University of Salford
A Greater Manchester University

BuHu 8th International Postgraduate Research Conference

June 26th-27th 2008

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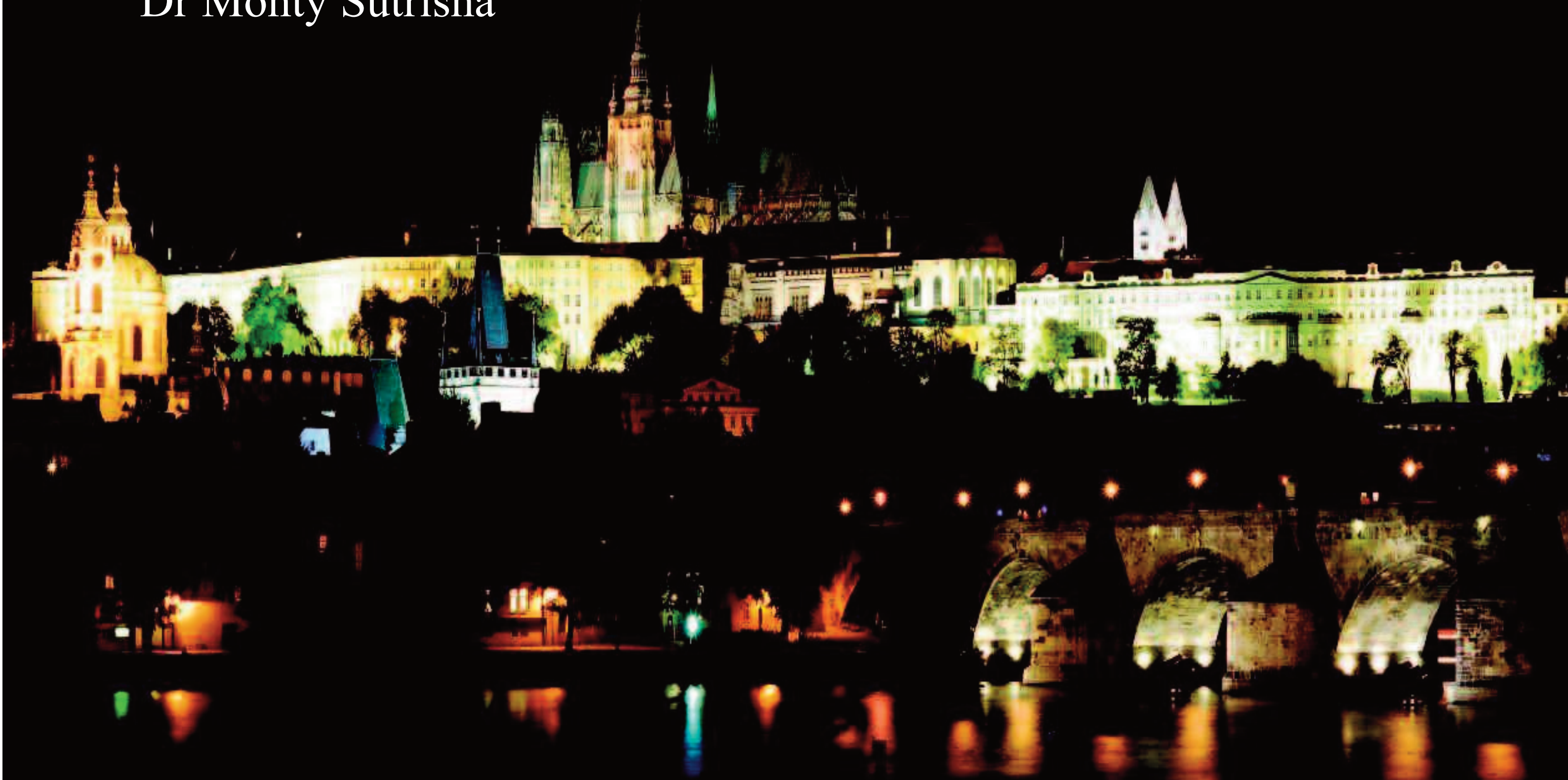

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Research Institute for the Built and Human Environment
at the University of Salford
Czech Technical University in Prague

PROCEEDINGS OF THE BUHU 8TH INTERNATIONAL POSTGRADUATE RESEARCH CONFERENCE 2008

Part II

Prague, Czech Republic
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research rated

Research Institute for the
Built and Human Environment

CZECH TECHNICAL UNIVERSITY
IN PRAGUE

THE UNIVERSITY OF SALFORD

University of Salford
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International Council for Research and
Innovation in Building and Construction

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These are the proceedings of IPGRC2008 which took place at the Czech Technical University in Prague from 26th to 27th June 2008.

The aim of the conference is an exchange of information and attitudes to the problems of studying for and completing a Post Graduate Higher Degree.

The organizing committee has selected a total of 94 contributions divided into 9 different areas or themes of interest:

- Theme 1: Business, Economics and Financial Management;
- Theme 2: People, Culture and Skills;
- Theme 3: Design and Urban Development;
- Theme 4: Procurement;
- Theme 5: Project Management;
- Theme 6: Structure and Material Science;
- Theme 7: ICT and Technology;
- Theme 8: Real Estate and Facilities Management;
- Theme 9: Sustainability.

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This conference originated as a part of the BuHu (Research Institute for the Built and Human Environment), University of Salford strategy for post graduate research development.

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PREFACE

On behalf of the Research Institute for the Built and Human Environment, University of Salford, UK, we welcome you to the annual International Post Graduate Research Conference for 2008 (IPGRC2008).

This year's conference has created a number of records, the largest number of expressions of interest, the largest number of submissions and eventually the largest number of accepted papers. This is expected to be translated into the largest number of delegates. You are a part of this record breaking experience and we urge you to make the most of this opportunity.

Research for a higher degree is by necessity an individual and often lonely process, this event is one of the few opportunities that arise when you can expose your ideas, concepts, designs, models, etc. to a wider audience than the normal supervisory team from your host University. Your ideas can be tested in front of an international academic audience. You can expect to be questioned on the substance of the research and the methodological approaches you have adopted. Frequently, individuals in the audience will have suggestions of how to modify your research approach or suggest new authors to read who may offer different insights into your research area. Grasp these opportunities, and in the breaks and at lunch or dinner, seek out these people and maximise the benefit from a unique opportunity.

Making these contacts and networking is a normal part of conference activities, but we urge you to take this further – turn those networking contacts into academic collaborators, and then turn those collaborators into lifelong academic friends.

By doing this you will be validating the incredible amount of hard work that goes on to deliver an event such as this.

As delegates you are free to move between parallel sessions, (please do so as quietly as possible so that you disturb the presenters as little as possible –many may be presenting at an international conference for the first time!) but remember that individual sessions are chaired in such a way as to utilise the available session time for the maximum benefit of session presenters. We will endeavour to provide notices outside the venues if particular presentations will not take place, but we cannot provide timings other than that papers will be presented within the allocated session time.

In conclusion, remember that the time outside of the auditorium is as important as the time inside, we hope that you enjoy the conference and benefit your studies from this opportunity. It is not possible to name everyone that has contributed to developing and delivering this event. Indeed this event has benefited from every previous years event. We must however, say a large thank you to our hosts for this years event, The Faculty of Civil Engineering, at the Czech Technical University in Prague.

With our best wishes for every success in your future academic studies,

8th International Postgraduate Research Conference Chairs and Organisers.
Salford, June 2008.

INTRODUCTION

Research in the Built and Human Environment is an enormously diverse and complex subject area. These proceedings present papers from what on the one hand can be best described as 'pure' research to, on the other hand, very specific applications of particular technologies.

That in itself makes for an exciting conference, since it is likely that most delegates will be exposed to completely new ideas or concepts at some point during the proceedings. However we recognise that students are also likely to benefit from hearing about other people exploring similar areas of study. To facilitate this, the conference has been structured into themes, these themes will have allocated sessions, which present papers from similar areas within the Built and Human Environment or present papers from different areas that are following similar research methodologies.

The first theme is **Business, Economics and Financial Management** - this theme explores the business environment in where the construction company operate and recognises that to deliver the Built Environment at an affordable price requires that decisions are made to prioritise what is financially achievable from a constrained budget. This decision making process is now evolving to consider the whole life cycle 'from cradle to grave'. This involves examining the net present value of past, present and future expenditure. Selections for construction solutions should then lead to the opportunity to manage the built environment as effectively and efficiently as is possible. The papers within this theme address models for environmental change management, company strategy management and input-output analysis and import dependency

The second theme is theme is **People, Culture and Skills**. This theme presents the 'real' picture. The delivery of a project is affected by and affects people. The citizen that experiences the delivery of a facility, or the designer or consultant commissioned to create such facilities, reacts to circumstances in idiosyncratic ways. This theme presents research on our current attempts to either predict how people behave in particular circumstances, or how systems should be structured to accommodate individual behaviour without prejudicing the successful delivery of projects. The papers in this theme includes work on training needs, personalised learning, virtual team working, the ideal team building, gender and site culture, and human resource management issues.

The third theme, **Design and Urban Development**, is an all-embracing category that explores all organised Built Environment that supports human existence. It sets the parameters for how and why our Built Environment appears the way it does. It expresses the expectation of every citizen to have access to the basic amenities of life, all available locally at an affordable price. The papers within this theme address issues such as sustainable settlements in flood prone areas, and old city renewal, the utilisation of learning space in higher education and community participation in regeneration.

The fourth theme is **Procurement.** Procurement is taken in its widest ambit and includes work on selecting designers, consultants, contractors, sub-contractors and suppliers. It demonstrates alternative routes that can accommodate the vast array of different constraints that affect an individual project. The papers in this theme include work on value for money uncertainties, a framework for infrastructure comparisons, managing supply chains and e-Kanban.

The fifth is **Project Management**. This theme concentrates on features that lead to the successful delivery of project objectives. It looks at identifying critical success factors for different design solutions or procurement options. It identifies how the site based staff can be most effective in attaining the aims of the client whilst at the same time recognising the constraint imposed on them by working for different organisations. Papers in this theme include programme management, schedules, time delays, optimising material logistics, innovative manufacturing and project risk management.

The sixth theme is **Structure and Material Science**. This theme explores the current advances in applying current structural principles and using existing materials for different purposes or using new materials in constructing our built environment. The papers in this theme include optimisation using Genetic Algorithm, bond stress of GFRP bars and concrete, nano-indentation modelling, the experimental use of alkaline-activated materials, and static stiffness of anti-vibration mats.

The seventh theme is **ICT and Technology**. The previous themes express the environment, structures, strategies or behaviours to deliver successful Built Environment. This theme delivers the technological systems that interact to enable all citizens to experience a satisfactory Built and Human Environment. The papers in this theme include Global e-readiness, GPS technology, predicting traffic noise, delivering training using virtual classes and ICT systems for small and medium enterprises.

The eighth theme is **Real Estate and Facilities Management**. Having taken design and construction decisions which are constrained, it then becomes essential to operate and maintain those facilities to the necessary standard to meet expectations. The papers within this theme include asset management of complex objects, hierarchical process mapping, risk management and housing shortages, grounded theory application for healthcare facilities, and green healthcare facilities

The ninth and final theme is **Sustainability**. Whilst there is no universally accepted definition, the concept is perhaps best defined as the cumulative net long-term maximisation of scarce resources to the benefit of the entire eco-system of our planet. This means that the Built and Human Environment is under increasing pressure to maximise its effective utilisation of all resources. The last in a long line of sustainability issues is the current massive surge in world-wide energy prices and the financial implications for society. Papers in this theme include corporate social responsibility, building sustainability index, eco-efficiency modelling and roof-top rainwater harvesting.

It also very apparent when examining the totality of papers that the thematic approach is a crude method of segregating papers, many of the papers could quite easily be allocated to a different theme, indeed the cross-cutting of themes within individual papers is very noticeable. We would urge the delegates to carefully examine the whole conference schedule, examine the abstracts and key words of all the papers and create a conference schedule that is customized to personal needs.

The editors

CONTENTS

THEME 8: REAL ESTATE AND FACILITES MANAGEMENT

THEME 9: SUSTAINABILITY

Theme 6:
Structure and Material Science

Experimental Determination of Bond Stress of GFRP Bars and Concrete

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Abstract:
The objective of this paper is experimental determination and comparison of bond strength between different types of GFRP (glass fiber reinforced polymers) bars and concrete. The bond strength is affected by shape and roughness of the reinforcement bar surface and is very important for the right function of reinforced concrete. The experiment for determination of bond strength is called pullout test. During the test a GFRP bar is pulled out of the concrete cube and the displacement of the bar end is measured. Shear stress develops between the concrete and the bar. Based on the value of shear stress the results are compared. This paper clearly shows that sand coated GFRP bar has the best bond strength, which is even better than for steel. Tests were executed from November 13th 2006 to April 3rd 2007 in Experimental Center of Czech Technical University in Prague, Faculty of Civil Engineering.

Key words:
Concrete, FRP, GFRP, composite, bond strength

1. Introduction

There is a big emphasis at present time on sustainable development that is projected to all parts of human activity including building industry. Structures are built much faster and more effectively. This requires new building materials and industrial processes. Composite reinforcement made of polymer matrix (FRP bars – fiber reinforced plastics/polymers bars) with carbon (CFRP), aramid (AFRP), basalt or glass (GFRP) fibers improve the properties of building or reconstructions into new dimensions. However, the price of FRP composites is much higher than common steel reinforcement. Composite armature is made of carbon, aramid, basalt or glass fibers, which are strained and placed in the form and than cast in polyester or epoxy resin. This technology is more energy efficient and more ecological than steel production.

This paper focuses on experimentally determined bond strength between GFRP bars and concrete. The bond strength between reinforcement and concrete is one of the most important characteristics for good function of reinforced concrete and that is why it should be investigated for all new types of armatures. Main motivation of this paper is determination which type of GFRP bar made by PREFA KOMPOZITY a. s. has the best bond strength with concrete.

2. Properties and possible usage of GFRP bars

Composite materials exceed steel with many of their outstanding mechanical and physical properties (Table 1). The most notable qualities are very high tensile strength, low weight, low heat conductivity, chemical durability in aggressive environment, corrosion resistance, non-conductivity and transparency for electromagnetic radiation. These properties can be exploited for improvement of many buildings. For example:

- high tensile strength and low weight can be used in many new structures, mainly simple beams and in combination with steel also in other structures. These qualities also can be suitably used for reconstruction of old buildings, for example with carbon fibers lamella or mat, which do not increase weight of construction elements.
- chemical and corrosion resistance is very suitable for bridges, chemical factories, prefabricates for coastal breakwaters and other construction in coastal locations or off shore structures where steel reinforcement without thick cover or with non-corrosion modification has no chance for long life.
- electrical non-conductivity and transparency for electromagnetic radiation of glass or basalt fiber could be used for structures where are undesirable high conductivity and magnetic characteristics. For example:
    - reinforcement of radio communication towers
    - armature for covers of antennas (security applications)
    - foundations and superstructure for NMR (nuclear magnetic resonation) tomography where high magnetic field could be produced. For instance buildings with superconductive magnets as cryostats etc.

On the other hand there are some disadvantages of GFRP bars that should be taken into account: low modulus of elasticity, fragility and high price. Low modulus of elasticity could cause large deformations of structures where the GFRP bars will be used. Usage of GFRP bars is more demanding for workers discipline because of the fragility that predisposes GFRP bars to break. Fragility is also a reason why GFRP bars cannot be bent as steel. The expected usage of GFRP bars is for strained or bend strained structures. In other structures these bars should be used in combination with steel reinforcement.

