all the sub-problems into a conclusion (Saaty, 1994). Further, it facilitates decision making by organizing perceptions, feeling, judgements and memories into a framework that exhibits the forces that influence the decision. Clinton et al. (2002) suggested that the AHP tool is mathematically rigorous yet easy to understand because it focuses on making a series of simple paired comparisons. Ahmed and Rafiq (1998) stated AHP helps not only in identifying major competitors of a company but also to assess the performance of the organisation on each attribute relative to its principal competitors. Rangone (1996) described AHP as a multi-attribute decision tool that allows financial and non-financial quantitative and qualitative measures to be considered and trade-offs among them to be addressed. Recently the AHP has been applied to several decision-making areas. Rangone (1996) enhanced the application of AHP to measure and compare the overall performance of different manufacturing departments based on multi-attribute financial and non-financial performance criteria. Dey (2001) applied AHP tool for construction risk management and Chan et al. (2004) used AHP method to determine the priority of processes for Occupational Health and Safety Management Systems for the Hong Kong construction industry.

Ahmed and Rafiq (1998) identified BSC and AHP as common tools, which assess common frameworks’ role in benchmarking. Stewart and Mohamed (2001) looked at potential applications and benefits of using the BSC as framework to evaluate the performance improvement resulting from information technology implementation by a construction organisation. According to Sale and Sale (2005), using the AHP to structure the BSC requires the decision maker to first structure the problem as a hierarchy. Sale and Sale (2005) combined AHP and BSC tools to create a technique that is superior to the use of either one in isolation.
4. Development of a building project performance evaluation model

Various research studies have been carried out to investigate and quantify performance in construction industry. However, there is no evidence in literature of any mechanism to identify KBPPIs. Therefore, a three-step approach was adopted to identify and prioritize Building Project Performance Indicators (BPPIs). Figure 1 describes the three-step approach with data collection and analysis tools and research outcomes at each step of the research.

**4.1 Identification of Balanced Scorecard perspectives and building project performance indicators**

Determination of BSC perspectives and BPPIs is one of the prime objectives of this study. A comprehensive literature review on construction and manufacturing industries was carried out to identify BSC perspectives and BPPIs. Currently, construction projects are highly influenced by project teams and health, safety and socio-environmental issues. Thus, the traditional BSC would need to be expanded to incorporate other perspectives such as “Project team” and “Health, safety and socio-environmental”. Further, the customer perspective in original BSC renamed as the ‘Client Perspective’ to comply with the construction terminology.

**4.2 Determination of key building project performance indicators**

Preliminary survey was carried out through informal interviews in order to revise the conceptual extended BSC model, with the aim of collecting common BPPIs, which are applicable in building construction project performance evaluation. Focused group consists of ten construction industry experts from the fields of project management, engineering and quantity surveying. Respondents were requested to identify the relevancy and the importance levels of BPPIs and perspectives in
conceptual model. Preliminary interview data analysis reveals that all extended BSC perspectives and BPPIs are relevant for each perspective in extended BSC model and the perspectives identified are relevant for building project performance evaluation. Moreover, three new indicators were identified and included in the revised extended BSC. BPPIs included in revised extended BSC model were named as the Key Building Project Performance Indicators (KBPPi). Figure 2 presents the revised extended BSC for building project performance evaluation.

![Figure 2: Extended BSC for Building Project Performance Evaluation](image)

### 4.3 Prioritization of BSC perspectives and key building project performance indicators

The next step in the building project performance evaluation model development process is data analysis using AHP tool. A series of focused and structured interviews were carried out with clients, quantity surveyors, engineers, project team members, health and safety officers and project managers. The respondents were asked to give their individual opinion and indicate the magnitude of the importance placed on selected KBPPi for each BSC perspective. For all decision alternatives, geometric mean was calculated from the allocated weights from the participants; the mean for each alternative was considered in the analysis. The AHP is consisting with set of mathematical calculations mainly focusing three steps, i.e. “Pair-wise Comparisons”, “Normalise the Comparison” and “Consistency Calculations”. The AHP analysis is used to identify the impact of each BSC perspective on overall project performance and the importance of KBPPi on each BSC perspective. The performance pair-wise comparison for BSC perspectives are given in Table 1. The weights of Table 1 are then normalised and presented in Table 2. The consistency calculations are given in Table 3.
Table 1: Pair-Wise Comparisons of Extended BSC Perspectives

<table>
<thead>
<tr>
<th>Performance Perspective</th>
<th>Client</th>
<th>Financial</th>
<th>Internal Business Processes</th>
<th>Project Team</th>
<th>Health, Safety and Socio-Environmental</th>
<th>Innovation, Learning and Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>1.000</td>
<td>1.613</td>
<td>2.006</td>
<td>3.008</td>
<td>2.035</td>
<td>2.594</td>
</tr>
<tr>
<td>Financial</td>
<td>0.620</td>
<td>1.000</td>
<td>2.028</td>
<td>2.967</td>
<td>2.351</td>
<td>2.963</td>
</tr>
<tr>
<td>Internal Business Process</td>
<td>0.498</td>
<td>0.493</td>
<td>1.000</td>
<td>1.328</td>
<td>1.256</td>
<td>2.329</td>
</tr>
<tr>
<td>Project Team</td>
<td>0.332</td>
<td>0.337</td>
<td>0.753</td>
<td>1.000</td>
<td>2.123</td>
<td>2.548</td>
</tr>
<tr>
<td>Health, Safety and Socio-Environmental</td>
<td>0.491</td>
<td>0.425</td>
<td>0.796</td>
<td>0.471</td>
<td>1.000</td>
<td>1.693</td>
</tr>
<tr>
<td>Innovation, Learning and Growth</td>
<td>0.385</td>
<td>0.338</td>
<td>0.429</td>
<td>0.392</td>
<td>0.591</td>
<td>1.000</td>
</tr>
<tr>
<td><strong>SUM</strong></td>
<td><strong>3.328</strong></td>
<td><strong>4.206</strong></td>
<td><strong>7.012</strong></td>
<td><strong>9.167</strong></td>
<td><strong>9.355</strong></td>
<td><strong>13.127</strong></td>
</tr>
</tbody>
</table>

Table 2: Pair-wise Normalized Comparisons of the BSC Perspectives

<table>
<thead>
<tr>
<th>Performance Perspective</th>
<th>Client</th>
<th>Financial</th>
<th>Internal Business Processes</th>
<th>Project Team</th>
<th>Health, Safety and Socio-Environmental</th>
<th>Innovation, Learning and Growth</th>
<th><strong>SUM</strong></th>
<th><strong>Performance Score</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>0.301</td>
<td>0.384</td>
<td>0.286</td>
<td>0.328</td>
<td>0.218</td>
<td>0.198</td>
<td>1.713</td>
<td>0.286</td>
</tr>
<tr>
<td>Financial</td>
<td>0.186</td>
<td>0.238</td>
<td>0.289</td>
<td>0.324</td>
<td>0.251</td>
<td>0.226</td>
<td>1.514</td>
<td>0.252</td>
</tr>
<tr>
<td>Internal Business Process</td>
<td>0.150</td>
<td>0.117</td>
<td>0.143</td>
<td>0.145</td>
<td>0.134</td>
<td>0.177</td>
<td>0.866</td>
<td>0.144</td>
</tr>
<tr>
<td>Project Team</td>
<td>0.100</td>
<td>0.080</td>
<td>0.107</td>
<td>0.109</td>
<td>0.227</td>
<td>0.194</td>
<td>0.817</td>
<td>0.136</td>
</tr>
<tr>
<td>Health, Safety and Socio-Environmental</td>
<td>0.148</td>
<td>0.101</td>
<td>0.114</td>
<td>0.051</td>
<td>0.107</td>
<td>0.129</td>
<td>0.650</td>
<td>0.108</td>
</tr>
<tr>
<td>Innovation, Learning and Growth</td>
<td>0.116</td>
<td>0.080</td>
<td>0.061</td>
<td>0.043</td>
<td>0.063</td>
<td>0.076</td>
<td>0.439</td>
<td>0.073</td>
</tr>
</tbody>
</table>

Table 3: Consistency Calculations for Extended BSC Perspectives

<table>
<thead>
<tr>
<th>Performance Perspective</th>
<th>Client</th>
<th>Financial</th>
<th>Internal Business Processes</th>
<th>Project Team</th>
<th>Health, Safety and Socio-Environmental</th>
<th>Innovation, Learning and Growth</th>
<th><strong>SUM</strong></th>
<th><strong>Performance Score</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>0.286</td>
<td>0.407</td>
<td>0.290</td>
<td>0.410</td>
<td>0.220</td>
<td>0.190</td>
<td>1.802</td>
<td>6.312</td>
</tr>
<tr>
<td>Financial</td>
<td>0.177</td>
<td>0.252</td>
<td>0.291</td>
<td>0.404</td>
<td>0.254</td>
<td>0.217</td>
<td>1.598</td>
<td>6.333</td>
</tr>
<tr>
<td>Internal Business Process</td>
<td>0.142</td>
<td>0.124</td>
<td>0.144</td>
<td>0.181</td>
<td>0.136</td>
<td>0.171</td>
<td>0.899</td>
<td>6.225</td>
</tr>
<tr>
<td>Project Team</td>
<td>0.095</td>
<td>0.085</td>
<td>0.109</td>
<td>0.136</td>
<td>0.230</td>
<td>0.187</td>
<td>0.841</td>
<td>6.175</td>
</tr>
<tr>
<td>Health, Safety and Socio-Environmental</td>
<td>0.140</td>
<td>0.107</td>
<td>0.115</td>
<td>0.064</td>
<td>0.108</td>
<td>0.124</td>
<td>0.659</td>
<td>6.087</td>
</tr>
<tr>
<td>Innovation, Learning and Growth</td>
<td>0.110</td>
<td>0.085</td>
<td>0.062</td>
<td>0.053</td>
<td>0.064</td>
<td>0.073</td>
<td>0.448</td>
<td>6.115</td>
</tr>
</tbody>
</table>

\[ \lambda_{\text{max}} = 6.208 \]

\[ \text{CR} = \left( \frac{\lambda_{\text{max}} - n}{n - 1} \right) \times \frac{1}{\text{RI}} = \left( \frac{6.208 - 6}{6 - 1} \right) \times \frac{1}{1.25} = 0.033 \]

Where CR is Consistency Ratio, n is size of matrix (i.e. Number of BSC perspectives) and RI is Random Index for n number of matrices.

The next step of AHP analysis is the pair-wise comparison of KBPPIs with respect to extended BSC perspectives. The same procedure is followed and results are given in Table 4. Results are discussed and building project performance evaluation model is presented in the following section.
5. Building project performance evaluation model

The ultimate objective of this study is to develop a ‘Building Project Performance Evaluation Model’ with prioritized BSC perspectives and KBPPIs. Table 4 presents the prioritized building project performance evaluation model. Relative performance scores of each BSC perspective and KBPPIs provide the importance level of perspectives and KBPPIs in building project performance evaluation.

Table 4: Prioritized Building Project Performance Evaluation Model

<table>
<thead>
<tr>
<th>Perspectives and Key Performance Indicators</th>
<th>Performance Score</th>
<th>Overall Score %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Client Perspective</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Client satisfaction for quality level</td>
<td>0.389</td>
<td>11.10%</td>
</tr>
<tr>
<td>Degree of quality of finished project</td>
<td>0.225</td>
<td>6.41%</td>
</tr>
<tr>
<td>Client satisfaction of on time completion</td>
<td>0.161</td>
<td>4.59%</td>
</tr>
<tr>
<td>Client satisfaction meeting budget</td>
<td>0.144</td>
<td>4.12%</td>
</tr>
<tr>
<td>Client requirements and assistance</td>
<td>0.082</td>
<td>2.34%</td>
</tr>
<tr>
<td><strong>Financial Perspective</strong></td>
<td>0.252</td>
<td>25.23%</td>
</tr>
<tr>
<td>Project profitability</td>
<td>0.333</td>
<td>8.39%</td>
</tr>
<tr>
<td>Project cost</td>
<td>0.210</td>
<td>5.29%</td>
</tr>
<tr>
<td>Project cash flow</td>
<td>0.197</td>
<td>4.97%</td>
</tr>
<tr>
<td>Meeting budget</td>
<td>0.143</td>
<td>3.61%</td>
</tr>
<tr>
<td>Project Productivity</td>
<td>0.117</td>
<td>2.96%</td>
</tr>
<tr>
<td><strong>Internal Business Process Perspective</strong></td>
<td>0.144</td>
<td>14.44%</td>
</tr>
<tr>
<td>Project quality level</td>
<td>0.316</td>
<td>4.36%</td>
</tr>
<tr>
<td>On time completion</td>
<td>0.179</td>
<td>2.59%</td>
</tr>
<tr>
<td>Defects level</td>
<td>0.171</td>
<td>2.47%</td>
</tr>
<tr>
<td>Machinery and manpower capability</td>
<td>0.136</td>
<td>1.97%</td>
</tr>
<tr>
<td>Project efficiency</td>
<td>0.125</td>
<td>1.81%</td>
</tr>
<tr>
<td>Flexibility of internal processes and nature of project</td>
<td>0.072</td>
<td>1.03%</td>
</tr>
<tr>
<td><strong>Project Team Perspective</strong></td>
<td>0.136</td>
<td>13.62%</td>
</tr>
<tr>
<td>Proper selection of project team</td>
<td>0.290</td>
<td>3.95%</td>
</tr>
<tr>
<td>Project team efficiency</td>
<td>0.243</td>
<td>3.30%</td>
</tr>
<tr>
<td>Project team satisfaction level</td>
<td>0.178</td>
<td>2.42%</td>
</tr>
<tr>
<td>Degree of project team work and partnerships</td>
<td>0.175</td>
<td>2.39%</td>
</tr>
<tr>
<td>Team appraisal levels</td>
<td>0.115</td>
<td>1.57%</td>
</tr>
<tr>
<td><strong>Health, Safety and Socio-Environmental Perspective</strong></td>
<td>0.108</td>
<td>10.83%</td>
</tr>
<tr>
<td>Number of health and safety issues</td>
<td>0.412</td>
<td>4.46%</td>
</tr>
<tr>
<td>Level of construction waste and sustainability</td>
<td>0.266</td>
<td>2.87%</td>
</tr>
<tr>
<td>Environmental Impact Assessment (EIA) score</td>
<td>0.163</td>
<td>1.77%</td>
</tr>
<tr>
<td>Number of socio-environmental complaints</td>
<td>0.159</td>
<td>1.72%</td>
</tr>
<tr>
<td><strong>Innovation, Learning and Growth Perspective</strong></td>
<td>0.073</td>
<td>7.32%</td>
</tr>
<tr>
<td>Continuous Professional Development (CPD)</td>
<td>0.282</td>
<td>2.07%</td>
</tr>
<tr>
<td>Investment on research and development</td>
<td>0.269</td>
<td>1.97%</td>
</tr>
<tr>
<td>Number of skills developed</td>
<td>0.188</td>
<td>1.37%</td>
</tr>
<tr>
<td>Technological enhancement</td>
<td>0.165</td>
<td>1.21%</td>
</tr>
<tr>
<td>Macroeconomic aspects and external factors</td>
<td>0.096</td>
<td>0.71%</td>
</tr>
</tbody>
</table>
According to Table 4 ‘Client’ is the most important perspective with 0.286 performance score. ‘Financial Perspective’ is in the second place in the revised BSC with a 0.252 performance score. The third, fourth and the fifth perspectives are ‘Internal Business Process Perspective’ (0.144), ‘Project Team Perspective’ (0.136) and ‘Health, Safety and Socio-Environmental Perspective’ (0.108) respectively. According to the research the least important perspective is the ‘Innovation, Learning and Growth Perspective’ with 0.073 performance score.

According to analysis of Table 4 ‘client satisfaction for quality level’ (0.389) is the most important KBPPI in client perspective, while ‘project profitability’ is the most important KBPPI in financial perspective with 0.333 performance score. Ward et al (1991) also found that when looking back on the conduct of a project, what sticks in the mind is often not the financial success or early completion, but memories of clients involved and abiding impressions of harmony, goodwill and trust or, conversely, of arguments, distrust and conflict. In internal business process, project team, health safety and socio-environmental and innovation, learning and growth perspectives, the most important KBPPIs are ‘project quality level’ (0.316), ‘proper selection of project team’ (0.290), ‘number of health and safety issues’ (0.412) and ‘continuous professional development’ (0.282) respectively. In client perspective ‘client requirements and assistance’ (0.082) is the least important KBPPI and for financial perspective it is ‘project productivity’ (0.117). ‘flexibility of internal processes and nature of project’ (0.072), ‘team appraisal levels’ (0.115), ‘number of socio-environmental complaints’ (0.159), and ‘macroeconomic aspects and external factors’ (0.096) are the least important KBPPIs respectively in internal business process, project team, health safety and socio-environmental and innovation, learning and growth perspectives. The CR for each perspective is less than 0.10. Therefore, data used for the study can be considered as acceptable and consistent.

The overall comparison of KBPPIs is providing a spectacular point of ranking all the PIs with the priority levels towards PM in building construction. According to the results ‘client satisfaction for quality level’ (11.10%) is the most apparent BPPI, while ‘project profitability’ (8.39%) is the second most important BPPI. ‘Degree of quality of finished project’ (6.41%) and ‘project cost’ (5.29%) have taken the places of third and forth, which are in client and financial perspectives respectively. ‘Macroeconomic aspects and external factors’ (0.71%) in innovation, learning and growth perspective is the least important BPPI in overall scorecard.

6. Conclusions

The study developed the Building Project Performance Evaluation Model to evaluate building project performance. A three step approach to evaluate building project performance using BSC and AHP tools has been presented. This included the use of comprehensive literature review to identify BSC perspectives, BPPIs and application of statistical analysis to determine KBPPIs. AHP tool was applied to prioritize BSC perspectives and KBPPIs in order to develop building project performance evaluation model. The implication of AHP tool for analysis scrutinized the perspectives and KBPPIs through pair-wise comparisons and bestowed relative performance scores for each perspective and BPPI. Therefore model developed, enriched with relative performance scores from importance levels to the building construction. These performance scores provide the opportunity to consider a
magnitude importance of each perspective or a KBPPI from another perspective or a KBPPI respectively. The prioritised model emphasised the important extended BSC perspectives as well as KBPPIs for building project performance evaluation. The approach developed benefits from its simplicity and operability. However the complexity of AHP analysis increases with the number of BSC perspectives and KBPPIs.

The analysis of responses revealed that “Client Perspective” and “Financial Perspective” in building construction projects hold higher importance levels compared to the other perspectives in the revised extended BSC. The two perspectives were comparatively two times more important than the other perspectives while comparatively three times more important than “Innovation, Learning and Growth Perspective”. Though the industry practitioners accepted the “Innovation, Learning and Growth Perspective” as an important aspect for performance measurement, the final analysis exposed the importance level of particular perspective as a lower amount. It was consisted the literature that using innovation learning and growth perspective is not much appropriate for project performance. According to the overall AHP analysis ‘client satisfaction for quality level’ is the most critical KBPPI followed by ‘project profitability’. Since these two most important KBPPIs indicate the final expectations of both parties of the contract. From the clients’ aspect it is client satisfaction, while from the contractors’ point of view it is project profitability.

The building project performance evaluation model developed here can serve as a tool to enhance construction project performance. It will enable strategic decision on client satisfaction, financial stability, efficiency and effectiveness of internal business process and project teams, sustainable projects and delivery of innovative projects to clients. Therefore this innovative three step approach and building project performance evaluation model can be simply applied by construction industry practitioners and academic researchers to optimise building project performance.

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Trust Yourself: A Doubting Thomas Perspective on Building Research

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Abstract

As physical artefacts, buildings provide material evidence of the process that led to their realization and the effectiveness of the decisions made prior to it: construction details implicitly reflect the knowledge of production factors embedded in the work and the efficacy of the contractual methods employed to structure underlying socio-technical relations; building use patterns validate or reject choices made at program definition and development stages; building maintenance requirements give an indication of the depth of thinking that went into the operational life of the building, or help assess the administrative and labour structure that put it together. Using a major public performance arts complex recently developed in Spain as an example, the paper seeks to validate such statements whilst showing that the empirical analysis required to do it can indeed help evaluate construction work, even in those (many) extreme cases where political sensitivity is likely to stop the disclosure of technical documentation and thwart building analysts’ ambitions to examine construction output. In connecting promoters’ declared objectives and buildings’ physical results with knowledge of the industry and participating actors’ alleged roles, scholars can be very effective at producing development portraits of specific construction experiences that enable technical and public scrutiny. Understanding the effectiveness of determinate building processes vis-à-vis their end products may assist public agencies, institutional bodies and industry actors in taking full advantage of the intellectual capital generated by specific projects, setting better conditions for the progress of technical knowledge, the introduction of innovation, the economic growth of the industry and, ultimately, the construction of a better built environment.

Keywords: case study organization, empirical analysis, socio-technical framework, public works, knowledge management.
1. Introduction: building scholars as doubting Thomases

To what extent can building artefacts reveal the effectiveness of their development process? If, as Groak and Krimgold (1989) suggest, project-based experiences represent a critical and significant way in which the construction industry brings together its output and tests its procedures, then buildings stand as the physical outcomes of the processes involved, and should be used to verify the validity of the decisions made within them. The ability to establish a connection between as-built products and underlying processes by looking at the evidence ‘concretely’ embodied in the former could help building scholars articulate a position about the works carried out without relying on specific technical documentation that may not be (or be made) available. This paper uses the Palau des Arts Reina Sofia, a major public performance arts complex completed in Valencia (Spain) in 2006, as an opportunity to explore the viability of this position.

In doing so, a ‘Doubting Thomas approach’ is indirectly proposed in relation to building research and information. The expression derives from the Biblical story of Thomas the Apostle, who refused to believe in the resurrection of Jesus without direct or physical evidence of the event. The type of skepticism suggested here is of course less profound and more prosaic than that of the parable in the Gospel but possibly very useful from an academic perspective because, notwithstanding buildings’ physical positions in the public domain, information about their design and construction processes tends to be relatively limited even to the community ostensibly in charge of their analysis.

Indeed, buildings embody many layers of retrievable information, which could each trigger questions and stimulate considerations about their procurement. One layer concerns the building’s interaction with the social, economic and environmental context in which it was produced. Another layer is defined by the connection between the design choices and technologies at the base of its development and the industrial involvement these generated. A third layer involves the public administrative structure of the project in relation to the work apparently required, whereas a fourth layer could coincide with the comparison between stated objectives and objective results. The following pages will show how these layers can find abode in the form and space of the building, its construction details, materials and performance, its use, and its maintenance.

Built form and space connect the appropriateness of design choices to the building’s scope and objectives, which finds ‘Doubting Thomas’ support in the actual use of the building. Occupants’ informed response, in fact, constitutes an ultimate test in building appropriateness, systems’ selection, design efficiency and fitness for purpose. Construction details tell stories about the rights, obligations and liabilities of the parties involved in the building’s realization by providing background material about the contractual system in use, the procurement path selected, and the relations within industry as evident at face value. In fact, the empirical quality of constructed details is likely to inform considerations surrounding not only the project’s detailed engineering but also the appropriateness of the technologies selected, the breakdown patterns of the work, the allocation of responsibilities in procuring and monitoring construction, the ordering of it. Level and the type of post-construction maintenance bring all this together, because the work a building requires after hand-over can reflect four things: the level of pre-construction thinking that went into its life-cycle needs, the circumstances of its construction, the quality of the operations, or the changes in use.
2. The art of building in a building for arts

2.1 The Palau des Arts Reina Sofia in Valencia

The Palau des Arts Reina Sofia is a public building commissioned by the local government of Valencia (Generalitat Valencia and Ayuntamiento de Valencia) to the architect Santiago Calatrava in 1997 to complete the City of Arts and Sciences (Ciudad de las Artes y de la Ciencia), a major urban project relying on the conversion of the Turia river’s old bed outside the old city into a public park and cultural centre. The management of the buildings comprising the ‘City’ is entrusted to C.A.C.s.a., a public authority instituted by the regional government but organised as an autonomous body.

The Palau des Arts is the most significant Opera theatre in Spain by size. The building, with a total height of 75 meters, hosts four halls conceived to host different kinds of performances, and covers a surface area of 40,000 square meters articulated on 14 different levels. When compared to the general output of the local building and construction industry, the building presents unconventional design features and structural complexity, which define many of its technological challenges. The volume is defined by two main double curved surfaces and by a cantilevered structure on the roof. The main body has a reinforced concrete structure while the envelope is in steel. Two lateral opening in the surfaces of the curved walls show the aggregation of the internal volumes. The main concrete body hosts the stage tower and has a supporting function for the steel envelope that lean on it through a rib structure system. Beneath the main envelope, the position of the stage tower of the main hall leads the hierarchical aggregation of the other halls and of the secondary and ancillary spaces.

![View of the Palau des Arts Reina Sofia, Figure 2: Lateral section](image)

The complexity of overall form and individual building volumes influences the layout of most internal spaces. Plans and sections of the four halls, for example, are arranged within the tridimensional shapes derived from the architect’s original idea. The result is that only the main Opera hall follows a consolidated arena theatre typology; the other three halls do not refer to any traditional layout, rather adapting to the space available beneath the volumes.