Table 1: Properties of reinforcing fibers in comparison with steel

Qualities	***Units***	***Steel***	***AR Glass***	***Basalt***	***Carbon***
Tensile strength	*(MPa)*	*350-550*	*1400*	*4800*	*3500-6400*
Specific weight	*(kg/m3)*	*7850*	*2700*	*2750*	*1700-1900*
Modulus of elasticity	*(GPa)*	*210*	*74*	*86*	*230-100*
Extension	*(%)*	*0,2*	*2,0*	*3,2*	*0,7-2,2*

3. Bond strength between concrete and composite reinforcement

3.1. Characteristics of tested GFRP bars

GFRP bars were made by PREFA KOMPOZITY a. s. Kulkova 10/4231, 615 00, Brno. Characteristics of the delivered GFRP bars were determined by the manufacturer and are shown in Table 2. Also characteristics of steel for comparison are shown in Table 2.

Table 2: Characteristics of GFRP bars and steel

	GFRP bar	**Steel**
Modulus of elasticity E (GPa)	32,5	210,0
Tensile strength $\mathbf{f_t}$ (MPa)	471	350-550 (yield limit)

Good bond between GFRP bar and concrete is very important for right function of reinforced concrete. Bond strength is affected by shape and roughness of reinforcement bar surface. Surface of carbon, aramid, glass or basalt FRP bars is very flat so there is a need to roughen or shape the bars. Shaping of the flat surface into wave shaped is made with one spiral shaped string (Figure 1) or with two strings oppositely winded around the bar (Figure 2). Roughness is increased by coating the surface with sand in epoxy resin (Figure 3).

Fig. 1. GFRP bar with one string
(Samples 11 to 16)

Fig. 2. GFRP bar with two strings
(Samples 21 to 26)

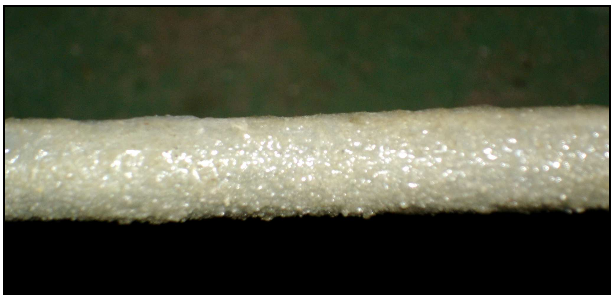

Fig. 3. GFRP bar coated with sand (samples 31 to 36)

3.2. Preparation of samples for pullout tests

GFRP bars were delivered 800 mm long with the specified diameter 14 mm. Steel anchor was attached to each bar for gripping into the jaws of the loading machine. One test sample consisted of one GFRP bar fixed in a concrete cube with edge 200 mm (Figure 4). The length of GFRP bar fixed in the concrete cube was about five times diameter that is 70 mm. The rest of the bar – 130 mm was separated from the concrete with a PVC tube for incoherency guarantee. Bottom of the bar overhung the lower cube face from 15 to 20 mm. During the concrete production sample cubes were made and compressive strength was tested.

Samples were marked as following:

GFRP bars with one string had numbers 11 – 16, bars with two strings had numbers 21 – 26 and bars covered by sand had numbers 31 – 36.

Fig. 4. Samples for pullout tests

3.3. Characteristics of concrete

Following prescription was used for production of 1 m^3 of concrete:

Aggregate 0 - 4mm:	743	kg
Aggregate 4 - 8mm:	371	kg
Aggregate 8 - 16mm:	672	kg
Cement II/B V 32.5R:	343	kg
Plasticizer Stachement:	0,7	kg
Water:	175	Kg
Water cement ratio w/c:	0,51	
Abrams test:	105	mm

Cubic compressive strength was determined on cubes with the edge of 150 mm after sixty days from production. That should match the time when the pullout tests were made. Average compressive strength of concrete for pullout test number 11 – 16 was 44,7 MPa for number 21 – 26 was 40,6 MPa and for number 31 – 36 was 46,9 MPa.

3.4. Pullout tests processing

Before the start of the test it was necessary to put the sample correctly into the jaws of loading machine and set up sensors. Manipulation with the samples had to be careful because of high fragility as described above and relative high weight of samples – c. 18 kg. Placement of the samples into the loading machine:

- the sample was hung into the jaws of the loading machine
- a steel 20 mm thick plate was set on the upper side of the cube for equalized load on the cube
- three inductive sensors HBM IWT 302 (marked as IWT 1 – 3) were stuck onto the steel plate in circle along 120° (Figure 5)
- one inductive sensor HBM IWT 102 (marked as IWT 4) was stuck to the lower side of the cube and its core was leaned to the overhanging open end of the bar (Figure 6)
- potentiometer was connected to the movable head of the loading machine by line

- the last step was linking the inductive sensors, the potentiometer and the loading machine to the data processing station HBM Spider 8.

General scheme of sample fixation is shown in Figure 7.

Tests were processed on the loading machine type FPZ 100, where was measured force, displacement of the head with the concrete cube and displacement of the inductive sensors (IWT 1 – IWT 4). Noted values were read by the data processing station with frequency 5 or 2,5 Hz, units mV/V and were saved into the spreadsheet file. Values were converted in the common units (kN, mm) after the calibration of the sensors.

Test were performed in this way: movable head pursued force (velocity of loading have to be slower than 20 kN/min) on the steel plate which pressed concrete cube down. Steel anchor of GFRP bar was fixed into the machine jaws. The main monitored value during the test was friction. Friction is the most important criterion for determination of the bond strength between concrete and GFRP bar. Test ended when the GFRP bar was pulled out from the coherent part of the concrete cube or when the FRP bar or the concrete cube broke.

Fig. 5. Upper view of sample setting

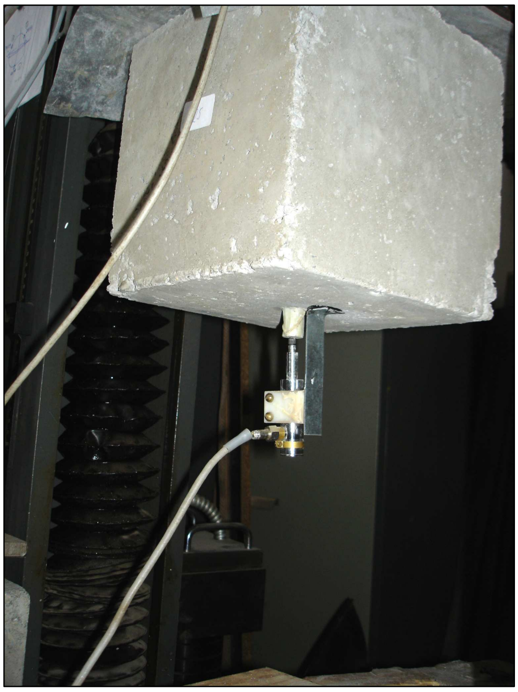

Fig. 6. Bottom view of sample setting

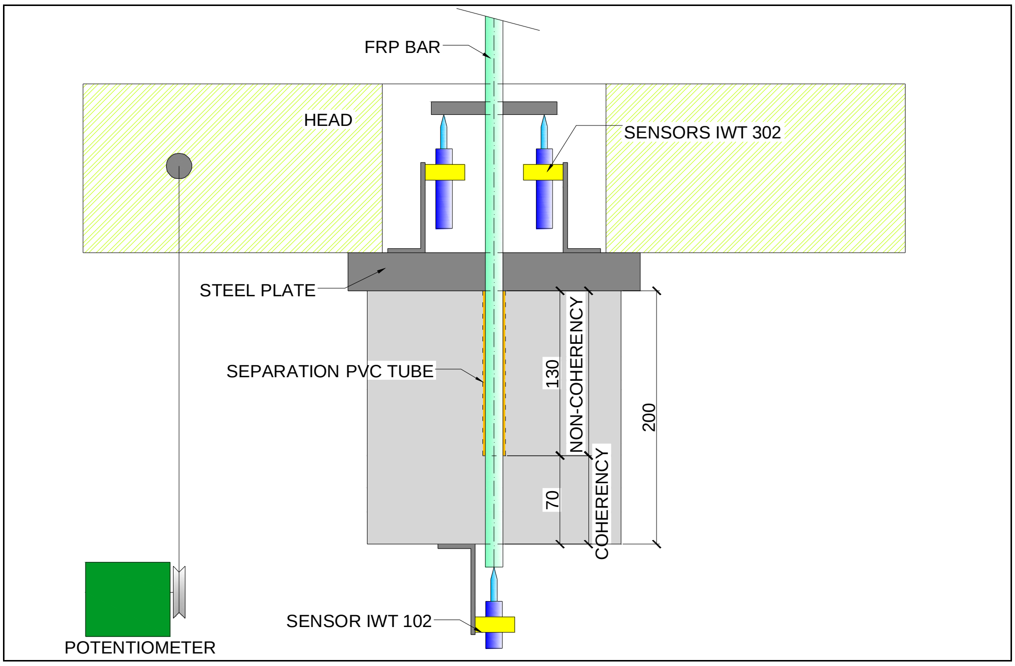

Fig. 7. Sample setting scheme

3.5. Shear stress

Average shear stress (ACI 440.4R-03, 2003) can be calculated:

$$\tau = \frac{F}{C_b \cdot l} \tag{1}$$

where: τ – average shear stress (MPa)
F – gained force (N)
C_b – equivalent circumference (mm)
l – fixed length (mm)

Equivalent circumference of the bar was calculated from the specified diameter 14 mm prescribed by the manufacturer.

3.6. Evaluation of the displacement of free and loaded part of GFRP bar

The displacement of the free end of GFRP bar needs to be corrected by the elastic displacement (ACI 440.4R-03, 2003) according to equation:

$$S_C = \frac{F \cdot L_C}{E_L \cdot A} \tag{2}$$

Where: S_C – elastic displacement (mm)
F – gained force (N)
L_C – distance between the upper edge of fixed length of the bar and point of attachment of the inductive sensors to the GFRP bar (mm)
E_L – modulus of elasticity (MPa)
A – area of the bar (mm^2)

Calculation of elastic displacement mainly depends on the predicted modulus of elasticity and the area of the profile. Modulus of elasticity was assigned as 32,5 GPa, this value can be slightly different for each bar because of fibers density possible variation. Also the area of the profile does not reflect reality and that is why these factors should be controlled when there are some anomalies.

4. Evaluation of the pullout tests

4.1. GFRP bars with one string (samples 11 to 16)

Examination of the samples 11 to 13 proceeded form 13/11/2006 to 15/12/2006. Samples with numbers 14 to 16 were examined from 2/4/2007 to 3/4/2007. Each exam was performed in temperature 18 – 20 °C on the loading machine type FPZ 100 in the range 100 kN. Inductive sensors IWT 1 to IWT 3 extended itself in the range from 9,0 to 11,5 mm and sensor IWT 4 had extension from 2,2 to 2,8 mm. Maximum gained force varied from 40 to 50 kN.

Shear stress was calculated as shown in Equation 1. The free end displacement (IWT 4) and the loaded part displacement (average of IWT 1 – IWT 3 minus elastic displacement, Equation 2) was plotted against the shear stress as can be seen in Figure 8. This represents typical shear stress process of one string GFRP bar. According to theoretical predictions both curves are same. However, there is sudden displacement of the loaded end (dashed blue) when shear stress reaches approx. 8 MPa. This effect is explained in chapter 4.1.1.

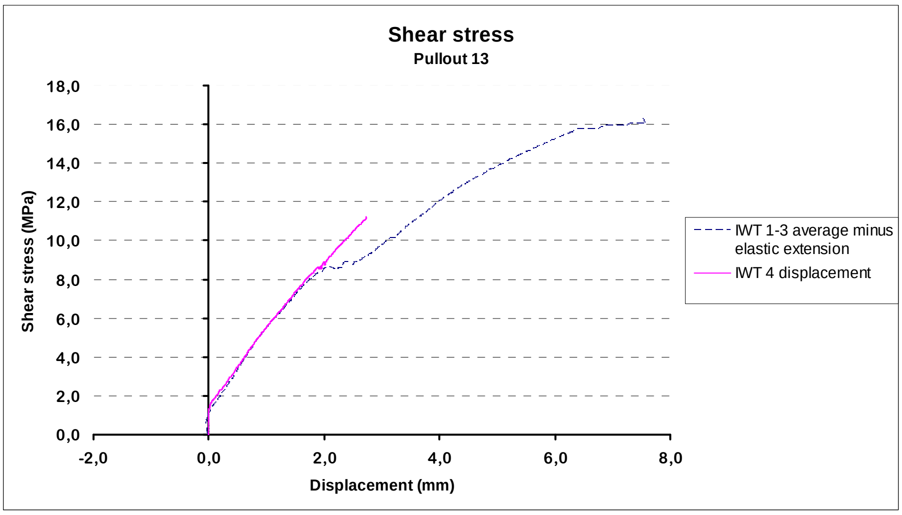

Fig. 8. Shear stress (pullout 13)

All tests had analogical process. Cracking of individual fibers or groups of fibers began close to the force 8 kN. Near this forces string winded around the bar began to snap which was obviously evoked by the effort of fibers to straighten.

Sample no. 11 – process was analogical as described above.

Sample no. 12 – process was analogical as described above. When the loading force reached 38 kN, the bar broke. Breaking of the bar influenced measurement because the cores of the sensors IWT 1 to IWT 3 were attached straight to the bar.

Sample no. 13 – process is noted above in this chapter.

Sample no. 14 – from beginning of this test the GFRP bar begun to slip in the steel anchor so that all parts of the sample are in the move including the sensors. Sensors

IWT 1 – IWT 3 noted only small elastic displacement and the sensor IWT 4 did not note any data. After achieving force about 8 kN, slipping in the steel anchor stopped and the test processed analogical as the tests noted above but calculated values of shear stress were high order then in the other samples.

Sample no. 15 – non-centric tension happened there and bending of the bar owing to incorrect placing into the jaws of loading machine. This affair leaded to the breaking of the bar. Measured values are not reliable and unusable because of human factor failure.

Sample no. 16 – process was analogical as the tests 11 and 13. In the end of the test, the bar was suddenly pulled out from the steel anchor which leads to the rapid fall on the sensors IWT 1 to IWT 3.

4.1.1. Conclusion of pullout test 11 to 16

Test processes were more or less analogical. Cracking of the fibers, snapping of the string and bristling of the bar were observed for the force higher than 8 kN. These effects were caused by the eccentricity of the bar (Figure 9) which was effected by the helix winding of the string around the bar. Moments of flexion were produced by eccentricity which is shown in the Figure 9. Average eccentricity was about 1,1 mm. Tension in outer fibers rises over 60 – 70% because of the eccentricity. Concretely near the force 8 kN when begins cracking of fibers, there was in outer fibers tension 85 MPa. Without calculation of eccentricity was tension 52 MPa, that’s considerable difference. These effects were raised with the curvature of the outer fibers that had trend to straighten. Straighten of fibers caused that the string is gradually snapped off and individual fibers or groups of fibers separated out (Figure 9 – red arrow) and broke – bristling of the bar.