The building finishes utilized to cover such volumes are peculiar. The external envelope shows vast surfaces treated with white concrete, glass and *trençadís*, a traditional Spanish tiling system that uses irregular cuts of ceramic tiles, but normally for interiors. Its extensive application on the curved
surfaces of the roof suggests a new use of the system and its related techniques. Also the glass is employed innovatively, as flooring system of the outdoor bridge from which one enters the theatre, and in the form of long vertical panels used to enclose the foyer. Inside, the main finishing materials are beech timber panels and trencadís. Both materials are applied in the concert halls, while corridors and public areas are treated with white concrete.

Changes in government and variations in scope and program characterized the construction process, which was managed by UTE Palacio, the temporary joint venture of two of the largest infrastructure and construction companies in Spain: Dragados s.a. and Necso s.a. Originally, the joint venture had been formed to construct a tower on the same site; yet due to a shift in political fortunes the development of the tower stopped, to be (literally) replaced by the Palau project. UTE Palacio, which by 1997 had already built the foundations for the tower, continued to erect a building on it, only with a different program, under the technical and artistic supervision of the same architects appointed for the tower, Santiago Calatrava Valls. In 2006, the construction cost of the project close to completion reflected a four-fold increase from the initial estimates.

2.2 In building truth

On the basis of the information provided above (and publicly available), it is interesting to visit the building or review its official press, to examine the way in which its construction tried to respond to the challenges built into its ‘formal’ design.

Indeed, the relationship between form and functional spaces has been difficult from the very beginning. Inadequate acoustic performance for two of the halls, for example, became apparent during the opening concert, in 2006, and required immediate substantial remedial works to correct their sub-optimal ‘inverted’ layout. Similar issues also exist in the aggregation and the interdependence of other spaces within the building volume - main spaces, service areas and circulation – which seem to suffer from a lack of functionality. The number of toilets serving the main hall, for instance, was found to be limited in relation to their number and location. In 2007, the hall located on the eight level of the building was substantially modified to provide more toilet facilities since, at the time of the opening, patrons had to walk around half the perimeter of the building, along outdoor terraces, to reach the closest blocks. The works also included the creation of a cloakroom and a more sheltered entrance. The only access to this hall was in fact through open terraces that did not offer any protected intermediate or waiting area for the audience.

Figure 3 and 4: View of the concert hall before and after the opening concert, Figure 5: Construction of the new toilets, Figure 6: Construction of shelter entrance and cloakroom for the hall in the eight level.
The relationship between building form and the resolution of technical aspects provides equally puzzling elements. The ceiling in the main hall, for example, consists of glass elements that contain fixed fluorescent lights running perpendicular to the stage. Each element is four-metre long and creates issues in relation to lighting maintenance, since it requires the removal of each panel. Moreover, ceiling design does not facilitate the functional installation of stage-related lighting because of its orientation and the lack of supporting structure. In the smaller concert hall, fixed fluorescent lighting system had to be fully replaced by a LED system in 2006 to obtain more appropriate lighting levels.

Acoustic quality issues have also appeared throughout the building, and not only in relation to layouts. In the stage area of the large concert hall, vertical wooden panelling had to be removed and replaced with boards laid at a different orientation in order to provide adequate levels of sound absorption. In the main hall, the use of *trencadis* as finish material produced unacceptable degrees of acoustic distortion, with the result that a special coating had to be applied to all the surfaces covered with it. In 2007, a year after the opening, a new acoustic ceiling and proscenium not defined in the original project were added to the stage, while 16% of the seats had to be moved because of visibility problems. The new seats are now located on a raised platform that improves view of the stage but also raises accessibility issues because of the steps required to reach them.

The coordination of building form and construction planning can be somewhat gauged by the way in which different components have been selected and put together, junctions between different materials are dealt with, and services and internal finishes relate to each other.

In the foyer, the details of the façade invert conventional construction thinking. Glass panes, metal frame and concrete structure on the external facade are visually connected by applied plaster elements disguised as concrete. Inside the space, glass panels don’t follow the modular distribution in the frame as defined by their structural mullions.

A lack of expansion joints between different materials may cause maintenance issues such as the deterioration of materials or structural cracks. Discolouration and cracking of white concrete is occurring around the perimeter of the building, where the material is adjacent to steel components. Coastal air salinity also facilitates its deterioration, as well as that of *trencadis*-covered surfaces, which were not subject to protective treatments. The broken or damaged ordinary float glass used as flooring surface on the bridge and in the foyer raises additional questions on the appropriateness of selected materials and on material detailing.

In general, an apparent lack of concern for the integration of trades transpires from the relationship between finishes and services. In one of the halls, for example, the bio box pierces the large back wall, interrupting the main pattern of the wall’s mosaic finish. Similarly, the power points located throughout the building show little consideration for the finishes they interrupt.

Issues with users’ requirements emerge not only in relation to patrons. The orchestra pit of the Opera hall is located on the axis between the two main entrances, and therefore in line with the only possible wind direction. Since the entrances do not have wind locks they allow breezes in, particularly during
intervals, when the doors are open. Consequent changes in temperature can be wide enough to effect the tuning of the musical instruments. Backstage changing room and rehearsal spaces are similarly affected, and, since long straight corridors separate them from the stage, singers’ voices also become susceptible and exposed to temperature variations. Service corridors in the Palau, however, also serve as workshops because of problems in the use of certain stage areas. The storage rooms and the set workshops are not adequate for their programmed function, neither are the number or for the dimension of their doors. In some cases in fact the workshop space would be adequate to build sets but the dimension of the doors would not allow bringing them out.

Figure 7: Seat relocation in the main hall, Figure 8: Connection by plaster element, Figure 9: White concrete degradation

At building level, the need for extra-ordinary maintenance has been massive. Since the opening of the theatre, in 2006, roof windows have had to be replaced or fixed nearly twenty times due to water infiltration problems. The trees located in the external terraces also need to be periodically replaced because of the dimensions of their planter boxes, too small to accommodate the growth of the roots. Moreover, in the absence of dedicated gantries, catwalks or access points, teams of professional climbers with specialised equipment must be contracted for daily, cleaning and light replacing building maintenance. Finally, in October 2007 the Palau des Arts was damaged by major flooding after three days of rain. The flood affected all basement areas, including offices, workshops, stage machinery and storerooms; it forced the closure of the complex, and required major reconstruction work. Multiple causes seem to have contributed to this incident: the location of the building in a sub-optimal site, its inability to cope with difficult but predictable weather conditions, and the difficulty of its fabric to manage unforeseen events or emergency circumstances.

Figure 10: Planting box maintenance, Figure 11: Roof window replacement, Figure 11: Daily maintenance
2.3 The communicative power of building

Many of the concerns raised by a visit to the actual building and reflection on how it operates are surely triggered by decisions taken within the architectural realm of the development process. Here one could comment on the level of open debate that exists on the viability (or straight-out appropriateness) of particular ideas. None of the official architectural literature on the Palau des Arts considers any of the issues described above. The Valencian performance arts complex is known to the public (and to the expert public) metaphorically from afar or in the abstract, and mostly through its forms rather than its technologies and functioning life. Most of the publications that refer to the Palau des Arts (Jodido 2007, Tzonis 2004) only analyse its formal importance rather than trying to understand the way in which the building answers specific technical challenges.

At a project and building procurement level, the investigation of the results needs to consider the responsibilities of the technical parties and the socio-technical definition of their interaction because, in a complex project such as the Palau, the guarantees for its correct development are provided through the scrutiny reciprocally exercised by all the agencies engaged. If this does not happen, as it seems to have been the case here, then the problem is not only with the architecture but also with the structure of work-plan in place.

The structure of the Palau des Arts’ project administration was organized according to a traditional scheme in which architect, client and main contractor manage all of the building development process. This organization appears to be limited in dealing with the realization of a building characterized by innovative features. Difficulties in managing the coordination between different phases of the project and the construction led to a final product that faces problems in its fitness for purpose (for example in the design plan of the halls, inadequate services and ancillary spacers), in the design and definition of its engineering of components (acoustic and lighting issues) and in the coordination between form and technologies (materials and joints). These issues bring into questions responsibilities for the quality of the product in the different project stages. The artistic direction of the architect may cover only part of the issues encountered in the construction of the building, which was primarily managed by the main contractor. First question that can be put foreword is therefore related to the appropriateness of the project administration structure put in place, and understand why a non-traditional building has been built while relying on a traditional scheme of building procurement? Were any alternatives methods available that may have led to more effective outcomes?

Moreover, it would be interesting to understand to what extent the contractual methods utilized influenced the relations between the parties involved and the responsibilities allocation. This aspect may influence the ability of the industry in answering the building’s specific technological requirements in terms of time, quality and performance.

The construction management of the Palau des Arts on face value appears to have made project timeline the most important imperative at the expense of construction, quality and project budget. Observations of the building suggest that fast-track and on-site solutions to construction challenges have been taken ad hoc in their implementation rather than following a determined project or program.
process. If this is the case, considering the scale of the project and technical complexity of the building, it would be interesting to understand if setting up a project control structure may have helped the construction process pursue more adequate and qualitatively advanced technological solutions rather than relying on the contractors and consultants’ ability of determining on site solutions.

Analysing the building maintenance issues encountered (for example the repeated replacement of the roof windows due to waterproofing problems), raises questions in relation to testing procedures and the level and degree of industrial and building standards. What were the forms of testing procedures applied to the components? Were any of the industrial and building standards applied to achieve minimum requirements for the building construction? What was the extent and degree of consideration and application? Were these standards adequate for the building formal and technical complexity? Can such building be used as testing ground to advance regulatory regimes or make them responsive to changing industrial conditions? These questions lead one also to considerations of the long-term and cost-benefit balance of the construction choices, such as the use and treatment of materials or the form and quality of the construction details. Issues related to maintenance can be traced back to the program in terms of how the building performs over time, as well as to a deficiency in the architectural and engineering services in considering the technical behaviour of the building during its lifetime. Therefore, it would be interesting to understand what value was assigned in the early stage of the project to detail definition, engineering of components, and materials treatment, in order to understand the rationale and output generated in the construction process.

This discussion serves to highlight that, if a strong linkage between design and construction exists at every level of the building development process, this linkage can be examined and interrogated by identifying and using clues coming directly from the artefact produced or assembled on site. Doing so increases not only our knowledge of the products of the industry but also our capacity to tailor research questions, so as to investigate production and professional experiences that are, by definition, idiosyncratic.

3. The tell-the-tale detail

In 1984, the Italian academic Marco Frascari wrote a famous article in VIA, the journal of the University of Pennsylvania, titled “The tell-the-tale detail”, in which he celebrated the communicative power of building details for architects. By the same token, we could say that building details are equally important for those interested in the organizational processes underlying construction activity, particularly from a scholarly perspective. By looking at details it is possible to tease out considerations about the development process that may help understand the impact of choices taken during the process on the final product to the benefit of the many actors involved.

Looking at details and the building as an artefact can trigger a connection with the design process and may provide information (or raise questions) that would not be available otherwise. Despite the importance of assigning a value to a built artefact and its performance, the information about technical outcomes of buildings is rare. Of the many reasons why this happens, we could suggest that the private nature of building projects downplays the importance of formally recording their experience
for future use, and makes the external appropriation of their lessons difficult. Moreover it seems to be
difficult to determine which actors are better positioned in the process to register or analyse the
building outcomes. Yet the information embedded in a building experience can be significant to the
industry or to scholars.

The ability to read information embedded in a building and formulate links with its realization process
can be significant for a building researcher to overcome difficulties in finding technical information or
documents or in defining unbiased framework about the building process. By looking at the outcomes
of a building it is possible to define a framework of information that can help understand the features
of a built artefact, providing guidance toward the formulation of specific questions and analysis that
can support building research.

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Implementation of Total Quality Management (TQM) in the Libyan Construction Industry (LCI)

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Abstract:

Purpose: The purpose of this paper is to present the main factors influencing the success of total quality management (TQM) implementation in the Libyan construction industries (LCI). And identify most important factors based on a survey of Libyan construction companies. Methodology approach: In order to achieve this objective literature review has been carried out to identify the main factors influencing the implementation of TQM in the Libyan construction industries. This was followed by a survey in the form of a number of questionnaire and interviews. Survey and analysis: A total of 130 fully completed questionnaires were returned giving a response of 65 percent. Among of these participating organizations about 36% to the private sector whereas 63% were government organization. The survey is analysed using IBM’s SPSS software package (originally, Statistical Package for the Social Sciences). Based on principal component analysis (PCA) the results reveal the internal structure of the data in a way which best explains the variance in the data.