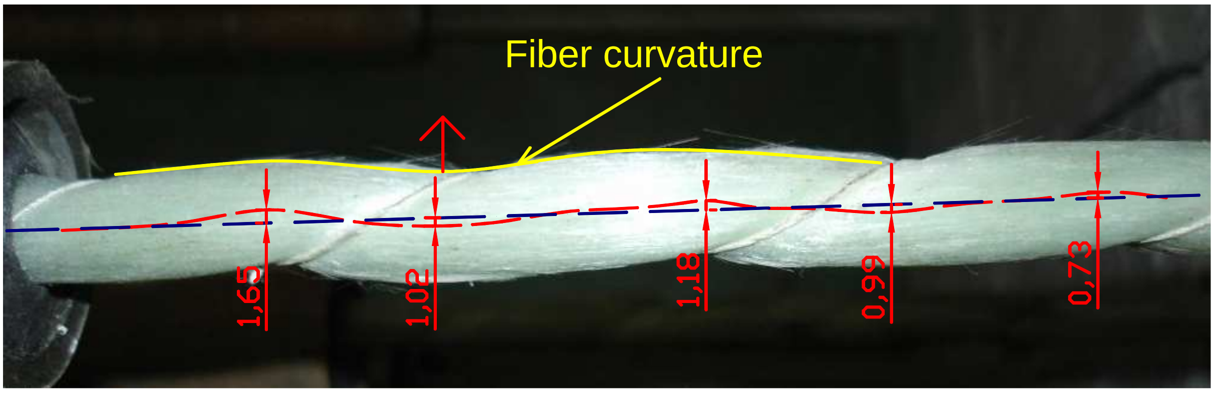

Fig. 9. Fibre curvature and excentricity (pullout 13)

According to the methodics of pullout tests implementation (ACI 440.4R-03, 2003) was requested to assign shear stress against displacement of free end over 0,05; 0,10 and 0,25 mm (Table 3). Results of tests 14 and 15 were not involved into the calculation of the final average shear stress. Differences between results of tests were caused by unknown factors. Nevertheless it could be assumed that aggregate allocation in concrete had important effect, namely contact of aggregate with the GFRP bar.

Table 3: Average shear stress of GFRP bars 11, 12, 13 and 16

	Displacement of open end (mm)		
	0,05	*0,10*	*0,25*
Average shear stress τ	*1,816 MPa*	*2,180 MPa*	*3,134 MPa*

4.2. GFRP bars with two strings (samples 21 to 26)

Testing of the samples 21 to 26 proceeded from 13/11/2006 to 15/12/2006. Temperature in testing room was 18 – 20°C. Samples were tested on the loading machine type FPZ 100 in the range 40 kN. Inductive sensors IWT 1 to IWT 3 extended itself in the range from 9,0 to 11,5 mm and the sensor IWT 4 had displacement from 2,3 to 2,7 mm. Maximum gained force varied from 15 to 22 kN.

Shear stress was calculated from the Equation 1 and plotted against the free end displacement (IWT 4) and the loaded end (average of IWT 1 – IWT 3 minus elastic displacement, Equation 2). Typical shear stress process is plotted in the Figure 10. Negative displacement on the beginning of the curve "average from IWT 1 – 3 minus elastic displacement" (dashed blue) was caused by deduction of elastic displacement in time when the sensors IWT 1 – 3 did not read any or only the minimal values (displacement ~ 0). There is no effect of this on final results.

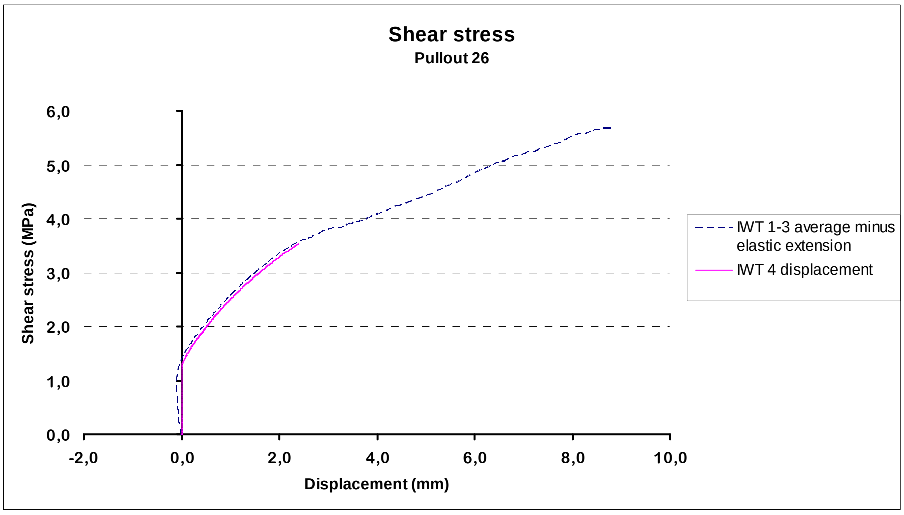

Fig. 10. Shear stress (pullout 26)

All tests proceeded according to the methodics of pullout tests implementation (ACI 440.4R-03, 2003). There were observed no anomalies. Each bar was fluently pulled out from the coherent part of the concrete cube (except sample 24). As can be seen in the Figure 10 there was very small sudden displacement in contrast with samples 11 -16. This could be caused by more regular and plane shape of the surface.

After the GFRP bars were pulled out of the concrete there could be seen that strings draw off the bars during loading. This caused that surface looses its roughness (Figure 11). Because of similar process of each test, there is no closer description of the samples 21 – 26.

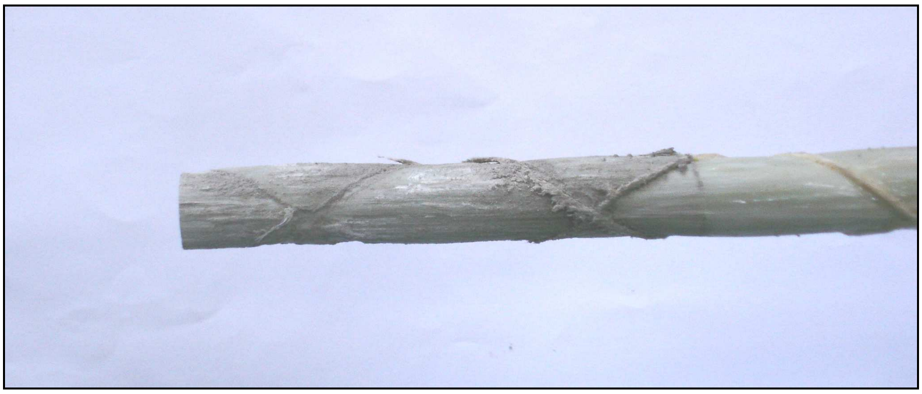

Fig. 11. Strings draw off

4.2.1. Conclusion of the pullout test 21 to 26

There were observed no special effects of tests of the GFRP bars with two strings. All tests proceeded according to the methodics of pullout tests implementation (ACI 440.4R-03, 2003). It is not necessary to present any closer description of this group of samples, because of similar process of all tests. Average shear stress is presented in the Table 4.

Table 4: Average shear stress of GFRP bars 21 to 26.

	Displacement of open end (mm)		
	0,05	*0,10*	*0,25*
Average shear stress τ	*0,874 MPa*	*0,955 MPa*	*1,157 MPa*

4.3. GFRP bars covered by sand (samples 31 to 36)

Testing of the samples 31 to 36 proceeded from 2/4/2007 to 17/4/2006. Temperature in the testing room was 18 – 20°C. Samples were tested on the loading machine type FPZ 100 in the range 100 kN. Inductive sensors IWT 1 to IWT 3 extended itself in the range from 11,9 to 13,1 mm and sensor IWT 4 had displacement about 2,6 mm. Maximum gained force varied from 36 to 40 kN.

Typical shear stress process is plotted in the Figure 12. As can be seen in Figure 12 there is very steep rise of shear stress against small displacements. That leads to very high bond strength of this GFRP bar type.

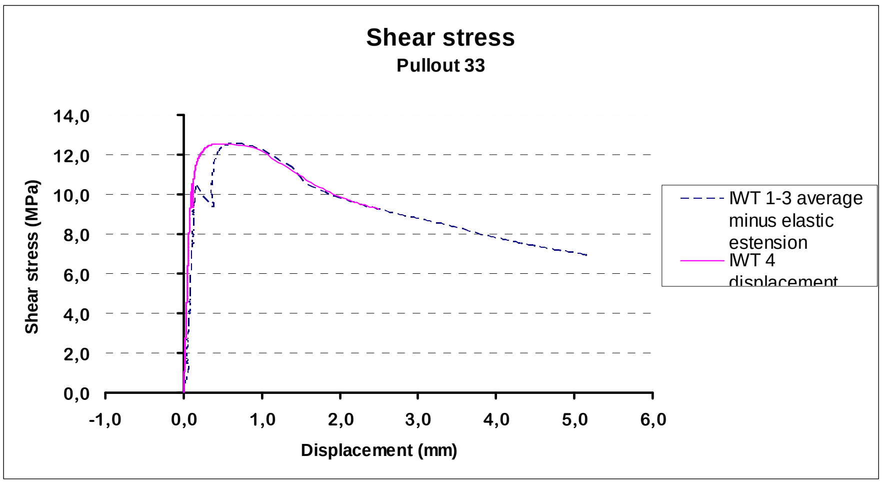

Fig. 12. Shear stress (pullout 33)

4.3.1. Conclusion of the pullout test 31 to 36

No special effect had been observed for the tests 31 to 36. All tests proceeded according to the methodics of pullout tests implementation (ACI 440.4R-03, 2003). Sensor IWT 4 had broken for the tests 31 and 36. Samples 31 and 36 are not involved for calculation of average shear stress. Calculated average shear stress is presented in Table 5.

Table 5: Average shear stress of GFRP bars 32, 33, 34 and 35.

	Displacement of open end (mm)		
	0,05	*0,10*	*0,25*
Average shear stress τ	*6,290 MPa*	*10,117 MPa*	*12,302 MPa*

5. Conclusion

In Figure 13 shear stress against free end displacement for different types of GFRP bars and common steel bar R 10505 (B 500) is compared. Bond strength of the conventional steel reinforcement is calculated according to the CEB-FIB 1990 model code (Červenka, Červenka, Jendele, 2006). Main conclusions are discussed in the next few points.

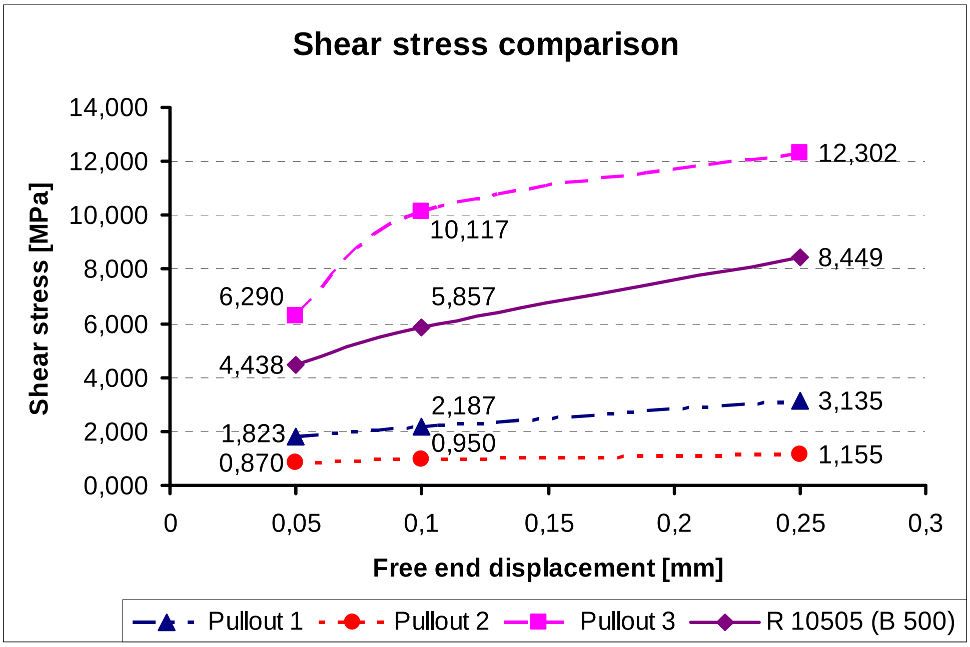

Fig. 13. Average shear stress comparison

- As shown in Figure 13, GFRP bars with one or two string have poor shear stress compared with high-bond steel bar R 10505 (B 500). GFRP bars with one string have more than 2,5 times worse bond strength and GFRP bars with two strings have been more than five times worse.
- GFRP bar coated with sand has better bond strength than steel bar R 10 505 (B 500). Based on this experimental work it is recommended to use this type of coating for practical applications.

- Tensile strength of samples 12 and 15 was only 247,0 and 325,0 MPa that was less than expected 471,0 MPa claimed by manufacturer. This indicates high unreliability of this GFRP bar type.
- Cracking of fibers can reduce tensile strength of “one string GFRP bars” for cyclic loading.
- Aggregate allocation in concrete has important effect on bond strength between GFRP bar and concrete.

From previous points it is obvious that the most suitable type of surface modification is coating with sand. GFRP bars with this modification have much better bond strength than the other two modifications with strings and than steel bar R 10505 (B 500).

Acknowledgements

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Impact of Water Content to Static Stiffness of Antivibration Mats

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Abstract:
Antivibration mats are the new and advanced elastic railway structure components used to absorb the vibrations caused by the railway vehicles. The article does only mention the antivibration mats produced from rubber recyclate. The manufacture of this kind of antivibration mats inflicts minimal harm on the environment. The water absorption was identified as the most important factor possibly affecting other properties of the antivibration mats such as static stiffness. There were five squared (200 x 200 mm) antivibration mats samples examined. Main property to choose the type of antivibration mats is static stiffness. In the Czech Republic there are three categories of static stiffness divided by speed. At the same time as water absorption, static stiffness was measured before and after the absorption. The measurements were carried out under laboratory conditions and evaluated. A dependence of the static stiffness on the absorptive capacity was clearly proven. Water absorption of antivibration mats can cause expressive changes in elastic properties.

Keywords:
Antivibration mats, static stiffness, water absorption.

1. Introduction

Antivibration mats (AVM) are elastic planar elements characterized by very good properties in terms of vibration absorption. They are successfully used as a bottom or separating layer between the source of vibrations and the surrounding structure or facility. They are particularly applied in the construction and reconstruction of railway tracks (railways, trams and underground) where by proper positioning they ensure limited transfer of vibrations from the railway vehicle into the surrounding environment. They may also be used as elastic pads under noisy machines or in foundations of buildings to protect structures situated in the vicinity of various sources of permanent vibrations.

A suitable material for all above-mentioned applications is rubber. Its elastic and absorption properties may well apply in here. The material used for the manufacturing of AVM may be classified into two categories. The first category is represented by mats produced of a new material – synthetic rubber (elastomer), which is expressly used for the production of such items, while the second category includes AVM made of recycled rubber.

The text below is devoted solely to AVM produced of recycled rubber and used in the substructure body construction. It deals with the problems of this type of AVM behaviour whose permanent exposure to water effects causes changes in some of their mechanical properties (overall static stiffness).

1.1. AVM production of rubber recyclate

Due to increasingly growing trends of efficient utilization of waste materials, manufacturers have been focusing on the processing of used tyres to produce AVM and other items of rubber recyclate. These so-called wasteless technologies are aimed at the maximum possible regeneration of existing waste through its recycling and return to the market.

Recycling of used tyres is a source of high-quality rubber granulate, which may further be processed by bonding using polymer binders to produce different types of products. This technology primarily uses elastic characteristics of rubber, its stability, long durability with relatively unchangeable properties and potential repeated recycling if the existing products become obsolete, useless or otherwise no more usable.

AVM are manufactured as planar, plate-shaped elements and their shape must allow a minimum number of joints during their laying. Individual pieces are joined together by a system of locks, by gluing or sealing the joints with adhesive strips, or they are mechanically fixed to structures in other ways.

1.2. AVM use in substructure construction

AVM are usually laid on levelled and compacted subgrade or on the substructure subgrade surface. The method of AVM laying depends on the type of application, but it is basically always necessary to keep in mind that AVM of any hardness and toughness invariably need solid and even ground. The load-bearing capacity of the subgrade must comply with regulations laid out in Annex 4 to the SŽDC Regulation S4 Substructure. The system of joining individual pieces must provide long-term strength and impermeability of the joint. Therefore, connection of plates and strips using the butt joint technique is inadmissible. The AVM surface must ensure proper rainwater drainage into drainage facilities. Commonly produced AVM do not provide reinforcing, filtration, drainage or damp-proofing functions. The conditions of AVM usage and placing in structural layers of the substructure body are laid out in the model sheet ČD Ž 4.13 and in Annex 28 to SŽDC Regulation S4 Substructure.

1.3. Requirements for AVM material characteristics

The basic material of which antivibration mats are produced must be environmentally friendly and must be resistant to the following effects:

- mechanical (transport, handling, storage, contact with surrounding material, loading etc.),
- climatic (temperature, moisture content, solar radiation, ozone etc.),
- chemical (resistance to chemical substances and petroleum products),
- biological agents (mould, bacteria, rot, rodents),
- high temperature (fire resistance).

The requirements for technical characteristics of antivibration mats are laid out in the OTP draft Antivibration mats in the substructure body. The main monitored AVM material characteristics are:

- volume density,
- tensile strength,
- extension,
- hardness Shore,
- resistance to high temperatures,
- resistance to low temperatures,
- water absorption,
- electrical insulating properties.

1.4. Requirements for AVM elasticity characteristics

The requirements for technical characteristics of antivibration mats are laid out in the OTP draft Antivibration mats in the substructure body. The main monitored AVM elasticity characteristics are:

- static modulus of deformation,
- impact modulus of deformation,
- overall static stiffness,
- overall dynamic stiffness,
- increase in dynamic stiffness,
- resistance to cyclic load.

Antivibration mats for use in the substructure body constructions are selected according to the value of the overall static stiffness *C(A)stat* and the design speed on the track as displayed in Table 1.

Table 1: Required values of overall static stiffness of antivibration matting in relation to design speed

Design speed V in km.h^{-1}	***Overall static stiffness $C_{(A)stat}$ in N.mm^{-3}***
$V \leq 120$	$0.03 \leq C_{(A)stat} \leq 0.05$
$120 < V \leq 220$	$0.05 < C_{(A)stat} \leq 0.10$
$220 < V$	$0.10 < C_{(A)stat} \leq 0.15$

2. Measurement of AVM water absorption

Five AVM samples of rubber recyclate by three different manufacturers were selected for absorption tests. The samples were marked as follows: AV800-1 (Renogum – NILOS company), FS700GR-1 (Pragoelast company), BELAR-1, BELAR-S-1, BELAR-HP-N (BELAR company).

By water absorption (*n*) is understood the maximum amount of liquid soaked into the AVM material after immersion into distilled water at room temperature expressed as a percentage of the unsaturated sample weight.

In order to measure water absorption, samples with dimensions of 200 x 200 mm, randomly cut out of AVM plates were chosen. Prior to the start of testing, the test pieces were measured with a precision of ± 0.01 mm and weighed with a precision of ± 0.1 g.

2.1. Measurement procedure and aids

After the determination of weight in unsaturated state (M_0) the test pieces were placed inside a vessel and seated on plastic pads (preventing the test piece contact with the bottom of the vessel and, at the same time, ensuring a minimum contact surface). Successively, the vessel was filled with distilled water so that the water level would reach at least 2 cm above the upper edge of the test pieces after their immersion. To make the test pieces sink, non-absorbing plastic “strut braces” of circular cross-section were used minimizing simultaneously the contact surface. These “strut braces” were so long to push the test piece into a suitable depth after the vessel was closed thus ensuring the necessary submersion. The scheme of the test piece position during the test is evident from Fig.1, while the real situation is shown in Fig. 2.

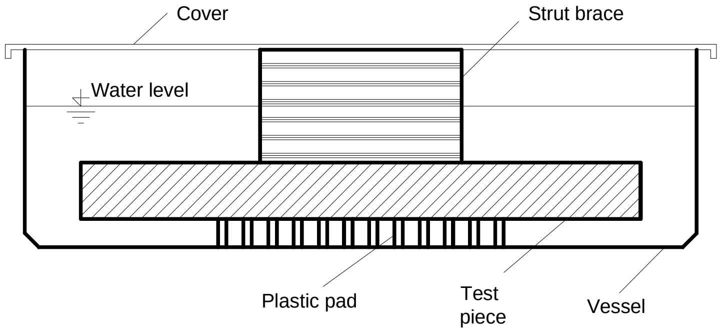

Fig. 1. Scheme of a test piece in the vessel

The test piece immersed as described above was monitored in various time intervals for a period of 6 weeks. Prior to each measurement of its weight and dimensions it was taken out of water and put in a vertical position, was left to drip for a period of 1 minute and successively its dimensions and weight were determined to specify volume changes and absorption capacity. All the time, the test pieces were handled in a vertical position.

This methodology was taken over from the OTP draft Antivibration mats in the substructure body.

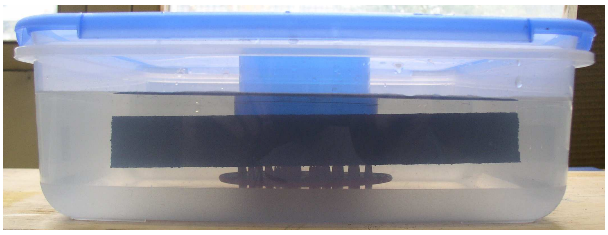

Fig. 2. Test piece in the vessel

2.2. Measurement results

The rate of absorption *n* is expressed by the formula:

$$n = \frac{100 \cdot (M_t - M_0)}{M_0} [\%] \tag{1}$$

where M_0…weight of a test piece after drying weighed in the air [g],

M_t…weight of a test piece saturated with water, wiped with damp cloth weighed in the air [g].

The measurements provide us with information on not only the rate of absorption itself, but also the changes in the volume of AVM samples during the testing period. The results of all measurements are evident from Charts 1 and 2.

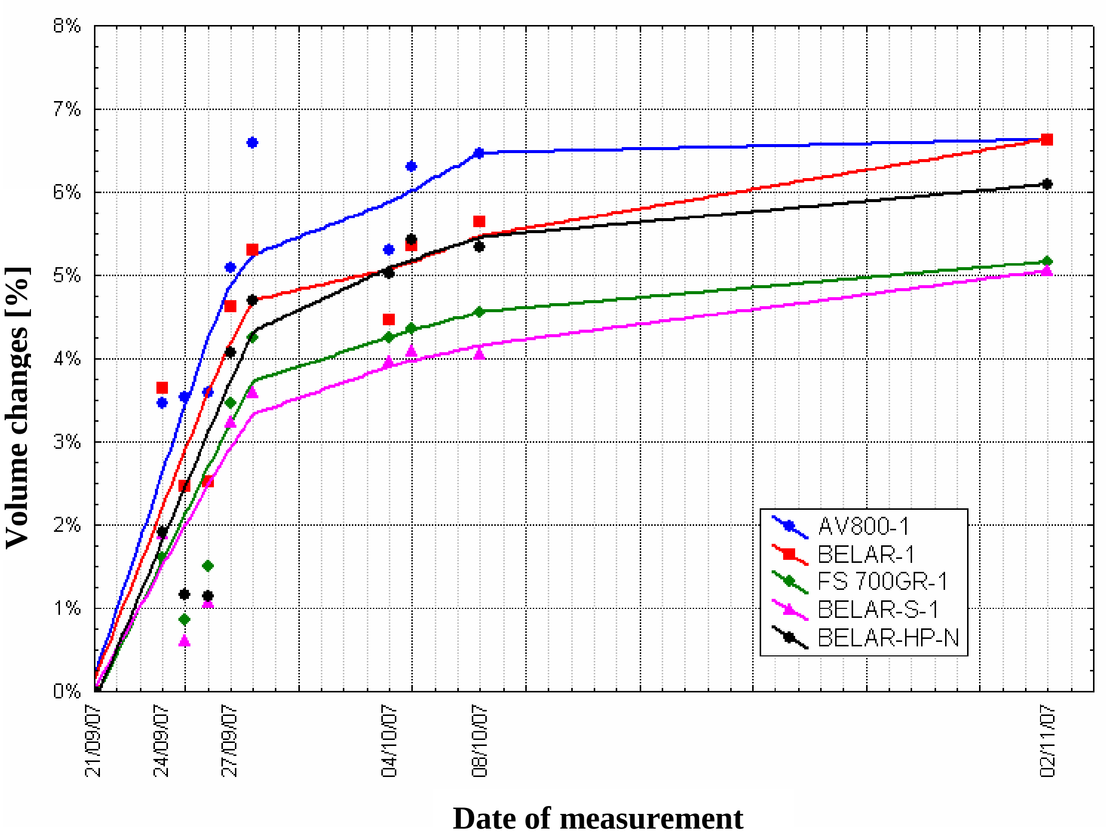

Chart 1. Changes in AVM volumes

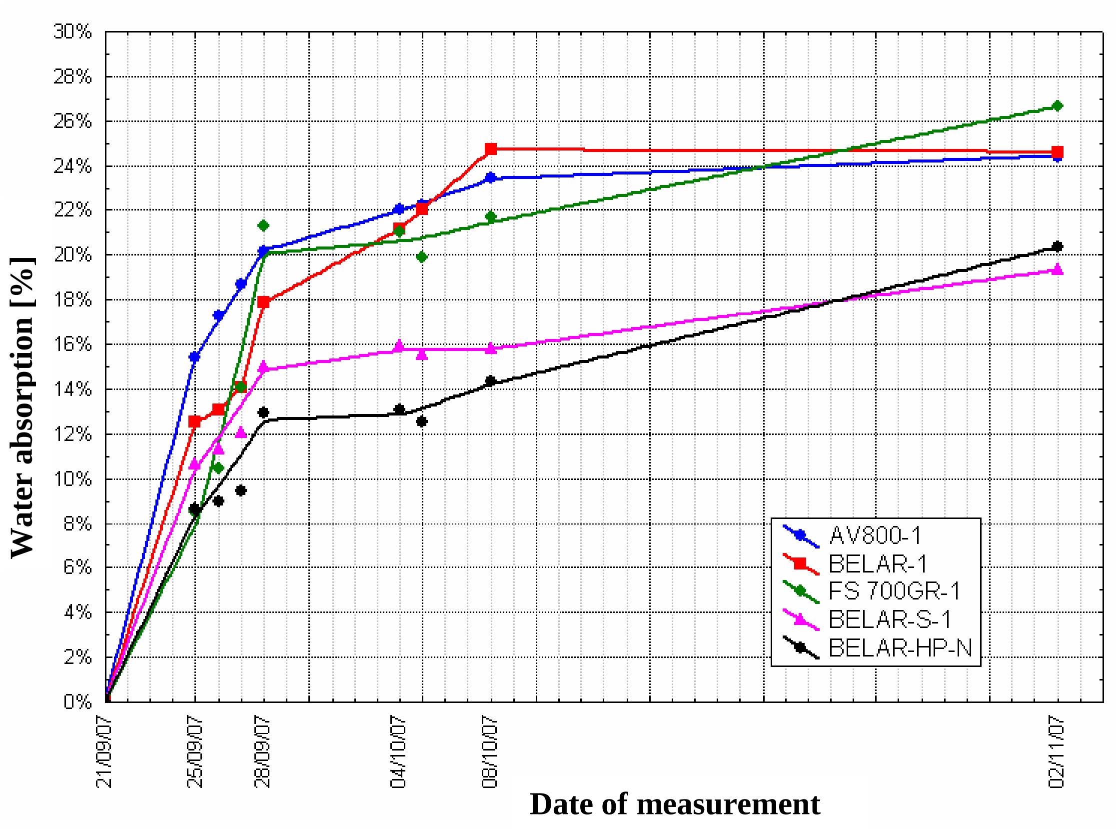

Chart 2. AVM water absorption

3. Measurement of AVM overall static stiffness

The overall static stiffness $C_{(A)stat}$ [N.mm^{-3}] is a basic elasticity characteristic of AVM. Prior to the start of absorption tests, overall static stiffness was measured on samples with dimensions of 200 x 200 mm in accordance with the German methodology (the test procedure is described below). Immediately after the end of water absorption measurements, this test was repeated and the effect on changes in overall static stiffness of saturated AVM was determined.

3.1. Measurement procedure

A test piece is placed between two load plates and inserted in an experimental hydraulic press. The upper load plate is evenly fitted with four path indicators so that the test piece compression may be monitored. The test piece is loaded in three loading cycles at a speed of 1 mm/min. The maximum value of stress in each measurement cycle must reach the value of the upper stress increased by 10 %. The minimum value of stress in each loading cycle must reach the value of the lower stress decreased by 50 %. The loading force and test piece compression are continually monitored during loading (Lidmila, 2007).

3.2. Measurement results

The results of overall static stiffness of unsaturated and saturated samples are compared in Table 2 and Chart 6.

Table 2: Required values of overall static stiffness of antivibration matting in relation to design speed

Overall static stiffness $C_{(A)stat}$ [N.mm^{-3}]			
	Unsaturated samples	***Saturated samples***	***Difference in %***
AV800-1	*0.175*	*0.142*	*19%*
BELAR-1	*0.057*	*0.054*	*5%*
FS700GR-1	*0.122*	*0.085*	*30%*
BELAR-S-1	*0.077*	*0.072*	*6%*
BELAR-HP-N	*0.072*	*0.067*	*7%*

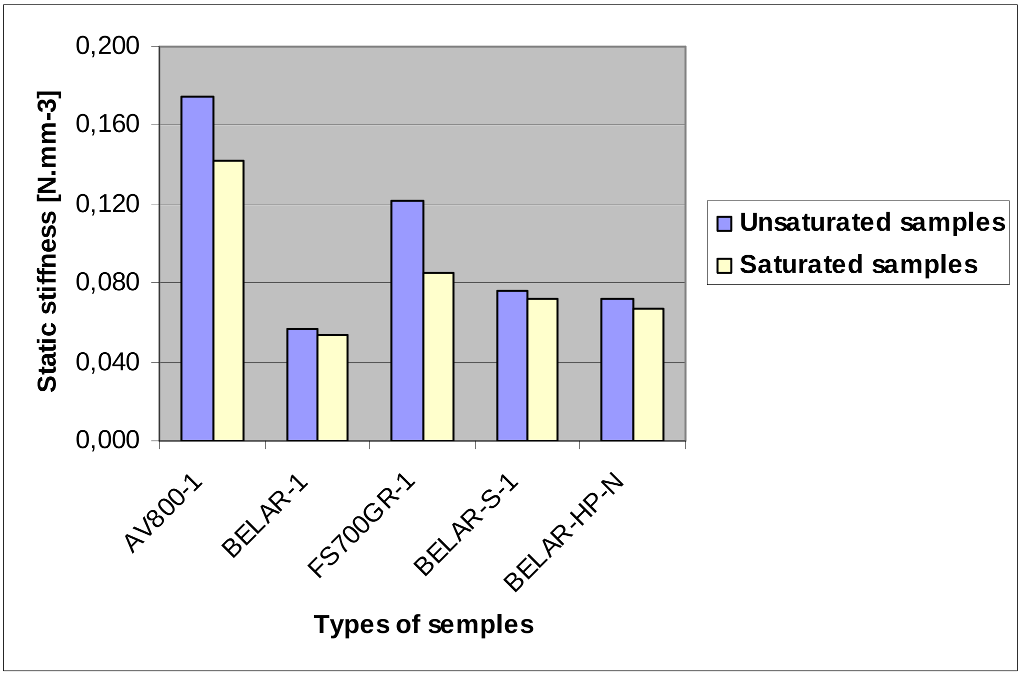

Chart 3. Comparison of overall static stiffness of unsaturated and saturated samples

4. Conclusion

The charts of AVM water absorption and overall static stiffness measurements lead to the following conclusions:

- Volume changes in all AVM types exceeded 5% of their original volume, which is undesirable in the substructure body construction.
- All AVM types exceeded the maximum water absorption of 10%.
- The measurement of the overall static stiffness of unsaturated and successively saturated AVM revealed that the overall static stiffness of saturated samples is in all cases lower than that of unsaturated samples.