Keywords: TQM, Libyan construction industry, factor analysis, PCA
1. Introduction

Well-implemented Quality Management System (QMS) can be one of the most important forces leading to organizational growth and success in national and international construction markets. In the competitive business climate it is critical for construction companies to provide consistently high-quality products and added-value to their clients and customers.

The research investigates main factors influencing successful total quality management (TQM) implementation in the Libyan construction industries (LCI). The construction industry in Libya, like anywhere else, is affected by the country’s economic cycle. However, discovery of oil was a turning point in Libya for industries such as construction etc. It brought great development to the construction industry in general as the government was able to spend substantially on construction. On other word the construction industry in Libya suffers from a shortage of skilled labour and poor quality and low productivity however. Libya, as a developing country, has been through a number of problems concerning quality, however, it has recently started liberalising its economy and opening it to competition, both at the national level and the global level. (Sandholm, 1999). A total of 200 fully completed questionnaires were returned giving a response of 65% among of these participating organisations 36.2% were from private sector whereas 63.8% were government organisation. The objectives of the present study to is to present the main factors influencing successful total quality management (TQM) implementation in the Libyan construction industries (LCI).

2. Research methods

The objective of the research was to assess TQM implementation initiative in a number of contracting organisations to explain and identifying the main factors influencing the TQM implementation, on the other hand As Arabic is the main language spoken in Libya, not many people can speak English especially in the construction industry, it is necessary to provide the questionnaire in Arabic. However, some English terms are commonly used in the construction industry in Libya, and there are only a small number of non-Arabic speakers working in this sector. To speed up the response, the questionnaires will be distributed and collected personally by hand during the interviews. This method is effective because there is direct communication between the researcher and the respondent. On the Other hand the City of Tripoli was employed as the location where the research was conducted, Data were obtained through questionnaires supported by a set of interviews, this was achieved by visiting firms and projects under construction in Tripoli then the data gathered was analysed by using Statistical Package Social Science (SPSS package) 16.0 windows.
3. Questionnaire & interviews

As the first step of delivering the questionnaires, a formal letter was sent to all organisations providing a general idea about the survey in addition the research encourage the participants to complete the questionnaires on time.

However 200 hard copies of the survey questionnaires were distributed to the construction companies in Tripoli (Libya). Each copy of the questionnaires was accompanied with another letter from the researcher providing explanation about the idea outcomes beyond conducting this survey. A total of 130 fully completed questionnaires were returned giving a response of 65% among these participating organisations 36.2% were from private sector whereas 63.8% were government organisation. So the research made number of interviews conducted at the preliminary literature review stage to support the preliminary review where the interviews helps in identifying the major problems in the (LCI) such as lack of top management commitment, culture and employees barriers, and managerial barriers. The preliminary stage of this research focused on the observation and analysis of the construction industry in Libya at this stage of identifying the problems this approach also used to collect data of TQM in Libyan construction industry.

4. The chart of TQM questionnaire

The design of the questionnaires and the selection of the statement resulted from two sources where the first source was conducting a comprehensive study of total quality management and its principles and the second source was the field study and interviews.

The figure represents the flow chart of the TQM questionnaire, showing the demographic questions and the TQM questions regarding to the key elements implementing of TQM such as management commitment and leadership (MCL), communication (COM), training and education (TRA), teamwork (TEA), employees empowerment (EMP), culture (CUL).
Figure 1: Chart of TQM questionnaire
5. Demography questions

To identify the demographic data of the key factors in the Libyan construction industry (LCI) respondents were asked questions related to their gender, age, education, qualification, years of experiences, size of company and number of employees and so on. Therefore, participants were asked to indicate their gender by placing a tick to the relevant options provides (male or female). All 130 participants responded. Of the 130 respondents 106 (81.5%) were male and 24 (18.5%) were female. This is indicates majority of respondents who working in the construction industries were male. Frothy three percent of the overall respondents had first degrees, thirty percent of the total respondents had a master, and 13 percent had a secondary school. Ten of the respondents had a PhD. This demonstrates that the respondents were educated workforce having sufficient technical knowledge.

The respondents were asked to indicate the length of time they had been working in the construction industry and their current firms or organisations they work at. The purpose of these questions was to identify the respondents experience and the stability in their work background. 16 percent of the sample had been working in construction Industry for 6-10 years and 26 percent had been working in the construction for 11-15 years in and about 23 percent worked in the construction industry between 16-21 years, and only 6 % less than 5 years. also 27 percent more than 21 years. These results indicate that most respondents were experienced in the construction activities and operations.

6. Factor analysis (FA)

According to (Kirlinger, 1996) factor analysis is “powerful and indispensable method of construct validation” Factor analysis can be defined as a group of statistical techniques whose common objective is to represent a set of variable in term of a smaller number of hypothetical variables or factors.

Chatfield and Collin, (1992) define the factor analysis (FA) is a data reduction techniques that uses the correlation between data variables. The underlying assumption of factor analysis is that a number of factors exist to be explaining the correlation or inter relationships between observed variables. Firstly the FA performed on all the variables (53) variables using principle component extraction (Tabachnick and Fidell, 1999), the main objective for this technique to extract the maximum variance from the data set within each factors. However, each statement on the questionnaires was coded as VAR1, VAR2, and VAR3 and so on.

7. Results of factor analysis

The result of the output obtained in this could be presented a followed:

The 53 items in the survey were made on a four point likert scale where 1 implied strongly disagree and 4 indicated the respondent strongly agree with the statements. The 53 item of the questionnaires were inter
correlated and subjected to an exploratory factor analysis (EFA) based on the principle component analysis (PCA) with Promax rotation was conducted using SPSS package version 16.0 to detect the factor structure in the variable.

Inspection of the correlation matrix reveals the presence coefficient of 0.3 and above the Kaiser Meyer Oklin (KMO).

The BARTLETT’S TEST OF SPHERICITY (APPROX.CHISQUARE) as shown in the Tables 7.19 reached statistical significance, supporting the factorability of the correlation matrix.

Table 7.16: show KMO and Bartlett's Test

<table>
<thead>
<tr>
<th>KMO and Bartlett's Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaiser-Meyer-Olkin Measure of Sampling Adequa</td>
</tr>
<tr>
<td>Bartlett's Test of Sphericity</td>
</tr>
<tr>
<td>Approx. Chi-Square</td>
</tr>
<tr>
<td>df</td>
</tr>
<tr>
<td>Sig.</td>
</tr>
</tbody>
</table>

(Kaiser, 1974) “recommended accepting value greater than 0.5 as barely acceptable, value between 0.5 and 0.7 are mediocre, value between 0.7 and 0.8 are good, value between 0.8 and 0.9 are great and value above 0.9 are superb. (Field, 2005). This indicates the value in our case 0.728 that indicate good.

According to (Norusis, 1994) the value of Kaiser-Meyer-Olkin (KMO) below 0.5 that indicated this value unacceptable and the high KMO measures allows more meaningful analysis to be obtained, this can be confirmed by Bartlett's Test of Sphericity which tested and Chi-Square test was significant this indicating that principle component analysis PCA can be meaningful applied.

(Torbico, 1997) PCA used to produce a structure matrix of variables after rotation where the number of component determined was based on the criterion that the Eigen value for each component must be more that one this method can be referred also as Kaise’s criterion however this derived five principle component which explain 83 percent of variation in the variable Table shows
Table 7.17: Eigen value, percentage and total variance explained

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigen values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>1</td>
<td>34.940</td>
</tr>
<tr>
<td>2</td>
<td>3.058</td>
</tr>
<tr>
<td>3</td>
<td>2.817</td>
</tr>
<tr>
<td>4</td>
<td>1.758</td>
</tr>
<tr>
<td>5</td>
<td>1.532</td>
</tr>
<tr>
<td>6</td>
<td>.965</td>
</tr>
<tr>
<td>7</td>
<td>.893</td>
</tr>
<tr>
<td>8</td>
<td>.849</td>
</tr>
<tr>
<td>9</td>
<td>.780</td>
</tr>
<tr>
<td>10</td>
<td>.760</td>
</tr>
<tr>
<td>11</td>
<td>.594</td>
</tr>
<tr>
<td>12</td>
<td>.540</td>
</tr>
<tr>
<td>13</td>
<td>.442</td>
</tr>
<tr>
<td>14</td>
<td>.347</td>
</tr>
</tbody>
</table>
8. Factor Extraction

Factor analysis with principal component extraction, using a promax rotation, was performed on the fifty-three management practice items to determine the number of factors. Besides using the scree plot as a guide to decide on the number of factors to be extracted, the KMO method (Eigen value greater than 1) was used, explaining 66%, 5.7%, 5.3%, 3.3%, and 2.8% of the variance respectively. Five factors were extracted which are bolded in Table 7.20.

Table 7.20: Eigen values and % of total variance explained of TQM elements:

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigen values</th>
<th>Extraction Sums of Squared Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
</tr>
<tr>
<td>1</td>
<td>34.940</td>
<td>65.924</td>
</tr>
<tr>
<td>2</td>
<td>3.058</td>
<td>5.770</td>
</tr>
<tr>
<td>3</td>
<td>2.817</td>
<td>5.315</td>
</tr>
<tr>
<td>4</td>
<td>1.758</td>
<td>3.316</td>
</tr>
<tr>
<td>5</td>
<td>1.532</td>
<td>2.890</td>
</tr>
<tr>
<td>6</td>
<td>.965</td>
<td>1.821</td>
</tr>
</tbody>
</table>

Note: components 18-53 are not shown.
Extraction Method: Principal Component Analysis.

Note components from 15 - 53 are not shown.

We can see that the first few factor explain relatively large amount of variance (especially factor 1 where the factor 1 equal 34.940%. SPSS extract all factors with Eigen value greater than 1 and the percentage of variance explained in the column which labelled Extraction sums of squared loading.

Table 7.22 shows the Correlation between component are medium high Interco relation between component, this indicate that variable in one component are also highly correlated with variables in other component

Table 7.22 shows components correlation matrix

<table>
<thead>
<tr>
<th>Component Correlation Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>
Extraction Method: Principal Component Analysis.

Rotation Method: Promax with Kaiser Normalization.

The final part of the output is correlation matrix between the factors (SPSS output 7.22). This matrix contains the correlation coefficient between factors. As predicted from the structure matrix, factor 2 has high relation with any other factors (correlation coefficient are high)

9. Conclusion

- From the interviews the researcher found that there was a clear lack of implementation of the critical success factors CSFs of TQM demonstrated through features such as, lack of knowledge of QM and lack of management commitment

- In my view the Libyan organisation are still in the early stage where most of the, Libyan companies was introduced ISO9000 only just prestige because some of local companies have been certified ISO9000.

- There are weakness in communication and information system in the LCI, the present system in the LCI are based on paper and verbal formats this result low quality and low flow of information

- Libya is not yet ready to accept and adopt TQM because the lack of infrastructure, top management are not keen to be involved in adopting TQM due to lack of education, skills, By this reasons the implementing of the quality management in Libyan construction industry difficult and take long time to understanding the exactly meaning of quality management system and how to implementing.

- Unfortunately some managers working in companies mentioned the policy of the company and government does not allowed the willing to get employees involve delegate them some authority, in this case the employees could not take a decision until back to the management (leadership, supervisors).
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Australian Construction Industry KPIs

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Abstract

The Australian Construction Industry Forum (which is a peak industry association) and the Australian Procurement and Construction Council (which is a peak government organisation) have jointly agreed on a set of KPIs for the Australian Construction Industry. The goal of such a process is to work collaboratively in order to lift industry performance overall, and thereby bring about economic and social benefits to the industry and broader community. This paper seeks to underpin the process of KPI measurement by providing: an overview of international approaches to KPI measurement, summary of difficulties identified in performance measurement together with possible responses to these problems, and finally a discussion on the various methods for reporting KPIs. A number of findings throughout the paper, based on the review, made in order to advance the goal of performance measurement in the construction industry in Australia. Such findings would be relevant to other countries considering a KPI measurement process as well.

Acknowledgement: Funding for this project by the CRC for Construction Innovation is gratefully acknowledged.

Keywords: construction industry, KPIs, performance management system
1. Introduction

1.1 Background

The Australian Construction Industry Forum [ACIF] (the peak industry body for the construction industry in Australia) and Australian Procurement and Construction Council [APCC] (the peak government body for construction in Australia) have jointly prepared a set of national goals for the construction industry in Australia. It is envisaged that a National Performance Framework will be established based on this set of Key Performance Indicators [KPIs] and metrics for the building and construction industry.