This result was achieved with financial support from MŠMT ČR, project 1M0579.

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Investigating the Optimum Design of Steel Portal Frame Using Genetic Algorithms

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Abstract:
This paper presents a structural optimisation based on modified distributed genetic algorithm (DGA) as a family of parallel genetic algorithm. The technique is developed to deal with discrete optimisation of steel portal frame. In order to have a realistic design and imitate the displacement and strength limitations, the DGA has been linked to BS5950 code of practice. Although the appearance of steel portal frames is simple, many complicated limitations and different structural criteria which are considered in complex structures must be taken into account. As the behaviour of steel portal frames necessitates using universal beam for both column and rafter, the algorithm selects the universal beam cross-sections from a standard table given in code of practice. In addition, it determines the minimum length and depth of haunch satisfying the limitations in order to reduce the weight and reach the most cost-effective form. Formulation of the design is based on elastic method. The objective function is in terms of total weight of frame as it gives a reasonable accurate cost of frame. A pitched roof steel portal frame has been designed to check its practicability.

Keywords:
Steel Portal Frames, Optimisation, Distributed Genetic Algorithm

1. Introduction

Single storey buildings are widely used in the UK; it is estimated that 50% of the single storey steel work buildings are constructed by portal frames (Salter et al, 2004). Because of its economy and versatility for large spans in construction of pitched roofs like shopping centres, warehouses, retail shops, pools, factories, etc, the steel portal frame has become the most often used structure within this sector. Furthermore, those aforementioned places need to have a large span without using intermediate columns and therefore it necessitates using steel portal frames whereas the steel yields economical solution for large spans (Saka, 2003). A number of steel portal frames are commonly available of which the pitched roof type is more popular. The design of steel portal frames can be carried out using either elastic or plastic methods.
Any structural designer attempts to conduct an economical design. This can be achieved by formulating a design problem as an optimisation problem and solving by a systematic way of optimisation and considering the limitations of a code of practice to control the safety of the structure (Toropov and Mahfouz, 2001). However, due to large number of iterations in implementing the optimisation technique, it cannot be achieved by using the designer's experiences and intuition. Optimisation is a mathematical way to seek the minimum and

maximum of a certain function. As the major cost of structural steelwork is its own weight, it has been endeavoured to minimise the weight using a systematic way of optimisation. In general, optimisation technique in structural engineering can be categorised into three different approaches: 1) Mathematical programming, 2) Optimality criteria methods and 3) Heuristic search technique (Camp et al. 1998). During the past decades, the attempts have been made to use any of the three aforementioned methods, see for example the work of Rizzi (1976); Arora (1980); Allwood and Chung (1984); Lin and Liu (1989); Krisch (1991); Saka (1991); Chang (1992) and Rozvany & Zhou (1993). Heuristic search method became the best option for dealing with discrete design variables, (Camp et al. 1998). Genetic algorithm as a sort of heuristic search method has been added to the optimisation technique. Genetic algorithm is the strategy that models a genetic evolution (Holland, 1975; Goldberg, 1989). Its core characteristic is based on the simulation of Darwinian 'Survival of the Fittest' theory and adaptation. A remarkable advantage of genetic algorithm appears when it does not require an explicit relation between objective function and constraints while this relation has to be defined using the mathematical programming and optimality criteria method. Genetic algorithm has been successfully implemented in structural optimum design by many researchers during the earlier past decades including the work of Rajeev and Krishnamorthy (1992); Adeli and Cheng (1993, 1994); Adeli and Kumar (1995); Camp et al. (1998); Mahfouz (1999); Pezeshk et al. (2000); Kameshki and Saka (2001); Toporov and Mahfouz (2001); Foley and Schinler (2003); Balling et al. (2006) and Liu et al. (2007).

Genetic algorithm (GA) as a robust and efficient technique can achieve the aforementioned requirements. The simple genetic algorithm, however, has quite low speed process. Therefore, the author has attempted to modify the simple GA in order to accelerate its operation. In this paper a Distributed Genetic Algorithm (DGA) has been chosen to minimise the weight of the pitched roof steel portal frame satisfying the limitations given in BS 5950 code of practice. As the genetic algorithm is used for unconstraint problems, therefore a penalty is used to bring a constraint problem into unconstraint one.

The basic mechanics of the GA is based on randomised procedures of selecting and reproduction of the population of individuals and copying the fittest individuals into the next generation. A basic GA consists of three main operators; reproduction, crossover and mutation. In the reproduction stage, a set of population are selected for mating depending on their fitness value which represent the objective function including the penalty function for any violation of constraints.

2. Distributed Genetic Algorithm

In DGA, the performance of conventional GA is improved by some minor modifications in its main algorithm that leads to quicker convergence and higher searching capability compared to conventional GA (Starkweather et al. 1990; Mühlenbein et al. 1991).

The DGA adopted in this paper can be described according to the following steps:

1) The parameters of DGA are specified.
2) The initial population are randomly selected for each group of population.

3) The objective function of each individual design is calculated. This is achieved by analysing the frame using the selected design variables (area of the section) and checking the feasibility of each individual with the constraints. For any violation of the constraint, a penalty is imposed. The penalised objective function is calculated (PF_i).
4) The smallest and largest penalised objective function (PF_{min} & PF_{max}) are specified.
5) The fitness function is evaluated for each individual design applying the formula

$$FF_i = PF_{min} + PF_{max} - PF_i \qquad \text{Eq. 1(a)}$$

6) The average fitness value is calculated

$$PF_{av} = \frac{\sum_{i=1}^{PopNo} FF_i}{PopNo} \qquad \text{Eq. 1(b)}$$

7) The individuals whose fitness values are below the average one are killed.
8) For the survived population new largest value of the penalised objective function is found which is slightly above the average fitness value and the new fitness values are evaluated.

$$PF_i^{new} = PF_{smal} + PF_{l\arg e}^{new} - PF_i \qquad \text{Eq. 1(c)}$$

9) The probability of all the survived individuals are calculated using

$$P_i^{Surv} = \frac{FF_i^{new}}{\sum_{j=1}^{SurvNo} FF_j^{new}} \qquad \text{Eq. 1(d)}$$

10) Using the percentage of elitism, find the best individuals among the survived population of each group.
11) The rest of the population are undergoing the crossover operation whereas the increment rate is specified the number of offspring produced by crossover operation for each group of population.
12) For each defined interval of the generation, the migration is taken place. Relying on the rate of migration, the best individuals of the groups (except that group 1) are migrating to the first group.
13) The termination conditions are checked. In this study, three termination conditions are used and if any one of them is satisfied then the process terminates.
    a. If during the 30 successive generations the fittest individual are not changed or the difference between their fitness values are very small, then the termination will take place. The formula below shows the explicit relationship between the fittest individual, F^{GenNo} and a range of small value R^{GenNo}.

$$\frac{F^{GenNo} - F^{GenNo-30}}{F^{GenNo}} \leq R^{GenNo} \qquad \text{Eq. 1(e)}$$

    b. While the genetic process proceeds, the best individuals are about to be selected. That causes the average of the fitness value to converge the best fitness value. Therefore, it necessitates defining another termination condition in terms of average fitness value so that the difference ratio between the average fitness value and the best individual's fitness value is limited as R^{avg}.

$$\frac{F^{GenNo} - F^{avg}}{F^{avg}} \leq R^{avg} \qquad \text{Eq. 1(f)}$$

    c. When the maximum allowable number of generation is reached.

14) Each gen of the strings is mutated depending on the adopted probability.

$$P_m^{N_{Gen}} = P_m^{\min} + \frac{GenNo - N_{Gen}}{GenNo}(P_m^{\max} - P_m^{\min}) \qquad \text{Eq. 1(g)}$$

15) The step 3 to step 14 must be repeated until one of the termination condition achieves.

3. Analysis

The elastic analysis of the pitched roof steel portal frame was conducted using two different stiffness matrices. A conventional stiffness matrix was applied for the prismatic member and a derived stiffness matrix for non-prismatic member whereby the haunched rafter was analysed. The non-prismatic stiffness matrix was derived using the virtual work method and column analogous (Ghali et al. 2003). Virtual work was implemented to derive the axial stiffness coefficient. Whereas, column analogy was employed to derive the non-prismatic stiffness matrix for bending and shear effect. Accordingly, the axial stiffness coefficient is:

$$K = \frac{E}{2L}(A_1 + A_2) \qquad \text{Eq. 2}$$

while the stiffness matrix for shear and bending is (*EI* changes in terms of *x*):

$$[S] = \begin{bmatrix} \frac{E}{2L}(A_1+A_2) & 0 & 0 & -\frac{E}{2L}(A_1+A_2) & 0 & 0 \\ 0 & \frac{1}{\int \frac{x^2}{EI}dx} & \frac{L_1}{\int \frac{x^2}{EI}dx} & 0 & -\frac{1}{\int \frac{x^2}{EI}dx} & \frac{L_2}{\int \frac{x^2}{EI}dx} \\ 0 & \frac{L_1}{\int \frac{x^2}{EI}dx} & \left(\frac{1}{\int \frac{1}{EI}dx} + \frac{L_1^2}{\int \frac{x^2}{EI}dx}\right) & 0 & -\frac{L_1}{\int \frac{x^2}{EI}dx} & \left(-\frac{1}{\int \frac{1}{EI}dx} + \frac{L_1 L_2}{\int \frac{x^2}{EI}dx}\right) \\ -\frac{E}{2L}(A_1+A_2) & 0 & 0 & \frac{E}{2L}(A_1+A_2) & 0 & 0 \\ 0 & -\frac{1}{\int \frac{x^2}{EI}dx} & -\frac{L_1}{\int \frac{x^2}{EI}dx} & 0 & \frac{1}{\int \frac{x^2}{EI}dx} & -\frac{L_2}{\int \frac{x^2}{EI}dx} \\ 0 & \frac{L_2}{\int \frac{x^2}{EI}dx} & \left(-\frac{1}{\int \frac{1}{EI}dx} + \frac{L_1 L_2}{\int \frac{x^2}{EI}dx}\right) & 0 & -\frac{L_2}{\int \frac{x^2}{EI}dx} & \left(\frac{1}{\int \frac{1}{EI}dx} + \frac{L_2^2}{\int \frac{x^2}{EI}dx}\right) \end{bmatrix} \qquad \text{Eq. 3}$$

In the special case, when *EI* is constant, $L_1 = L_2$ and $A_1 = A_2$ then the stiffness matrix degenerate to what is used for the prismatic members.

4. Design to BS5950

BS 5950 states that when an elastic analysis is used for the design of steel framework such as the one shown in Fig. 1, the capacity and buckling resistance should be calculated. It is required to use the effective length equal to that between two intermediate restraints.

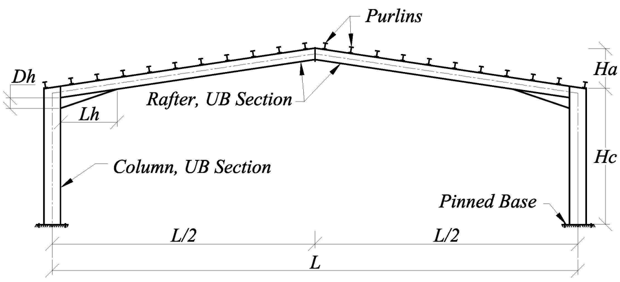

Fig. 1. Typical pitched roof steel portal

The members or portion of members restrained should satisfy the conditions to ensure the stability between two effective torsional restraints. For the prismatic members the following requirement should be satisfied:

$$\frac{F}{P_c} + \frac{mM_A}{M_b} \le 1 \qquad \text{Eq. 4(a)}$$

and for the haunch part (i.e. non-prismatic member):

$$\frac{F}{A} + \frac{M}{S_x} \le p_b \qquad \text{Eq. 4(b)}$$

5. Optimum Design

In the design of pitched roof steel portal frames, it is common to have the same universal beam section for the both rafters and a different universal beam sections for the columns. For the reason of economy, the same section of rafter is used to produce the haunch. Fig. 2 shows more details of the haunched rafter section. Therefore, the optimum design of the pitched roof steel portal frame necessitates using two design variables; one for rafter and its haunch and another for the columns. However, if it is necessary to use different section for the haunched section, the number of design variables increases to three. Moreover, due to the complexity of the design constraints in the formulation of the design problem only vertical gravity load is considered at this stage.

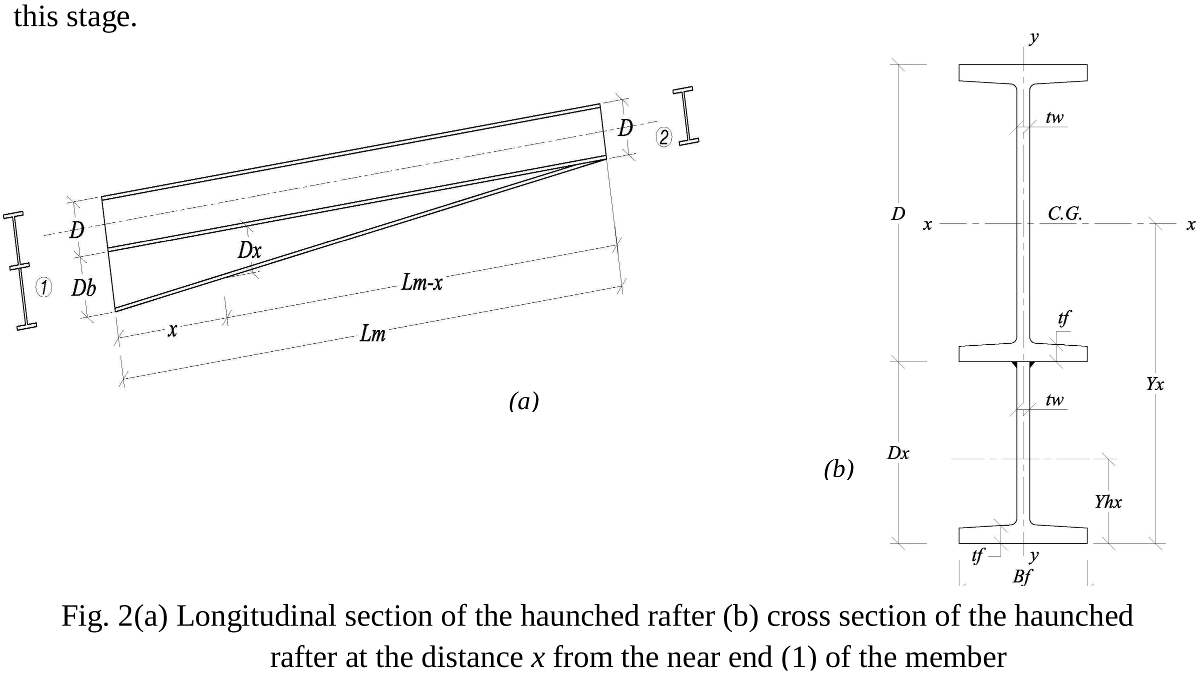

Fig. 2(a) Longitudinal section of the haunched rafter (b) cross section of the haunched rafter at the distance *x* from the near end (1) of the member

The design of pitched roof steel portal frame with haunched eaves when the objective is obtaining minimum weight and the constraints are implemented according to BS 5950 has the following form of formula:

Minimise $w = w_m + w_h = \sum_{i=1}^{GrNo} G_m \sum_{j=1}^{MemNo} L_w + \sum_{k=1}^{HauNo} H_w$ Eq. 5 (a)

Subjected to:

$\delta_i \le \delta_{iu}$ *i=1, 2, 3 …., JointNo* Eq. 5 (b)

$\frac{F_j}{A_{gj} p_y} + \frac{M_{xj}}{M_{cxj}} \le 1$ *j=1, . . . , MemNo* Eq. 5 (c)

$\frac{F_j}{A_{gj} p_{cj}} + \frac{m_j M_{xj}}{M_{bj}} \le 1$ *j=1, . . . , MemNo* Eq. 5 (d)

$\frac{F_k}{A_k} + \frac{M_k}{S_{xk}} \le p_b$ *k=1, 2, . . . , TapMNo* Eq. 5 (e)

$\frac{F_n}{P_{cn}} + \frac{\overline{M}_d}{M_{bn}} \le 1$ *n=1,2, … , UniMNo* Eq. 5 (f)

Eq. (5b) checks the displacement of the joints. BS 5950 has limited the horizontal displacement of the joints to column/300 and the upper limit of the beam deflection is span/360. Inequality (5c) defines the load capacity check for beam-column with semi-compact or slender cross section. Inequality (5d) is the simplified approach of the overall buckling check for beam-column. Inequalities (5e) and (5f) define the stability constraints for rafters and columns respectively where the compression flange is unrestrained.