The purpose of this paper is to provide a review of international approaches to measuring KPIs in the construction industry, together with some of the advantages and limitations of these approaches, and discuss the main ways in which KPIs can be reported. Lessons can be learned from these summaries for the implementation of a national KPI measurement and reporting system in Australia (as well as in other countries).

It is not within the scope of this paper to report on any KPI measurement undertaken to date. This is envisaged as forming the basis of a subsequent paper.

A key reason for undertaking KPI and other forms of performance measurement is so that management can assess progress towards goals and take appropriate action should performance fall below anticipated targets (Fernie et al. 2006). Such a process ensures that KPIs move from being merely an external marketing exercise, to an internal quality improvement exercise – a performance management system (Beatham et al. 2004). In order to be effective, a number of authors have advanced key aspects of any performance management system for the construction industry. Particularly. The following list of such aspect is compiled from the work of Anderson (1996) and El-Mashaleh et al. (2007) and the United States Airforce (1991). These authors argue, to be effective, the measures and reporting mechanisms for performance management systems should be:

1. Acceptable (Anderson 1996; United States Air Force 1991);
2. meaningful to industry (El-Mashaleh, Minchin and O’Brien 2007; United States Air Force 1991)
3. easily understood (Anderson 1996) (i.e. are simple, understandable and logical (El-Mashaleh, Minchin and O’Brien 2007)
4. repeatable, (El-Mashaleh, Minchin and O’Brien 2007, United States Air Force 1991);
5. show a trend over time (United States Air Force 1991);
6. suitable – they measure important things (Anderson 1996);
7. feasible – they are easy (Anderson 1996) and economical to collect (United States Air Force 1991);
8. effective – they concentrate on encouraging the right behaviour (Anderson 1996) and are unambiguously defined (El-Mashaleh, Minchin and O’Brien 2007; United States Air Force 1991);
9. aligned – must link to national goals for the industry (Anderson 1996);
(11) drives appropriate action (United States Air Force 1991);

1.2 Proposed process

There are various processes for performance measurement systems which are advanced in the literature. One which would seem to follow the process envisaged by ACIF and APCC is set out below – based on (Camp (1989) and Alarcón et al. (2001). The first step has already been undertaken by ACIF and the APCC in their agreement on the initial set of KPIs, and methodology for reporting these KPIs. A future project is envisaged which will collection and report data (the second stage). The CRC for Construction Innovation, soon to enter a new life as the Sustainable Built Environment Centre, has developed a number of tools which can assist construction firms to address short falls in specific areas (the third stage in the diagram).

![Diagram of Australian Construction KPIs as a performance management system](based on Camp (1989) and Alarcón et al. (2001).

The rest of this paper is devoted to examining international approaches to KPI measurement, and possible reporting formats for such data. Please note that all data used in the preparation of this paper is fictional, and does not represent actual industry performance, and is only meant to represent what such data might look like. In order to put such processes into perspective, the next section of the paper provides an overview of construction KPI measurement in other countries.

1.3 Summary of international approaches to KPI measurement

Bakens, Vries and Courtney (2005) undertook a comprehensive survey of approaches to benchmarking and KPI measurement across a number of countries. A number of different options clearly emerged from their study are summarised below:

---

1 Data in this table is drawn from Bakens, W., Vries, O. and Courtney, R. (2005) *International Review of Benchmarking in Construction*
### Table 1: Options available in KPI measurement

<table>
<thead>
<tr>
<th>Unit of Analysis for data collection</th>
<th>Reporting levels</th>
<th>Data collection process</th>
<th>Data collection source</th>
<th>Data collection methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Project</td>
<td>Continuous</td>
<td>Internal</td>
<td>Voluntary surveys</td>
</tr>
<tr>
<td>Firm</td>
<td>Firm</td>
<td>Longitudinal</td>
<td>External</td>
<td>Compulsory surveys</td>
</tr>
<tr>
<td>Industry</td>
<td>Sector</td>
<td>Cross-sectional</td>
<td>(to company)</td>
<td>Professional assessment</td>
</tr>
<tr>
<td></td>
<td>Industry</td>
<td></td>
<td></td>
<td>National statistical data</td>
</tr>
</tbody>
</table>

The proposed Australian KPI process would include:

<table>
<thead>
<tr>
<th>Industry. Future stages may extend to the firm</th>
<th>Industry. Future stages may extend to the firm level</th>
<th>Longitudinal</th>
<th>External (possibly internal)</th>
<th>Nationally statistics, supplemented with surveys (if necessary)</th>
</tr>
</thead>
</table>

A number of issues should be noted from this international comparative approach. Firstly, the **unit of analysis**. Bakens, Vries and Courtney (2005) found that most current approaches to Construction KPIs around the world are conducted at the firm or project level. Consequently, the methodology for data collection requires the extensive use of surveys of firms. Such an approach certainly allows for fine grained analysis of data at the project or firm level, and allows for firms to compare their performance against national averages. However, it is reliant upon self reporting of data, and requires significant resources to maintain. Additionally, analysis of the performance of the industry as a whole is reliant upon aggregating up from the specific voluntary responses of individual firms, so is fraught with sampling issues. This is the source of numerous difficulties noted in Section 2.

The EUROSTAT approach is different, as it uses existing statistical data for its reporting. However, the available EUROSTAT reports do not make for easy reading apart from by economists. The other approaches— including the UK model — do provide simple reporting mechanisms.

**Finding 1:** Ideally the Australian model would obtain data from available data sources (such as the Australian Bureau of Statistics) in order to be cost effective. However, data should be reported in a format which is readily understandable by industry (charts).

As the most widely imitated, and critiqued, the Constructing Excellence approach from the UK deserves further attention. The UK system of KPI assessment initially included **10 KPIs** (Kagioglou, Cooper and Aouad 2001). 1) Client satisfaction – product; 2) Client satisfaction – service; 3) Defects; 4) Predictability – cost; 5) Predictability – time; 6) Profitability; 7) Productivity; 8) Safety; 9) Construction cost; and 10) Construction time. More recently these KPIs have been broadened to include social and environment performance as well as economic performance (an example of triple bottom line reporting). For example, the 2006 data collection involved the following set of 30 KPIs and was derived from 12 separate numerous sources(Constructing Excellence 2006).
Table 2: Current set of UK KPIs being measured and reported (Source: Constructing Excellence 2006).

<table>
<thead>
<tr>
<th>Economic KPIs</th>
<th>Social KPIs</th>
<th>Environment KPIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client satisfaction – product</td>
<td>Employee satisfaction</td>
<td>Environmental impact</td>
</tr>
<tr>
<td>Client satisfaction – service</td>
<td>Staff turnover</td>
<td>Energy use – product</td>
</tr>
<tr>
<td>Defects</td>
<td>Sickness absence</td>
<td>Energy use – process</td>
</tr>
<tr>
<td>Predictability – Cost</td>
<td>Safety</td>
<td>Water use – product</td>
</tr>
<tr>
<td>Predictability – Time</td>
<td>Working hours</td>
<td>Water use – process</td>
</tr>
<tr>
<td>Safety</td>
<td>Qualifications &amp; skills</td>
<td>Waste removed from site</td>
</tr>
<tr>
<td>Productivity</td>
<td>Equality and diversity</td>
<td>Commercial vehicle movements</td>
</tr>
<tr>
<td>Profitability</td>
<td>Training</td>
<td>Impact on biodiversity</td>
</tr>
<tr>
<td>Construction Cost</td>
<td>Pay</td>
<td>Area of habitat created / retained</td>
</tr>
<tr>
<td>Construction Time</td>
<td>Investors in people</td>
<td>Whole of life performance – product</td>
</tr>
</tbody>
</table>

Two important elements should be noted here – firstly, the number of KPIs being measured and reported has increased over time. As with any process, the involvement of multiple stakeholders can tend to increase the number of issues being measured.

Finding 2: Future extension to the Australian Construction KPI project could include additional measures to facilitate international comparisons.

Secondly, there are numerous sources of data for the various KPIs being measured (Constructing Excellence 2006). While this can increase the rigor of the results, it also increases the resources required to measure. Some of these issues have resulted in critiques of the UK approach to KPI measurement from industry, which are discussed in Section 2 below.

2. Difficulties with measuring and reporting KPIs

In order to properly provide advice on KPIs for the industry, a review of some of the drawbacks of current implementations is necessary. The purpose of this summary is not to argue against the implementation of KPI measurement in Australia, but rather to summarise perceived difficulties with other approaches, and learn from this discussion. Numerous authors have identified difficulties with KPI implementation in various countries, although critiques of the UK models are the most prevalent. Critiques include such matters as:

- Subjective assessment of some of the key measures (particularly satisfaction and some approaches to the assessment of quality) (Chan and Chan 2004)
- Some of the measures are crude and open to interpretation (Fernie, Leiringer and Thorpe 2006), or lag behind activity so far as to not be very useful (Costa et al. 2006)
- While raising the profile of benchmarking in the industry - attempts to improve industry performance have largely failed due to lack of involvement with top level coordinating agencies (Fernie, Leiringer and Thorpe 2006) or failure to engage significant numbers from industry (Costa et al. 2006)

2 To be fair the UK model has also been the most widely adopted and may yet prove to have the widest impact of all the schemes reviewed here
- Large number of KPI schemes under way at the same time leading to fragmentation, frustration in
  the industry (Kagioglou, Cooper and Aouad 2001)
- data overload\(^3\) (Robinson et al. 2005) and
- large investment (cash and in-kind) required to implement, measure and report on the data
  (Robinson et al. 2005)

It would be wise to consider how to respond to such criticisms for any implementation of a KPI based
performance management system in Australia. In order to respond to these criticisms raised in relation
to implementation of KPIs in other countries the following recommendations are made:

Table 3: Summary of Criticisms to KPI Measurement and Proposed Responses

<table>
<thead>
<tr>
<th>Criticism</th>
<th>Proposed Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective assessment</td>
<td>Rely on objective measures collected by independent organisations / sources</td>
</tr>
<tr>
<td>Crude / questionable measures</td>
<td>Use measures which are agreed to by all stakeholders, and are valid</td>
</tr>
<tr>
<td>Lack of coordinating agencies</td>
<td>Engagement of peak bodies (ACIF and APCC)</td>
</tr>
<tr>
<td>Large number of schemes (\rightarrow) fragmentation</td>
<td>Engage peak bodies (ACIF / APCC)</td>
</tr>
<tr>
<td>Data overload</td>
<td>Report results simply (perhaps with indexes of multiple KPIs)</td>
</tr>
<tr>
<td>Large (cash and in-kind) investment required</td>
<td>Where possible, use data which is already collected to reduce costs</td>
</tr>
</tbody>
</table>

It should be noted that these solutions involve some trade-offs. While cheaper to implement and
resulting on less demands on industry, using available statistical data collected external to firms
means that the reporting occurs at an industry level\(^4\). Consequently, this high level of ‘granularity’
means that it will be difficult to single out individual entities which may be contributing significantly
to poor performance against a particular metric. Largely this is due to the Privacy Act, which
prevents individual entities from being identified in government statistics. In specific cases through
(such as OH&S) jurisdictions would take logically take action against specific firms which
contributed to the death or injury of workers, so this may not prove to be as significant an issue in the
reporting of KPIs. In other words, using and reporting data collected at the industry level:

- is efficient – the majority of data is already collected and is publicly available;
- can be sustained over the long haul, as significant high level funding is not required for this
  specific activity
- is less suspect to respondent error, and controls are in place to ensure quality of data
  collection in the various agencies;
- lends itself readily to time series analysis – which are critical to establishing trend data;

\(^3\) An example of this is a report to a minister which proposed KPI measurement and reporting at multiple levels (headline,
operational and diagnostic), across all levels in the supply chain, and at multiple points in the project life cycle.
\(^4\) Externally collected statistics have long been advocated in the benchmarking literature (Fernie, Leiringer and Thorpe
2006), so should not be seen as ‘second best’ to surveys. However, the majority of construction specific KPI
implementations around the world have relied upon internal assessment reporting by companies
enables the performance of the construction industry to be compared to the performance of other industries, which is a goal in the current KPI framework.

Finding 3: Where possible data from existing national data sets should be used

3. Methods of reporting KPIs

A number of possibilities exist for the reporting of KPI data. The main options (line charts, Venn diagrams, bar charts, tables and graphic representations, are reviewed below. 5

3.1 Line charts

Depending on the data being represented, a number of possible formats exist. For numerical data, the KPI target can be represented as a straight line with the actual data shown against the goal. Such charts can be shown for individual KPIs and a graph is needed for each KPI.