The solution of the optimum design problem is given in Eq. (5a) necessitates selecting universal beam section from the table of standard section for rafters, columns and haunched section. This manipulates using the discrete design variables. Implementing mathematical programming on the discrete problems require discretising the problems which does not give an efficient solution and is somewhat cumbersome. Alternatively, genetic algorithm can handle with discrete design variable and can give the efficient optimum solution.

6. Solution by Distributed Genetic Algorithm

The optimisation of the pitched roof steel portal frame is based on distributed genetic algorithms. The individuals (design variables) are the area of the standard steel sections table. The author has decided to formulate the mutation probability (Eq. 1(g)) to check its suitability and effect on the convergence of the solution. The mutation probability was used as constant by researchers Adeli and Cheng (1993, 1994), Pezeshk et al. (2000) and Saka (2003, 2007). In addition, a probability has been given to produce the greater offspring than the usual by the same parents (Fig. 3, increment rate of population) to increase the number of population and likely get the best individuals in the earlier stage of the solution. As the DGA can only handle unconstraint objective function, a penalty function has to be introduced to include the constraints in calculations. There are different types of the penalty function which can be used in GA such as linear double segment, linear multiple segment and quadratic penalty functions (Adeli and Cheng, 1994). In this paper the transformation of the constraints given in Eq. 5 is based on the violation of the normalised constraints according to following rearrangement (Rajeev and Krishnamoorthy, 1992).

$$g_i = \frac{\delta_i}{\delta_{iu}} - 1 \le 0 \qquad i=1, 2, 3 \ldots, JointNo \qquad \text{Eq. 6(a)}$$

$$g_j = \begin{cases} \left(\dfrac{F_j}{A_{gj} p_y} + \dfrac{M_{xj}}{M_{cxj}}\right) - 1 \le 0 \\ or \\ \left(\dfrac{F_j}{A_{gj} p_{cj}} + \dfrac{m_j M_{xj}}{M_{bj}}\right) - 1 \le 0 \end{cases} \qquad j=1, \ldots, MemNo \qquad \text{Eq. 6(b)}$$

$$g_k = \frac{\dfrac{F_k}{A_k} + \dfrac{M_k}{S_{xk}}}{p_b} - 1 \le 0 \qquad k=1, 2, \ldots, TapMNo \qquad \text{Eq. 6(c)}$$

$$g_n = \left(\frac{F_n}{P_{cn}} + \frac{\overline{M}_d}{M_{bn}}\right) - 1 \le 0 \qquad n=1,2, \ldots, UniMNo \qquad \text{Eq. 6(d)}$$

The unconstraint function P is then constructed by adding the normalised constraints to the objective function as in the following

$$P = W\left(1 + C\sum_{m=1}^{ConNo} Z_m\right) \qquad \text{Eq. 7}$$

Where W is the objective function given in Eq. 5(a), C is a constant to be selected depending on the problem under consideration which for this study it is taken as 10 and Z_m is the violation coefficient determined as

$$\text{If } g_m > 0 \text{ then } Z_m = g_m$$
$$\text{If } g_m \le 0 \text{ then } Z_m = 0 \qquad \text{Eq. 8}$$

Saka (2003) has designated C as 10 after several trials he carried out. The unconstraint function (Eq. 7) is used to obtain the fitness value of individuals according to the Eq. 1 (c). The chosen number of population for each group was found after several trials to be 30. The adopted number of group is 2.

For the purpose of implementing the DGA, software was developed by the author known as Optimum Design of Steel Portal Frames (ODSPF). Visual Basic Language was employed to code ODSPF. A part of software is depicted in Fig. 3 which shows up the input genetic parameters.

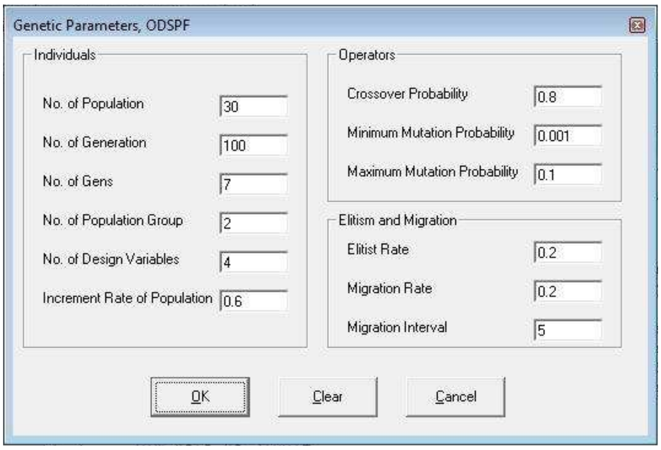

Fig. 3. The genetic parameters which have been input for this study into one of ODSPF

7. Design Example

A typical pitched roof steel portal frame with pinned supports was selected to test the efficiency of the developed DGA. The relevant data and diagram of the structure are presented in Table 1 and Fig 4 respectively. The problem has already been solved by Saka (2003) using simple GA. Unlike the example designed by Saka (2003), the frame is not subdivided into a large number of elements of relatively small lengths. Instead, the overall numbers of the frame members was taken as six: two for columns, two for rafters and the rest for haunched part of the rafter. This outperforms the operation speed of the algorithm as the less number of members, the more speed of the analysis of the frame will be, hence the convergence will dramatically be improved. Eighty steel sections from the standard steel tables given in Steel work Design Guide to BS 5950 are employed as design variables while Saka (2003) used 64 sections to have 2^6 upper limit. The final optimum design is shown in Fig. 5. This achieved after 10 re-designs running of the pitched roof steel portal frame with varied seeds as presented in Table 2. Initially running the program took place 50 times, but later it was found out that the optimum design obtained with 10 runs revealed the same result as 50 runs. Therefore for saving the time of calculation, it was adopted to re-design the frame in 10 times.

Table1: The required data for design of the pitched roof steel portal frame

Span, m	Column, m	Purlin Space, m	P, kN	Modulus of Elasticity, E, kN/m^2	Haunch Depth Range & increment, cm	Haunch Length Range & Increment, m
20	5	1.25	5	200	10 – 74, & 2	0.5 – 5, & 0.25

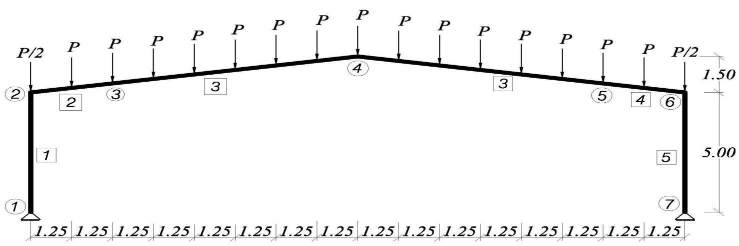

Fig. 4. The pitched roof steel portal frame of the example

It is observed from Table 2 that, whatever the number of generation increases, the likelihood of getting the optimum or near optimum solution is raised. Due to inputting a smaller value for the max mutation probability and consequently premature convergence of Run 6, the optimum result has been booked as heaviest. This was achieved after 36 generations. The design carried out for different applied load values and the best output is collected into Table 3 with the associated frame weight. It is clear that whatever the applied load increases the weight of the frame turns to be heavier and the depth of the haunch turned to be smaller, because the heavier member necessitates having smaller depth of haunch. Furthermore, the obtained designed is compared with what was done by Saka (2003) using simple genetic algorithms. The implemented DGA increased the speed of the operation and the convergence took place after 63 generations which took 204 seconds of physical time (using Pentium 4, 2.40 GHz CPU, with 512 MB RAM). Also the obtained depth of the haunch for each seed is less than that designed using simple genetic algorithms. The reason refers to the reduction in number of considered members for design and using the derived non-prismatic stiffness matrix. The depth of the haunch is required to be less than the section depth of the rafter. However, some of the design run reveals that the depth of the haunch exceed that of the rafter. It therefore, raises the requirement for adding another constraint which will restrict any exceeds in the depth of the haunch. This constraint could be defined as $D_h < (D - t_f - r)$. This makes it possible to use the same section of the rafter for the haunch. By making a comparison between Fig. 5 and Fig. 6, it can be realised that adding the aforementioned constraints resulted in a heavier frame which caused an increasing in the weight by 20.02%.

Fig. 7 shows the convergence of the problem into optimum solution. After reaching the 63rd generation, the best individual dominated consistently in the population. This refers to the application of elitism and migration strategy which caused a convergence within a few generations. As a consequence, it saved the time consuming for checking the constraints and performing the analysis accordingly. Fig. 8 depicted the percentage of domination the best individual after certain number of generation.

Table 2: Result of the optimum solution from different Run for P=5kN

Run	Section Designation		Depth of Haunch, m	Length of Haunch, m	Generation No. for Optimum Design	Weight, kg
	Column	Rafter				
1	457x191x89 UB	356x127x33 UB	0.38	3.00	59	1562.3
2	457x191x74 UB	356x127x39 UB	0.40	3.25	71	1530.3
3	457x191x89 UB	356x171x45 UB	0.36	2.75	46	1902.7
4	457x191x74 UB	356x127x33 UB	0.40	3.25	63	1515.9
5	457x191x74 UB	356x171x45 UB	0.38	3.50	49	1774.8
6	457x191x98 UB	356x171x67 UB	0.32	1.50	36	2415.8
7	457x191x74 UB	356x127x33 UB	0.42	3.50	64	1528.6
8	457x191x74 UB	356x127x33 UB	0.42	3.25	67	1520.3
9	457x191x82 UB	356x171x67 UB	0.30	2.0	41	2124.2
10	457x191x98 UB	356x127x33 UB	0.28	1.75	48	1694.6

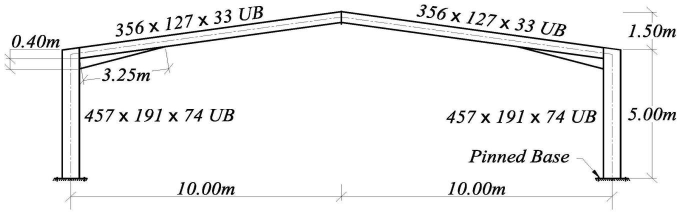

Fig. 5. The best optimum design from 10

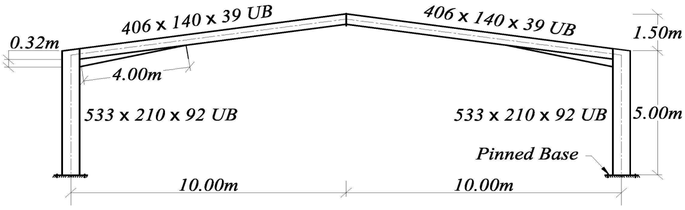

Fig. 6. The best optimum design accounting the haunch depth

Table 3: Optimum design parameters for different load values

Load P, kN	Section Designation		Depth of Haunch, m	Length of Haunch, m	Weight, kg	Weight, kg By Saka (2003)
	Column	Rafter				
5.0	457x191x74 UB	356x127x33 UB	0.40	3.25	1515.9	1521.4
7.5	610x229x101 UB	406x140x39 UB	0.36	3.00	1893.6	1903.7
10.0	610x229x101 UB	406x178x54 UB	0.26	3.00	2202.9	2260.0
20.0	610x229x140 UB	533x210x92 UB	0.14	2.25	3334.3	3224.0
30.0	914x305x210 UB	610x229x101 UB	0.12	2.75	4141.8	4197.7

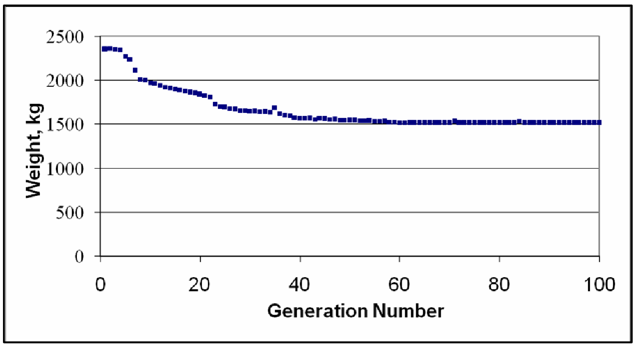

Fig. 7. Converging of the design to Optimum Solution when P=5kN

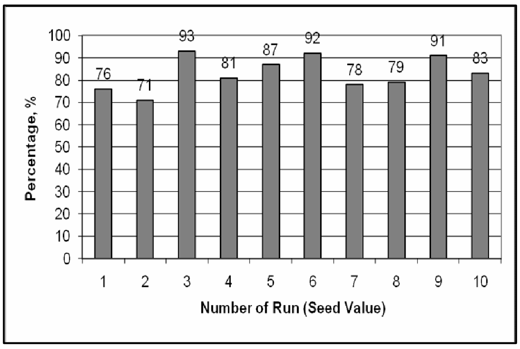

Fig. 8. Percentage of domination of best individual in each run

8. Conclusion

The distributed genetic algorithm was presented to investigate the optimum design of the pitched roof steel portal frame. The algorithm was linked to a data base containing the standard universal beam sections table. The performance of the algorithm was checked by comparing it with the simple genetic algorithm. The design obtained by using the DGA was slightly lighter than the design obtained by simple genetic algorithms. In addition, the optimum design was achieved after a small number of the generation. This shows the great capability of the DGA to converge into the optimum or near-optimum solution rapidly. The derived stiffness matrix for non-prismatic member played the great role to reduce the depth of the haunch and consequently the total weight of the structure. In fact, it could handle the analysis of the frames with tapered members. Using the seed, representing the number of design running increased the likelihood of getting the best design among different runs. This improves the possibility to cover more domains of the design spaces. As a result, it potentially eliminates any entrapment into local optimum. The developed software ODSPF uses DGA, the derived stiffness matrix and formula of the mutation to reach the optimum solution of steel portal frame within a certain number of generations. By gradually decreasing the mutation probability as the generation increases, the premature convergence of the solution (which could lead to a non-optimal solution) can be avoided. Producing more offspring raised the likelihood of having the best individuals in earlier stages of the solution.

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Notations:

A_1 and A_2 : The areas of member ends
A_{gj} : Gross cross sectional area of the member *j*
ConNo : Total number of the constraints
D_h Depth of the flange
E : Modulus of Elasticity
F^{avg} Average fitness value of the population
FF Fitness value of individuals
F^{GenNo} Fitness value of the current generation
F_j : Applied axial force at the critical region of the member *j*
GenNo : Number of generation
G_m : Group of member from the table of standard sections
GrpNo : Number of population group
H_w : Weight of the haunched eaves
I : Moment of the inertia
JointNo Total number of frame joints
K : Stiffness Coefficient
L : Length of the member
L_w : Member weight
m : Equivalent uniform moment factor
M Equivalent uniform moment
M_b buckling resistance
M_{bj} : Buckling resistance moment capacity for member *j* about its major axis (Clause 4.3.7 of BS5950)
M_{cxj} : Moment capacity of the member about the major axis
M_k Applied moment in member k
M_{xj} : Bending moment around the major axis at the critical region of the member *j*
MemNo : Total number of the members
N_{Gen} : Current generation
p_b Bending strength
P_c Compression resistance
P_c : Crossover probability
p_{cj} : Compression strength obtained from the solution of the quadratic Perry–Robertson formula
P_{en} : Increment rate of population
P_E : Elitism rate
P_i Survival probability of the individual *i*
P_m : Mutation probability
$P_m^{\max}$: Maximum range of mutation probability
$P_m^{\min}$: Minimum range of mutation probability
$P_m^{N_{Gen}}$: Mutation probability in current generation
P_{mig} : Migration rate
p_y : Bending strength
PF Penalised fitness value of the individuals
PF_{max} Maximum penalised fitness value of the current population
PF_{min} Minimum penalised fitness value of the current population
PopNo : Number of population in each group
r root radius of the universal beam section
S_x plastic modulus of a section about x–x axis
TapMNo : Number of tapered members
t_f Thickness of the flange
UniMNo : Number of the uniform member
δ_i : Displacement at joint *i*
δ_{iu} : Upper limit displacement of the joints

Multi-objective optimization of nanoindentation model parameters

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Abstract:
Optimization of material parameters from a finite element nanoindentation model is discussed in this paper. An experimental method called nanoindentation allows testing physical properties of heterogeneous material in the scale of their components. This testing is very expensive therefore it is effective to use numerical models. The target of the optimization is to find input material parameters for the model to achieve the best agreement between the numerical response and the experiment. For that, a forward mode of the inverse analysis was applied. As an optimization algorithm, the multi-objective evolutionary algorithm PAES was used. Objective functions are based on a difference between an optimized curve and a result from the model. Results of the method are presented on a set of illustrative problems created by computer-generated data. From the point of view of efficiency and accuracy, the proposed methodology provides a promising alternative to the existing approaches.

Keywords:
Evolutionary algorithms, Inverse analysis, Multi-objective optimization, Nanoindentation, Pareto set.

1. Introduction

A variety of engineering tasks nowadays lead to an inverse analysis problem. Generally, the aim of an inverse analysis is to rediscover unknown inputs from the known outputs. In common engineering applications, a goal is to determine the initial conditions and properties from physical experiments or, equivalently, to find a set of parameters for a numerical model describing the experiment. Therefore, existence of such numerical model is assumed in this work and the task is to find parameters of this model to match outputs from model with results from the experiment.

In overall, there are two main philosophies as a solution of this problem. A **forward** (classical) mode/direction is based on the definition of an error function of the difference between outputs of the model and experimental measurements. A solution comes with the minimum of this function. The second philosophy, an **inverse mode**, assumes existence of an inverse relationship between outputs and inputs. If such relationship is created, then, the retrieval of desired inputs is a matter of seconds yet repeatedly.

An application of a *forward mode* is introduced in this contribution. As a goal, the identification of material parameters of a finite element nanoindentation model is presented. Generally, the forward mode leads to a multi-modal optimization problem. Here, this problem is solved by a multi-objective solution.

2. Nanoindentation: the method and the model

Nanoindentation is an experimental method (Němeček et al., 2006), which allows testing the physical properties of materials on the scale of the typical dimension of individual components. It is based on loading the testing material by a very sharp and rigid point (see Fig. 1). This testing is very financial demanding; hence it is useful to use numerical models instead. Because the loading imposed by the indenter introduces highly heterogeneous stress and strain fields, the extraction of the material parameters from the experiment is far from being straightforward. In particular, the closed-form relations are available only for the simplest material models (linear elasticity); more realistic constitutive description leads to a large-scale computational simulation based on, e.g., the Finite Element Method. The problem then is to calibrate the material parameters for the chosen discrete model to achieve the best agreement between the numerical "response" and the experiment.

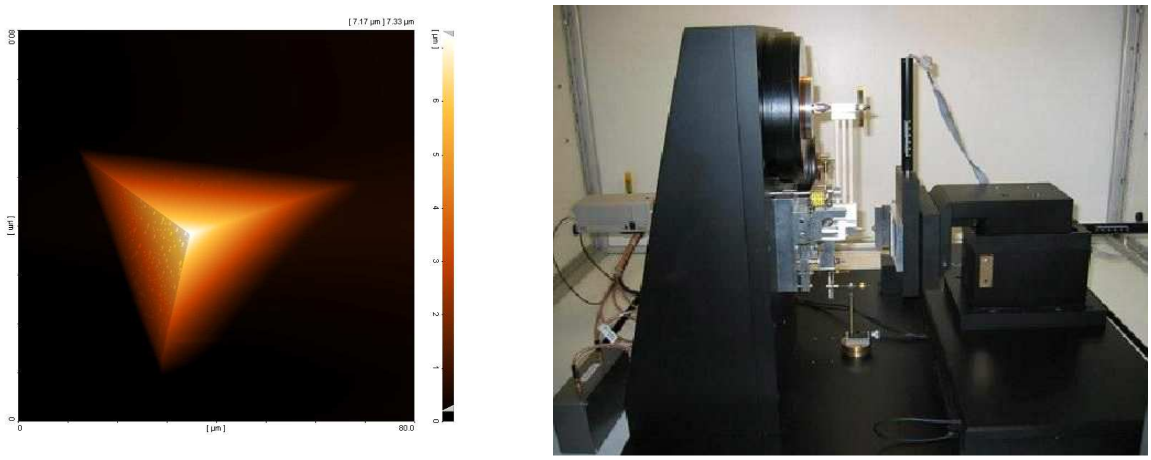

Fig. 1. Picture of indent from atomic force microscope (left) and nanoindenter (right).

In this case physical properties of the cement paste are tested. Specimens are characterized by a 30 mm diameter and a 4 mm height. The water-cement ratio (w/c) is equal to 0.5; a Portland cement CEMI 52.5 N is used. For indentation, Berkovich's indenter with pyramidal shape is applied. The loading is cyclic and is driven by a force in a short period of time (only several minutes). The whole experiment consists of five loading and unloading periods with a small constant force period aimed at creep development, see Fig. 2.

The numerical analysis was implemented using the ADINA software (Adina, 2005). The spatial problem could be solved as a planar problem thanks to axisymmetry (Jůn, 2005). A finite element mesh is decomposed into 1800 isoparametric four-node elements and is refined around the tip. The indenter is ideally rigid and the contact between indenter and paste is updated every iteration.

To properly describe cement paste non-linear behavior, a combined visco-plastic model was chosen. The tensor of the total strain is composed of three parts:

$$\varepsilon = \varepsilon^E + \varepsilon^C + \varepsilon^P$$

where ε^E is time independent elastic part,

ε^C is time dependent creep strain and

ε^P is time independent plastic part.

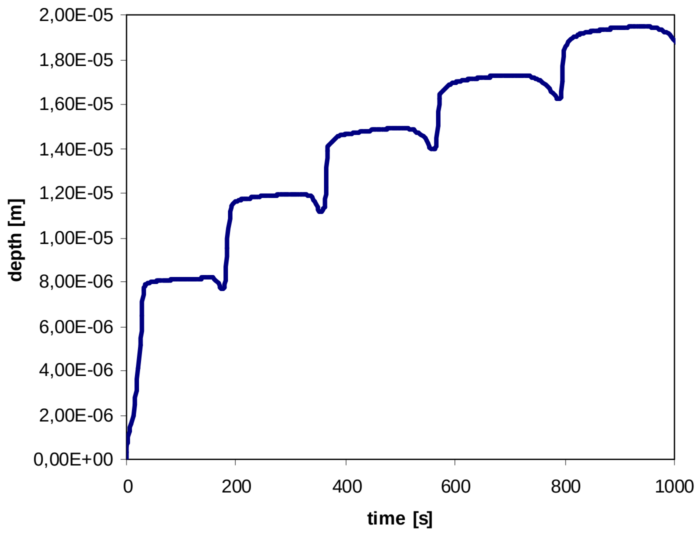

Fig. 2. Typical evaluation of indentation test: depth vs. time curve.

An effective creep strain is described by the power creep law:

$$\varepsilon^C = a_0 \sigma^{a1} t^{a2}$$

where a_0, a_1 and a_2 are free model parameters. Remaining tuning parameters are Young's modulus E and the yield stress σ_y. Bounds for parameters for the identification are stated in Tab. 1.

Table 1: Bounds for nanoindentation model parameters.

Parameters	Units	Minimum	Maximum
E	GPa	15	45
σ_y	MPa	20	600
a_0	-	$1.32 \cdot 10^{-19}$	$1.32 \cdot 10^{-14}$
a_1	-	0.49	2.50
a_2	-	0.05	0.55

3. Identification algorithm

The gradient-based methods are usually considered to be the most computationally efficient optimization algorithms available. For the current model, however, analytical determination of sensitivities is fairly difficult, mainly due to the history dependency of the model as well as complex interaction of individual parameters. As an alternative, techniques of soft-computing can be employed for optimization of complex objective functions (Hrstka et al., 2003). The single-objective optimization using Radial Basis Function Networks and evolutionary algorithm GRADE was tested recently without satisfactory results (Lepš and Vitingerová, 2007).

A majority of realistic optimization problems do not rely on one objective function only but require simultaneous optimization of more objective functions. Several contradicting goals should be satisfy simultaneously, therefore the solution is found as a compromise satisfied partially all of them. One of possible approaches is to merge all objective functions together, for example using weighted sum.

Another approaches search the solution as a set of solutions. Here, multi-objective evolutionary algorithms are usually applied. The scalar concept of optimality has to be replaced with Pareto optimality within the multi-objective optimization. Pareto optimal solutions present a set, for which no better set can be found while minimizing (or maximizing) all objective functions together. The result of optimization is found as a Pareto set that is a set of Pareto optimal solutions.

No application of the multi-objective identification algorithm has been published yet to the best knowledge of authors. Several applications of the multi-objective approach can be found e.g. in the domain of material design, see, for instance, (Egorov-Yegorov and Dulikravich, (2005)) or a special issue of Materials and Manufacturing Processes (2007). However, multi-objective solution for identification purposes seems to be authors' invention. Oppositely, single-objective identification is quite common and a lot of applications of evolutionary algorithms can be found. For example, (Kučerova et al., 2007) published a meta-modeling optimization using a *Radial Basis Function Network* to obtain concrete parameters on a macroscopic level. *Genetic programming* applied as an interpolation tool is shown on the identification of parameters of nanoindentation test by (Toropov and Yoshida, 2005). Effective combination of a *Genetic Algorithm* and a *Back-propagation Neural Network* is presented in (Pichler et al., 2003). Last but not least, (Most et al., 2007) present utilization of results from a *Neural Network* as starting points to a gradient-based optimization search for concrete parameters.

Our optimization procedure was based on an evolutionary algorithm called Pareto Archived Evolution Strategy (PAES) (Knowles et al., 2000). Each individual in optimization represents a unique set of input parameters. PAES in the simplest version 1+1 was used; this version works only with an individual and not with a population. All so far found Pareto optimal solutions are stored in an archive, which represents Pareto set. PAES does not use the crossover and the selection is replaced by updating the archive. The flowchart of the algorithm is shown in Fig. 3.

In our approach, two objective functions were used and both were to be minimized. The first function was the mean square error between the target curve and a simulation:

$$R_j = \sum_{i=1}^{t} \left(\frac{h_{\exp,i} - h_{sim,j,i}}{h_{\exp,i}} \right)^2 ,$$

where $h_{exp,i}$ is the depth in the i-th time step on the target curve and
$h_{sim,j,i}$ is the depth in the i-th time step on the j-th simulation.

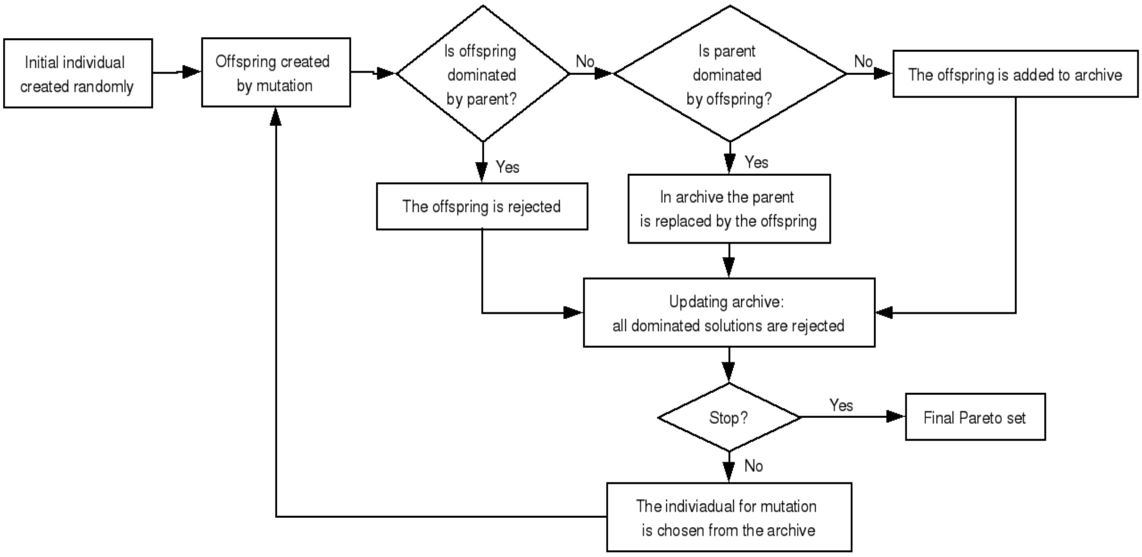

Fig. 3. Flowchart of PAES.

The second objective function was based on the difference between “shapes” of two curves by minimizing the errors among slopes of the given curves:

$$D_j = \sum_{i=1}^{t} \left(\frac{d_{\exp,i} - d_{sim,j,i}}{d_{\exp,i}} \right)^2 ,$$

where $d_i = \dfrac{h_i - h_{i+1}}{t_i - t_{i+1}}$,

t_i is the i-th time and

$t_{(i+1)}$ is the $(i + 1)$-th time.

4. Results

Following figures show the final Pareto set after 100 iterations. We tested three different curves generated by computer as a target; therefore we can judge not only the shape of curve (bigger graph) but also the precision of parameter estimation (smaller graph), see Figs 4 - 6.

Apparently, the shape of target curve (the black curve) and shapes of curves from the final Pareto set are very similar, but not all parameters are found exactly. The successfulness in parameter estimation corresponds with their importance on values of objective functions. For example, the curve I (Fig. 4) has bigger creep deformation than other curves, and therefore final parameters are more accurate in estimation of parameters a_0-a_2, which influence the creep strain. In other words, the error in estimation of unimportant parameters has minimal influence for the final value of an objective function; therefore, more parameter sets can produce equally accurate results.