This type of reporting mechanism is used for individual measures reporting in the UK by Constructing Excellence (Constructing Excellence 2006), although the data is represented in order for individual companies to benchmark their performance against other organisations. In order to represent the entire set of KPIs, a wall chart of A3 size is needed in order to display the multiple graphs (Packham and Print 2007)

Figure 2: Actual performance versus KPI (individual KPI)

The Scottish Construction Forum provides a useful example of this, which is similar to that of Construction Excellence in the UK. The advantages of this approach are that the trend over time can be seen – although the amount of data shown may be overwhelming if large numbers of KPIs are reported

3.2 Venn diagrams

For a summary graph which reports the performance of a company against all of the KPIs a Venn diagram is often useful. Many existing KPI researchers use Venn diagrams such as that used by the Centre for Construction Innovation (CII 2006). A similar approach is used in the Scottish Construction Forum, which reports overall performance against multiple criteria.

5 Data in all of the graphs in this report is based on fictional data and is for representation purposes only. No actual or future industry performance against of KPIs is implied or intended.
This approach has the advantages of providing a summary of the performance against multiple KPIs at once, so that the strengths and weaknesses of a company become readily apparent.

The advantage with this approach is that all of the performance against individual KPIs is reported in a single diagram. The down side with this approach is that the historical trend data is not shown, just a snapshot over time.

### 3.3 Data tables with colour coding

The USA based Construction Industry Institute also conducts KPI reporting, although at the project and organisational level (CII 2006). Below is an example of the types of graphs they use to report against various KPIs. The colour coding indicates areas which are performing well (white and light grey), or poorly (dark grey and black). (CII actually use various colours for their charts). With this type of diagram, multiple KPIs are reported, but the trend data is not shown.

<table>
<thead>
<tr>
<th>KPIs</th>
<th>Target</th>
<th>Actual</th>
<th>Difference between target and actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>KPI 1</td>
<td>1600</td>
<td>1400</td>
<td>0.875</td>
</tr>
<tr>
<td>KPI 2</td>
<td>1400</td>
<td>1300</td>
<td>0.928571</td>
</tr>
<tr>
<td>KPI 3</td>
<td>1600</td>
<td>400</td>
<td>0.25</td>
</tr>
<tr>
<td>KPI 4</td>
<td>1400</td>
<td>1350</td>
<td>0.964286</td>
</tr>
<tr>
<td>KPI 5</td>
<td>1600</td>
<td>1200</td>
<td>0.75</td>
</tr>
<tr>
<td>KPI 6</td>
<td>1400</td>
<td>1200</td>
<td>0.857143</td>
</tr>
<tr>
<td>KPI 7</td>
<td>2000</td>
<td>1500</td>
<td>0.75</td>
</tr>
<tr>
<td>KPI 8</td>
<td>1200</td>
<td>600</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### 3.4 Bar chart with graphic symbols

Another example from the Scottish Construction Forum is the use of bar charts, with additional graphic symbols. The advantage of the bar chart is comparison with other states can be undertaken, and those targets which are being met, or are not being met can be highlighted with simple graphical elements.
3.6 Graphical symbols with trend data

The final option presented here is the methodology for reporting on Sweden’s environmental quality objectives. Under this system a set of national targets for the environment have been agreed to at a national level, and a simple reporting system indicates whether the targets will be met 😊, can be met if additional measures are put in place ☹; and the objective will be very hard to meet in the defined time frame ☹️. Trend data is also included. Sub goals and overall goals are all reported on the one page. Full details for each KPI are presented in subsequent sections of the report.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Performance for 2014</th>
<th>Trend</th>
<th>Legend:</th>
</tr>
</thead>
<tbody>
<tr>
<td>KPI 1</td>
<td>😊</td>
<td>☝</td>
<td>😊 - KPI has been met</td>
</tr>
<tr>
<td>KPI 2</td>
<td>😊</td>
<td>☝</td>
<td>😊 - KPI can be met with additional resource</td>
</tr>
<tr>
<td>KPI 3</td>
<td>☐</td>
<td>☝</td>
<td>☐ - KPI unlikely to be met even with additional resources</td>
</tr>
<tr>
<td>KPI 4</td>
<td>😊</td>
<td>☝</td>
<td>😊 - trend in KPI is positive</td>
</tr>
<tr>
<td>KPI 5</td>
<td>😊</td>
<td>☝</td>
<td>☝ - there is no trend evident</td>
</tr>
<tr>
<td>KPI 6</td>
<td>☐</td>
<td>☝</td>
<td>☐ - the trend in KPI is negative</td>
</tr>
</tbody>
</table>

Figure 6: Report card using trend and summary graphics (Based on Swedish Environmental Objectives Council 2007)

3.7 Summary of dashboard approaches

In this section we have reviewed a number of possible ways of reporting KPIs – particularly the graphical approaches. As noted in the text there are strengths and weaknesses with each approach and these are summarised below:
Table 4: Summary of Graphical Reporting Method

<table>
<thead>
<tr>
<th>Reporting style</th>
<th>Positives</th>
<th>Negatives</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line graphs</td>
<td>Able to show historical perspectives and compare KPI goals with actual performance</td>
<td>One graph per KPI, means that a large amount of space is required if multiple KPIs are being measured.</td>
<td>The line graph provides an excellent way of showing industry performance against the KPI. Can only show performance of a single KPI per chart. May be best suited for the detailed reporting of KPIs.</td>
</tr>
<tr>
<td>Venn Diagrams</td>
<td>Able to show performance of companies or industry against multiple KPIs</td>
<td>Unable to report on trend data</td>
<td>Venn diagrams show performance of multiple KPIs at the same time, although trend data is not available</td>
</tr>
<tr>
<td>Colour coded tables</td>
<td>Colour coded tables provide a higher level of detail. Multiple KPIs can be reported</td>
<td>Unable to show trends. May not be attractive to people who prefer visual representation (graphics)</td>
<td>Colour coded tables can provide significant amount of data. However, not graphical and does not show trends</td>
</tr>
<tr>
<td>Bar chart with graphic symbols</td>
<td>Bar charts provide another way of showing performance against targets. Multiple KPIs can be reported</td>
<td>Not able to show trend data.</td>
<td>While able to show multiple KPIs, trend data is not available.</td>
</tr>
<tr>
<td>Graphical symbols</td>
<td>Graphical approaches provide simple ways of reporting performance and trends</td>
<td>Some people may regard 'smiley faces' as trivialising the data.</td>
<td>Simple reporting of multiple KPIs and trend data, although alternative graphics need to be identified.</td>
</tr>
</tbody>
</table>

Ideally, dashboard reporting should be able to demonstrate both performance as well as trend data against a goal. While the line graphs can do both of these tasks easily, where a large number of KPIs to be measured and reported, then this can result in an overload of charts and diagrams, and therefore be counterproductive. As an example, the UK chart now comprises some 30 KPIs (Constructing Excellence 2006), and reporting of this number of KPIs using line diagrams requires an A3 poster, which is reflected in the criticism of data overload. With 30 charts and diagrams to review, the data load can be overwhelming. One possible way around this is for the one page dash board report envisaged, to report KPIs at an aggregate level – to create indexes around the key areas identified by ACIF – safety, productivity, economic security, skills and training, and environmental sustainability. This would reduce the number of charts on the page, while still providing a robust assessment of the performance of the industry against the KPI.

Obviously there are a number of options available for reporting KPIs. The option below is recommended, as it attempts to provide the best of each of the reporting formats identified above.

### 3.8 Recommended reporting format

The following sample does not exist but demonstrates how various elements can be combined in an attempt to provide a best of breed for the Australian context Venn diagram and line diagram with
graphical symbols. Obviously each KPI would have its own graph. A tick is used instead of a smiley face as this provides top level overview of the KPI.

Legend:  
- ✔️ On target to reach goals  
- 🔔 Needs attention to achieve goals  
- 🚨 Significant effort needed to achieve goals

4. Conclusion

This paper has set out to advance the goal of establishing an Australian Construction Industry KPI measurement process. To this end, a review of current international approaches to KPI measurement has been undertaken, together with a summary of perceived weaknesses of current approaches. Potential responses to minimise or address these perceived weaknesses have been advanced. Subsequently a review of approaches to the reporting of KPIs has been advanced. This review also resulted in a suggested format for reporting on Australian Construction KPIs at a national level.

While focussing on the implications of these findings for Australian context, other countries and industries can also derive information from this paper which would assist them as they consider implementing a KPI measurement system.

References


CII. 2006. *Key Report Summary View with Percentiles* CII


Current Performance Measurement Practices – Studies in the United Kingdom (UK) and Malaysia

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Abstract

All types of construction businesses are aware of the importance of performance measurement (PM). It is becoming increasingly difficult to ignore it, as it is an important way of improving and sustaining businesses in the long-term as well as creating and developing strategies for organisations. This paper focuses on the implementation of PM by construction sector organisations. It explores current practices of PM in construction organisations of two different countries, the UK and Malaysia. Aspects such as PM processes, tools and models used and the relationship between PM and strategy development are explored. Also, the challenges and improvements in PM are investigated. The main investigation consists of a literature review and interviews with selected organisations in these countries. Interviews involved twelve large construction organisations in order to seek their views on how organisations approach and conduct PM within their establishments. They revealed that PM is being practised in organisations either directly or indirectly to help improve business and profits. The appropriate use of tools and models to measure performance simplifies the PM process. Furthermore, aspects such as financial and non-financial, for example staff or workers’ performance, client satisfaction and social, are evaluated and measured. The interviews also revealed that PM has a direct relationship with strategy development. However, the PM practices in organisations remain a challenge. Staff or workers, especially the new ones, faced difficulty to understand the PM process, and where the appropriate data for measuring performance can be sourced. Improvement should be made in the level of awareness of this PM and in the PM process itself and there are several approaches to addressing barriers and challenges in implementing PM. The results from these interviews and the critical analysis of the literature review will enable solutions to be devised for the effective use of PM from a strategic perspective.

Keywords: construction organisations, current practices, performance measurement, strategy development.
1. Background

The aim of this paper is to investigate the current practices in performance measurement (PM) by construction organisations in two countries with a view to understanding the implementation of PM within organisations and its purpose in helping to improve organisations’ business in those countries. Many organisations have been alerted to the importance of measuring performance of their business because of their understanding that measurement can help to realise business potential for sustaining long-term competitiveness. The changing nature of work such as increasing competition, specific improvement initiatives, national and international quality awards, changing organisational roles, changing external demands and the power of information technology have driven organisations from all sectors to search for ways of monitoring and improving performance (Beatham, 2003; Robinson et al., 2005). PM is an approach to identifying the current situation of organisations and gives directions to them in making plans for future organisation movement in markets. PM is therefore on the management agenda (Neely et al., 2002). It is used in aligning with business management and is needed in developing organisations’ strategies. Yet although formulating strategies for long-term business to compete in markets is fundamental to the strategic management process, only a few construction organisations have adopted formal processes for such formulation (Price, 2003).

Success in implementing PM that can be used as an approach to improve business performance is dependent on cooperation among all staff or workers in an organisation and a management style related to a firm-specific strategy and information systems (Hoque, 2004). How to measure and what needs to be measured depends on what is the organisation aim and what it needs to achieve. It is important for organisations to measure the right elements of their organisation as this will guide it to its success in business. ‘To achieve sustainable business success in the demanding world market place, a company must use relevant performance measures’ (Neely et al., 2002). Therefore, an organisation has to be aware of all sources and data that might be used to measure its overall performance.

Economics keep changing, therefore organisations keep changing their aim and strategies for sustainability in business and seize new opportunities in order to sustain themselves and stay in the markets. Competition will never end and each organisation must take whatever opportunities to achieve success in their business.

2. Performance measurement and it use to organisations

Performance measurement (PM) is a process that identifies efficiency and effectiveness by undergoing a critical evaluation of all aspects of management such as leadership, planning, human resources, finance and workers. By the end of the process, it will help managerial staff to formulate effective strategies that help towards achieving organisations’ objectives and goals (Ahmad-Latifffi et al., 2009). Organisations measure their performance because they want to identify their level of excellence in financial and non-financial aspects such as leadership, customer satisfaction and policy compared to their competitors. The results obtained will be used to create and develop further strategies for the organisation.
PM is used for many reasons. It is used as a business tool for formulating corporate strategy (Yu et al., 2007). Acceptance of PM in the strategy development process is a way to make sure that organisations take good consideration of all aspects when developing their objectives and goals (Luu et al., 2008). An organisation has not only to consider what it intends to achieve in the future but also to accept PM as a consideration for making its goals and objectives more realistic, achievable and accepted by everyone for a brighter business future. An organisation has to accept that the strategy needing to be developed must also involve assessment and evaluation. This is to ensure that the strategy created is suitable and achievable by the organisation within a certain period. A strategy that will be created and developed must be reflected by the organisation in its current performance and align with the current economic situation.

Apart from that, the implementation of PM by organisations can attract future investment to retain and attract more customers and to remain competitive and innovative in order to increase profit and share prices (Kagioglou et al., 2001; Robinson et al., 2005). With PM, organisations can improve their business in all aspects, financial and non-financial, such as leadership, profit margins and policy goals. It is clear that PM is primarily to manage the outcome and to reduce or eliminate an overall variation in the work product or process. The goal is to arrive at actions affecting product or process.

3. Performance measurement implementation in UK and Malaysia

Performance measurement (PM) is being practised by most large organisations in the construction industry. The UK Government initiated the Latham Report in 1994 and the Egan Report in 1998, which recommended improving business performance of the construction industry. Since then, many organisations in the UK have been aware of PM needs for their businesses (Khalfan et al., 2001; Ahmad-Latiffi et al., 2009).

In Malaysia, PM is not a new thing for all industries, including construction. The concept has grown since the former prime minister, the fourth, Tun Dr Mahathir Mohammed announced the aim to declare Malaysia a developed country in the year 2020. Many organisations from various sectors of industry have since been aware of PM as they believe it can bring organisations to an international level (involved with international projects, enlarged businesses and growth in markets) just to align with the vision of 2020. Even though industries are aware of it, there is no proper standard or guidance for industry for its implementation as one of the approaches in organisation management. For that reason, many organisations do not consider measuring performance to improve businesses and mitigate risks. As globalisation is a dream of success for all types of organisations including construction, PM is implemented by those which know the benefits to be gained. From time to time, many construction organisations have implemented and are implementing PM as an additional way of improving and sustaining business in the long-term. With the introduction of the Construction Industry Master Plan (CIMP) 2006 - 2015 by the Construction Industry Development Board (CIDB) as an initiative to improve performance of the construction industry, PM will be an approach to achieve the ten year target of the industry. CIMP has been developed with the intention to rectify the weaknesses and to improve the industry’s performance as well as its image (Sundaraj, 2007).
4. Research methods

A literature review of the PM concept has included definitions of PM, criteria, tools and models as well as the importance of PM and its connection with strategy development. Besides an in-depth review of theoretical literature on PM, semi-structured interviews have provided information on current practices of PM. The interviews were with twelve large construction organisations in the UK and Malaysia, six from each, involved in building and civil works and services. The semi-structured interviews, which consisted mainly of open-ended questions based on topics needing to be covered, as suggested by Fellows and Liu (2008), gave an opportunity to explore answers more widely and expand on specific areas (Barbour, 2008).

4.1 Interviews and procedure

Interviews were a major part of data collection to gain data on current practices in the two countries. The purpose was to identify the differences in implementing PM for running businesses so as to identify the needs of both countries in using PM as an approach to management of organisations’ businesses. The interviews had four objectives:

- To identify knowledge and understanding of PM in construction organisations.
- To assess current practices and effectiveness of PM in construction organisations.
- To identify PM tools and models used in organisations.
- To identify the relationship between PM and strategy development.

Pilot interviews took place before the main interviews to examine whether or not the interview questions were well developed and suitable to obtain data for the study.

The face-to-face interviews used a set of questions developed from extant literature. Topics covered included reasons for implementing PM, measurement processes, tools and models used and relationship between strategy development and PM, challenges to implementing PM and approaches to addressing the challenges. Information obtained was then analysed, evaluated and presented using content analysis.

The semi-structured interviews involved twelve managerial staff of different organisations, all of whom have many years of experience with the industry and are responsible for the development of PM in their organisations. They all are directly concerned with arranging, managing, implementing and evaluating organisation performance. A brief summary of respondents’ backgrounds is given in Table 1.
Table 1: Respondents’ backgrounds

<table>
<thead>
<tr>
<th>No.</th>
<th>Organisation</th>
<th>Business Type</th>
<th>Role</th>
<th>Experience in PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>U1</td>
<td>Building and Civil</td>
<td>Process Improvement Manager</td>
<td>10 years</td>
</tr>
<tr>
<td>2</td>
<td>U2</td>
<td>Building and Civil</td>
<td>Head of Business Excellence</td>
<td>26 years</td>
</tr>
<tr>
<td>3</td>
<td>U3</td>
<td>Building</td>
<td>Performance Improvement Director</td>
<td>22 years</td>
</tr>
<tr>
<td>4</td>
<td>U4</td>
<td>Infrastructure Services</td>
<td>Business Improvement Director</td>
<td>2 years</td>
</tr>
<tr>
<td>5</td>
<td>U5</td>
<td>Building</td>
<td>Business Improvement Manager</td>
<td>7 years</td>
</tr>
<tr>
<td>6</td>
<td>U6</td>
<td>Building</td>
<td>Director of Strategy Development</td>
<td>25 years</td>
</tr>
<tr>
<td>Malaysia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>M1</td>
<td>Building, Civil and Infrastructure</td>
<td>Technical Director</td>
<td>More than 10 years</td>
</tr>
<tr>
<td>8</td>
<td>M2</td>
<td>Building and Civil</td>
<td>Executive Director</td>
<td>11 years</td>
</tr>
<tr>
<td>9</td>
<td>M3</td>
<td>Building, Civil and Services</td>
<td>Senior Manager</td>
<td>14 years</td>
</tr>
<tr>
<td>10</td>
<td>M4</td>
<td>Trading services</td>
<td>Chief Executive Officer (CEO)</td>
<td>12 years</td>
</tr>
<tr>
<td>11</td>
<td>M5</td>
<td>Building and Civil</td>
<td>Chief Executive Officer (CEO)</td>
<td>20 years</td>
</tr>
<tr>
<td>12</td>
<td>M6</td>
<td>Mechanical and Electrical Services</td>
<td>Managing Director</td>
<td>28 years</td>
</tr>
</tbody>
</table>

5. Results and discussion

The analysis of all the interview data is presented in this section which discusses the results in detail under the following seven headings.

5.1 Knowledge and understanding of performance measurement in organisations

Generally, all respondents shared a similar understanding that PM was to 'improve business' and 'maximise profits'. Improve business was in the sense of making improvement in the process of projects and overall business organisation. Furthermore, some respondents believe that performance measurement is an approach to maximise opportunity for organisations and mitigate risk. All respondents agreed that PM has benefits rather than negative impacts for an organisation. The benefits gained from PM as identified by the respondents are as follows:

- Identifying potential areas to be improved by organisations.
• Improving productivity in work.

• Assisting in managing projects, knowing what can help to deliver projects (what gets measured, gets done).

• Managing resources.

• Enhancing organisation reputation and market position.

• Improving employers’ efficiency in delivering their tasks.

• High passion of staff in commitment to their organisations.

It was stated that,

‘It allows us to manage our resources…it allows you to make quality decision-based’.

Apart from that, PM helps them in the process of creating and developing strategies for their organisations.

It was stated that,

‘It does not really matter how you measure it. It is about knowing where you are and where you want to be and put them in the action plan’.

This quotation illustrates that PM can assist in identifying organisation needs for strategy development.

From the interviews, Malaysia is lagging behind in comparison to the UK in implementing PM, even though awareness of the importance of implementing PM for businesses emerged eight years ago. This is happening because there is no enforcement of implementation from government. Besides, most organisations at one time were used to playing safe by not focusing on global business and rather sticking to extending business in local markets. At the moment, PM has not appeared critically in organisation management but, from time to time, economics keep changing and lots of organisations focus on embracing success and expanding business in the global market, PM is becoming important and needs to be implemented to identify what should be improved by the organisation and what its position is in business. Even though there are differences in length of respondents’ direct involvement with the PM process and also in position (see Table 1), these are not shown in their interpretation of PM. Ten had more than 10 years’ direct PM experience and the other two had less.
5.2 Performance measurement processes

The interviews revealed that staff with a wide spectrum of responsibility are involved either directly or indirectly in the PM process. Generally, employees play a vital role by supporting managerial staff in doing their tasks and playing their roles to create efficient and effective ways of management. Managerial staffs are responsible for assisting business and functional units’ staff in doing their tasks and aligning these with the organisation’s target.

The managerial staff decide organisation targets needing to be achieved every year and every individual has his or her own objectives and targets to achieve those of the organisation. The main objectives come from the main board and are cascaded to everybody in-group. The individual objectives and targets need to be aligned with organisation needs and senior managers will monitor them to ensure they are suitable to be used and practised to achieve those of the organisation. Any individual objectives and targets not meeting the organisation’s targets or maybe clashing with them will be reset.

5.3 Performance criteria measured

In discussion of performance criteria measured, there is not much difference in choosing the appropriate ones. All aspects, both financial and non-financial have been measured by organisations in improving areas needing to be improved in their organisations. One respondent mentioned that the serious intention to measure non-financial aspects started ten years ago. Until then, the financial aspect was the only necessary criterion measured by any organisation.

It was stated that,

*If we went back more than ten years, there was very little measurement of anything other than financial performance*.

This illustrates that the financial aspect is the long standing one to be measured by industry. Nowadays, it has been changed to align with the changes in the economy, trends and needs in the industry. People are interested not only in the financial aspects but also non-financial aspects.

There are many criteria used by respondents to measure the results of business performance. All used four main criteria: business performance, staff or workers, customer or client and society feedback. Business performance means profit margins, turnover and organisation budget. Staff or workers are measured by looking at their performance in doing their tasks and playing their roles for achieving the organisation’s target and aim in business. Customer or client satisfaction is measured to gain information on their level of satisfaction with services delivered as well as product. Society feedback means information gained from the public by understanding the needs of organisation related to local people, environment, economy and social impact on others. All these criteria have been measured with PM tools and models suitable for the organisation’s need.
Even though there were quite a number of similarities in the performance criteria, there were still differences in measuring organisation performance. Some of the criteria were measured monthly and some yearly. All organisations mentioned that identification of criteria is based on organisation needs. No matter what criteria have been and are being used, the overall target of all respondents is to make a profit in their businesses.

5.4 Performance measurement tools and models

All respondents agreed that PM tools and models are needed to measure performance. The type is not important as long as they can measure things that need to be measured correctly. It also depends on what organisations need to see in the results of PM. One UK respondent stressed that the most critical things are what action can be taken after measurement and delivering the right choice for the organisation to improve business. Another from the UK added that the use of PM tools and models is also influenced by clients.

All respondents also justified that the appropriate tools and models to measure performance must be best suited to the organisation's business, the simplicity of the tools and models and the action to put in place for the measurement element. It is not about measurement but about what you do with the information and how to improve it. Table 2 shows the PM tools and models used by each respondent.

*In terms of what tools and models we want to use, I guess it will be looking at what is out there, what benefit different things give us and then how they fit with what works for us and how easy they are*.  

<table>
<thead>
<tr>
<th>Types</th>
<th>KPIs</th>
<th>BSC</th>
<th>BUSINESS EXCELLENCE</th>
<th>MANAGEMENT OF QUALITY SYSTEM</th>
<th>OTHERS (OWN CREATION)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td>ISO 9000/1</td>
<td>ISO 14001</td>
</tr>
<tr>
<td>U1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U2</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>U3</td>
<td>√</td>
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</tr>
<tr>
<td>U4</td>
<td></td>
<td>√</td>
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<td>U5</td>
<td></td>
<td>√</td>
<td></td>
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<tr>
<td>U6</td>
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<tr>
<td>M1</td>
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<td>M2</td>
<td>√</td>
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<td>√</td>
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<tr>
<td>M3</td>
<td>√</td>
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<tr>
<td>M4</td>
<td>√</td>
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<tr>
<td>M5</td>
<td>√</td>
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</tbody>
</table>
UK respondents use a wider variety of tools compared to Malaysia. None of the Malaysia respondents uses the Excellence Model. However, one respondent had heard about the Excellence Model. All respondents mentioned that the board of directors made the decision on what type of tools and models will be used to measure performance of their organisations. Other factors influencing the selection of tools and models are clients’ requirements and government requirements. In Malaysia, the Standards of the International Organisation for Standardisation, widely known as ISO, need to be implemented by construction organisations if they want to tender for projects, especially government ones. The ISO 9000/1 is a necessity to be implemented by those who want to get projects, especially government ones.

It was stated that,

’We have no choice, government requirement. If you do not have the ISO, you cannot tender for government project’.

One respondent stressed that, recently, ISO is a prerequisite announced by CIDB that every construction organisation must get ISO 9000/1 certification to qualify for construction projects. For the respondent, ISO is not new as his organisation has used it for seven years. Two more respondents have used it for nearly ten years. The ISO is used to ensure things are done in sequence. All respondents, in any case, mentioned that they were considering use of any PM tool or model to measure performance even though it has not been made compulsory by the government or any other bodies in the country. They believe that if they want to grow, they have to measure performance of organisations and the right and appropriate tools and models can help them.

When all respondents were asked whether they have a plan to change the tools and models they use, all answered that nothing more needs to be changed. They stressed that they need to determine what they have to establish first rather than thinking about using different types of tools and models.

### 5.5 Relationship between performance measurement and strategy development

All respondents held shared views about the relationship between PM and strategy development. Eleven believe that there is a direct relationship between PM and strategy development. They all had similar thoughts that PM influences strategy development at all levels of the process. It involves everything from the planning stage or where their project should go and what the organisation needs to do in the implementation and evaluation stages.

Organisations need to measure their performance based on the specific criteria or areas for getting the results for improvement (if needed) and identify what will be the next target to be achieved for the
following year and beyond. PM is involved at the implementation stage and evaluation of projects every month. All respondents were aware that an organisation's strategy needs to be revised annually, even though some have made long-term strategic plans for more than three years. One respondent expressed the belief that PM does not have any relationship with strategy development but understood that it is needed for getting information on what needs to be improved by the organisation. Even though all respondents have different points of views on the relationship between these two, all agreed that PM is one of the key success indicators for organisations to achieve objectives or targets and strategy.

5.6 Challenges to implementing performance measurement

The interviews revealed that there are barriers and challenges to implementing PM. All respondents agreed that implementing PM is not as easy as other people think. The most challenging part is changing people’s mindset about it. Many employees think that by implementing PM in organisations, they have to work much harder than they should. Workers try to justify the measurement rather than understand how to achieve the target. It was stated that, ‘The perception about this is because of lack of understanding and thinking it is more complicated than it should be’.

Employees are seeing PM as a criticism of them, as everything will be revealed and measured, including individual performance in conducting their tasks and responsibilities. If they are interested in doing the work, they are willing to do it without any pressure. If not, they will not perform in their work. One respondent explained that employees’ lack of awareness of PM is a real problem in measuring performance. Employees tend not to look at PM as a part of their responsibility to which they must give full commitment. For organisations new to PM, one of the challenges is to really understand in depth the PM process of the organisation and the way to make it easy to be implemented and followed by all staff or workers and align with the existing management practices in the organisation.

Another challenge is using numerous PM systems in an organisation. It can create difficulty for staff. One respondent from the UK mentioned that her difficulty was in the way of delivering information to the right person in the fastest way. Not all the systems can be accessed and used by all staff. An accounting system can be accessed and read only by staff working in that area and involved with accounting activity. Not all departments can easily or maybe cannot get access to the system. Even though it gives benefit to the person needing the system, it does not for several staff who have to get all data and information every time from other staff.

Based on the experience of three respondents from Malaysia, unclear performance measure is one of the main challenges to its implementation. Many employees are unaware about what they have to measure and what they can get from what they measure. It is easy for managerial staff to come up with the list of criteria needing to be measured by the organisation. The managerial staff might not have any problem or difficulty to understand what needs to be measured but it can be a problem and
difficult for functional level staff, especially new ones not familiar with PM. Making mistakes in measuring performance and fully understanding the criteria needing to be measured will reflect different points of view on the relationship between these two, but all agreed that PM is one of the key success indicators for organisations to achieve objectives or targets and strategy.

### 5.7 Approaches to addressing challenges

They were several approaches to addressing barriers and challenges in implementing PM. The approaches as follows:

- Firstly, giving early understanding to all staff or workers in organisations of what PM is. Everybody works to achieve targets for organisations. It is not an individual’s agenda but it is the responsibility of all staff and also the organisation for the benefits of both parties.

- Improvement should be made in the level of awareness of this PM. Two respondents mentioned that mostly lower level staff are not aware of it. The best way to make them understand performances and quality is by giving them training that will benefit them in their career and also benefit the organisation.

- A suggestion has been made by one respondent to improve the storage and delivery of information in an organisation. All information gathered from all departments or units can be put in one system. Creating a ‘central system’ or ‘warehousing facility’ can be a good idea for storage of information gathered. Doing so will make it easy to be accessed by all staff or workers in the organisation. Details of the data can also be referred to by the staff or workers (if needed for their roles and tasks). Telephone use can be avoided if such a system exists.

All respondents in Malaysia said that they need to be given more time to use PM and become familiar with it for the benefit of the organisation. They are still in the PM learning process even though all of them had more than ten years’ experience of it.

### 6. Conclusions and further work

Performance measurement (PM) is being practised by organisations because it is an important way of improving and sustaining business in the long-term. Selection of the appropriate and necessary criteria to be measured brings massive impact to an organisation in achieving its aims, objectives and strategy for gaining success in the future. Studies of PM in two countries revealed both similarities and differences in implementing PM. The similarities are that PM has been practised and implemented by large organisations to improve business and increase profit margins for the organisation. More benefits are gained from implementing PM. Aspects such as financial and non-financial are evaluated and measured for creating strategy. The appropriate use of tools and models to measure performance are needed to complete the PM process. Besides the similarities, differences between these two countries in implementing PM are the duration of implementing PM and tools and
models used to measure performance. Malaysia organisations do not use the Excellence Model and ISO 9000/1 is a prerequisite to qualify them for construction projects especially government projects. Apart from that, difficulty to understand PM process by functional level staff or workers as well as staff new to PM is another difference between both countries.

PM has been more advanced in implementation in organisations in the UK. It can be concluded that UK is more mature in PM than Malaysia as the duration of implementation is more advanced compared Malaysia. The PM practices in the UK can be adopted by another country and lessons learnt from the UK will help in improving the PM process in organisations in Malaysia. There is a need to understand the maturity level of the PM process in Malaysia and for a maturity model to help organisations to structure and organise the PM practices. The maturity model will be the next work for this research.

References


CIB’s mission is to serve its members through encouraging and facilitating international cooperation and information exchange in building and construction research and innovation. CIB is engaged in the scientific, technical, economic and social domains related to building and construction, supporting improvements in the building process and the performance of the built environment.

CIB Membership offers:
- international networking between academia, R&D organisations and industry
- participation in local and international CIB conferences, symposia and seminars
- CIB special publications and conference proceedings
- R&D collaboration

Membership: CIB currently numbers over 400 members originating in some 70 countries, with very different backgrounds: major public or semi-public organisations, research institutes, universities and technical schools, documentation centres, firms, contractors, etc. CIB members include most of the major national laboratories and leading universities around the world in building and construction.

Working Commissions and Task Groups: CIB Members participate in over 50 Working Commissions and Task Groups, undertaking collaborative R&D activities organised around:
- construction materials and technologies
- indoor environment
- design of buildings and of the built environment
- organisation, management and economics
- legal and procurement practices

Networking: The CIB provides a platform for academia, R&D organisations and industry to network together, as well as a network to decision makers, government institution and other building and construction institutions and organisations. The CIB network is respected for its thought-leadership, information and knowledge.

CIB has formal and informal relationships with, amongst others: the United Nations Environmental Programme (UNEP); the European Commission; the European Network of Building Research Institutes (ENBRI); the International Initiative for Sustainable Built Environment (iiSBE), the International Organization for Standardization (ISO); the International Labour Organization (ILO), International Energy Agency (IEA); International Associations of Civil Engineering, including ECCS, fib, IABSE, IASS and RILEM.

Conferences, Symposia and Seminars: CIB conferences and co-sponsored conferences cover a wide range of areas of interest to its Members, and attract more than 5000 participants worldwide per year.

Leading conference series include:
- International Symposium on Water Supply and Drainage for Buildings (W062)
- Organisation and Management of Construction (W065)
- Durability of Building Materials and Components (W080, RILEM & ISO)
- Quality and Safety on Construction Sites (W099)
- Construction in Developing Countries (W107)
- Sustainable Buildings regional and global triennial conference series (CIB, iiSBE & UNEP)
- Revaluing Construction
- International Construction Client’s Forum

CIB Commissions (August 2010)
- TG58 Clients and Construction Innovation
- TG59 People in Construction
- TG62 Built Environment Complexity
- TG63 Disasters and the Built Environment
- TG64 Leadership in Construction
- TG65 Small Firms in Construction
- TG66 Energy and the Built Environment
- TG67 Statutory Adjudication in Construction
- TG68 Construction Mediation
- TG69 Green Buildings and the Law
- TG71 Research and Innovation Transfer
- TG72 Public Private Partnership
- TG73 R&D Programs in Construction
- TG74 New Production and Business Models in Construction
- TG75 Engineering Studies on Traditional Constructions
- TG76 Recognising Innovation in Construction
- TG77 Health and the Built Environment
- TG78 Informality and Emergence in Construction
- TG79 Building Regulations and Control in the Face of Climate Change
- TG80 Legal and Regulatory Aspects of BIM
- TG81 Global Construction Data
- W014 Fire
- W018 Timber Structures
- W023 Wall Structures
- W040 Heat and Moisture Transfer in Buildings
- W051 Acoustics
- W055 Construction Industry Economics
- W056 Sandwich Panels
- W062 Water Supply and Drainage
- W065 Organisation and Management of Construction
- W069 Housing Sociology
- W070 Facilities Management and Maintenance
- W077 Indoor Climate
- W078 Information Technology for Construction
- W080 Prediction of Service Life of Building Materials and Components
- W083 Roofing Materials and Systems
- W084 Building Comfortable Environments for All
- W086 Building Pathology
- W089 Building Research and Education
- W092 Procurement Systems
- W096 Architectural Management
- W098 Intelligent & Responsive Buildings
- W099 Safety and Health on Construction Sites
- W101 Spatial Planning and infrastructure Development
- W102 Information and Knowledge Management in Building
- W104 Open Building Implementation
- W107 Construction in Developing Countries
- W108 Climate Change and the Built Environment
- W110 Informal Settlements and Affordable Housing
- W111 Usability of Workplaces
- W112 Culture in Construction
- W113 Law and Dispute Resolution
- W114 Earthquake Engineering and Buildings
- W115 Construction Materials Stewardship
- W116 Smart and Sustainable Built Environments
- W117 Performance Measurement in Construction
R&D Collaboration: The CIB provides an active platform for international collaborative R&D between academia, R&D organisations and industry.

Publications arising from recent collaborative R&D activities include:
- Agenda 21 for Sustainable Construction
- Agenda 21 for Sustainable Construction in Developing Countries
- The Construction Sector System Approach: An International Framework (CIB 293)
- Red Man, Green Man: A Review of the Use of Performance Indicators for Urban Sustainability (CIB 286a)
- Benchmarking of Labour-Intensive Construction Activities: Lean Construction and Fundamental Principles of Working Management (CIB 276)
- Guide and Bibliography to Service Life and Durability Research for Buildings and Components (CIB 295)
- Performance-Based Building Regulatory Systems (CIB 299)
- Design for Deconstruction and Materials Reuse (CIB 272)
- Value Through Design (CIB 280)

Themes: The main thrust of CIB activities takes place through a network of around 50 Working Commissions and Task Groups, organised around four CIB Priority Themes:
- Sustainable Construction
- Clients and Users
- Revaluing Construction
- Integrated Design and Delivery Solutions

Recent CIB publications include:
- Guide and Bibliography to Service Life and Durability Research for Buildings and Components (CIB 295)
- Performance Based Methods for Service Life Prediction (CIB 294)
- Performance Criteria of Buildings for Health and Comfort (CIB 292)
- Performance Based Building 1st International State-of-the-Art Report (CIB 291)
- Proceedings of the CIB-CTBUH Conference on Tall Buildings: Strategies for Performance in the Aftermath of the World Trade Centre (CIB 290)
- Condition Assessment of Roofs (CIB 289)
- Proceedings from the 3rd International Postgraduate Research Conference in the Built and Human Environment
- Proceedings of the 5th International Conference on Performance-Based Codes and Fire Safety Design Methods
- Proceedings of the 29th International Symposium on Water Supply and Drainage for Buildings
- Agenda 21 for Sustainable Development in Developing Countries

Publications: The CIB produces a wide range of special publications, conference proceedings, etc., most of which are available to CIB Members via the CIB home pages. The CIB network also provides access to the publications of its more than 400 Members.

CIB Annual Membership Fee 2010 – 2013
Membership will be automatically renewed each calendar year in January, unless cancelled in writing 3 months before the year end

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All amounts in EURO

The lowest Fee Category an organisation can be in depends on the organisation’s profile:

- FM1 Full Member Fee Category 1 | Multi disciplinary building research institutes of national standing having a broad field of research
- FM2 Full Member Fee Category 2 | Medium size research Institutes; Public agencies with major research interest; Companies with major research interest
- FM3 Full Member Fee Category 3 | Information centres of national standing; Organisations normally in Category 4 or 5 which prefer to be a Full Member
- AM1 Associate Member Fee Category 4 | Sectoral research & documentation institutes; Institutes for standardisation; Companies, consultants, contractors etc.; Professional associations
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