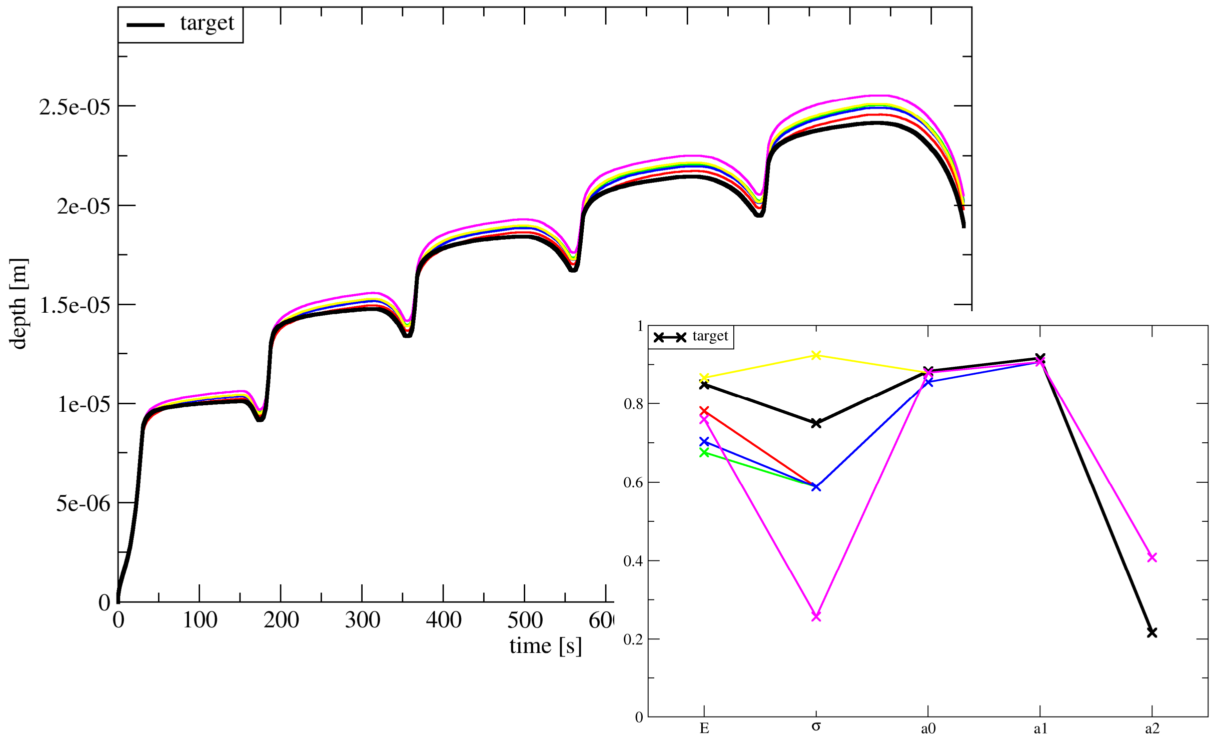

Fig. 4. Final Pareto set for curve I

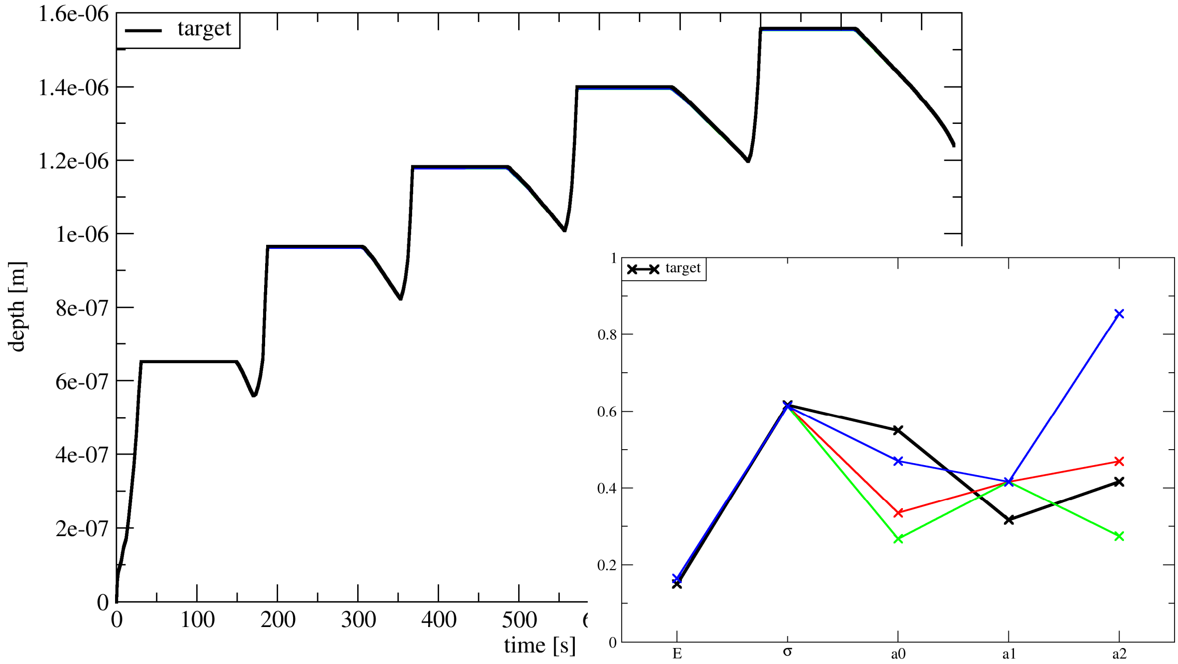

Fig. 5. Final Pareto set for curve II.

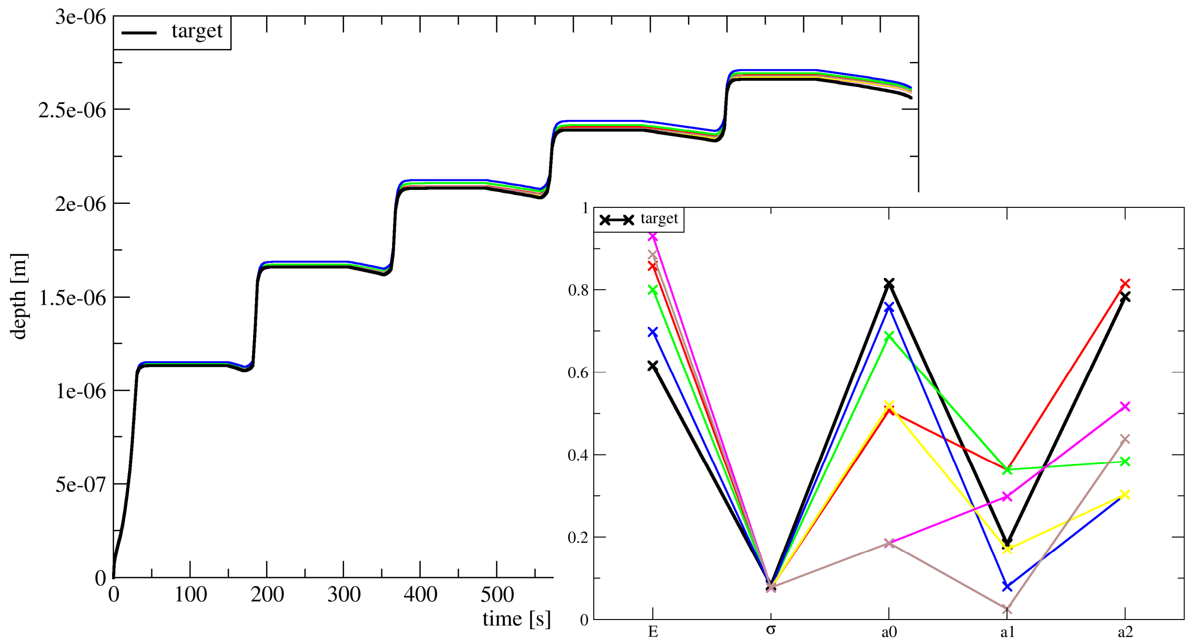

Fig. 6. Final Pareto set for curve III.

5. Conclusions

Multi-objective optimization of input material parameters for nanoindentation model was presented. Particularly, multi-objective formulation was tested. Our current results from multi-objective approach indicate the proposed method as very promising. The performance and the successfulness of the optimization could be increased by using PAES in version $\mu+\lambda$. In that case the space of parameters will be searched faster and more thoroughly and the final set will not be so dependent on initial solution. Moreover, the adaptive probability and size will be implemented for finer search near existing solutions.

The next problem in proposed methodology is the inability to deal with the multi-modal problems; this will be solved by an implementation of the niching strategy CERAF developed by (Hrstka and Kučerová, 2004).

Acknowledgements

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Utilization of the research results of alkaline-activated materials in construction use

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Abstract:
Investigation of the inorganic polymer materials that use, as a base, alkaline-activated fly ash, have revealed a number of positive results that are fundamental prerequisites for the utilization of the alkaline-activated fly ash in the construction industry. These results are in this context: the strength and toughness of the product; the resistance to freezing temperature cycles; the values of the coefficient of elasticity; and last, but not least, the expansion behaviour caused by changes of the temperature and moisture of the environment.

One of the aims of the project* is the utilization of fly ash waste material in the construction industry when producing small objects like pavers, curb segments, round ferroconcrete blocks, road panels and other statically less demanding products.

For this purpose a number of methods are used to model the conditions that would affect the products containing the chemically-activated materials during their life cycle and also methods to define the product’s response to initial conditions which have the most important impact on their behavior and the interaction of these products within the whole building structure.

The expected outcome of the implementation of alkaline-activated fly ash in the construction industry is the reduction of the quantity of waste fly ash that presently represents a significant burden to the environment (disposal as land fill).

Keywords:
Alkaline-activated materials, Fly ash, Utilization, Waste Recycling, Environment

1. Introduction

This paper deals with partial results of the extensive research focused on the utilization of the chemically activated waste materials, particularly brown-coal fly ash, as an alternative material to ordinary Portland cement used in the building industry. The aim of the presented research is to find the correct mix of alkali activated systems, which would adequately substitute for the hydraulic system in common concrete, in which the main physical and chemical binder is provided by cement.

Above all, the recent research results have shown a great versatility of the alkali activated fly ash, especially when aiming for a product mix with properties that are most suitable for specific applications.

2. Literature review

As in the case of other construction materials the aim is to make a building product that will, as far as possible, fulfill the specific requirements and application conditions, while maintaining minimal costs. Should we intend to focus on the application of the chemically activated materials, for example in the construction of a pavement in a certain locality, it would be essential to query the conditions to which such a pavement would be exposed during its expected use, whether the pavement could serve for pedestrians as well as for cyclists, since in such case there would be a need for a better quality of pavement surface, namely good abrasion resistance of the surface (Wang et al. 2005), whether the pavement would be exposed to a chemical action (e.g. salt solutions during the winter) and - last but not least - whether the pavement would be of a decorative or of a lower category – where the colour stability would not be the deciding criteria (see figure 2). From the above it is clear that it is required to carefully choose from the range of the properties that chemically activated materials possess but always considering the clearly specified requirements that result from the specific use of the final product. The key properties of the alkaline-activated materials are: above all the high compressive strength (Lee et al. 2002); high level of resistance to a large number of chemicals (Palomo et al. 1999); the accelerated process of solidification and hardening without any delayed heat release; abrasion resistance; low shrinkage; high fire resistance (deformation starts in temperatures above 565°C); and finally low heat conductivity.

Since we are dealing with the subject of substituting the traditional cementitious binders (Gartner 2004) with the chemically activated fly ashes, it is important to mention the principles of the behaviour of these different functional systems - the well known cementoid concrete systems and systems based on alkali activated fly ash. It is expected from these systems: identical behavior; properties; and also methods of placing and treatment of produced compounds, even though the hydratation of cementitious binder and the chemical reaction of the alkaline-activated fly ash are two completely different phenomena.

The basic difference between these systems is the absence of cement - the inorganic material that after mixing with water in time solidifies and hardens. The process of hydration is the deciding property of the cement. During the process of hydration to some extent gels are formed but more importantly crystals are formed and these are drawn closer to each other as they grow and then mutually interlock - a process that produces the strength of cementoid concrete. The solidification of the cementoid concrete is from the physical aspect accompanied by thermal changes. The beginning of the solidification of the cementoid concrete is demonstrated by a sharp increase of the temperature with the maximum value obtained at the completion of the solidification. Slowly solidifying Portland cement will begin to solidify after approximately 60 minutes and, depending on ambient conditions, will complete the solidification in about 15 hours from the time the water was added to the cement. The solidification is affected by a number of factors; the most important being the fineness of the cement grind and the quantity and temperature of the additive water.

In the case of alkaline-activated fly ash (Duxson et al. 2007) hydration does not take place, the hydration process is replaced by the chemical reaction of the alkaline-activated fly ash. During the chemical activation, using sodium hydroxide and liquid glass, within a few minutes; significant heat is produced. This thermal rise begins immediately after the mixing of the activating components with water in the mixing phase of the production. Once the temperature rise has culminated, no further heat producing reaction will occur.

The wet inorganic polymer concrete thus has different rheological properties in comparison with cementitious concrete. In general it is possible to say, that in the overwhelming quantity of cases, the rheological properties of the activated fly ash mix are up to five times slower compared to cementitious wet concrete.

The rheological behavior of the chemically activated fly ash within the first hours and days after the removal of the product from the form can be observed in figure 1.

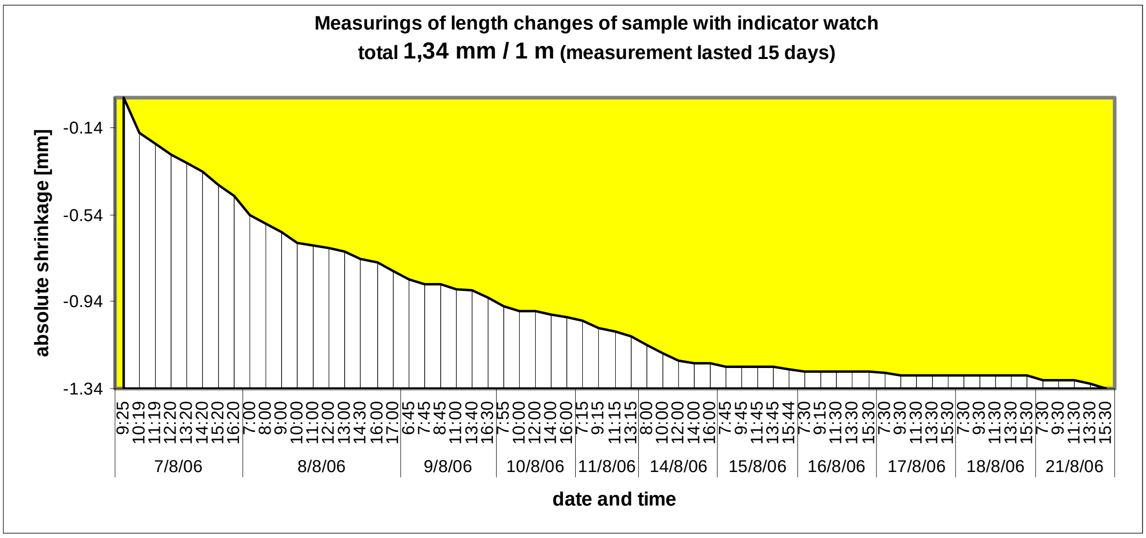

Fig. 1. Graphic illustration of measured merits of length contraction - sample S124

For the majority of applications it is important to obtain the compact structure of the chemically activated fly ash, namely the optimization of all components in the mix, their structure and interrelation, in order to obtain an increase of the strength, at the ambient temperature of 20°C, while maintaining or increasing long-term strength. The initial strength during the activation of the fly ash by chemical reaction, at lower temperatures, has to be such as to allow the removal of the product from the form within 48 hours of casting, while the product should not loose the shape or stability, and have adequate strength to allow manipulation should this be required. The long-term strength, i.e. strength reached after 200 days and more, shall not decrease.

The strength of the product is directly related to the amount of water contained in mix. The amount of water has a significant impact not only on the toughness, hardness and strength of the product, but it has also a basic importance for the length and volumetric changes of the product (see figure 1). The resulting consistency of the mix and consequently the value of water-binder ratio should already be selected during mix design taking into consideration the method of handling the wet concrete, whether in the workshop or on construction site. If a inorganic polymer concrete mix of higher strength and surface hardness is proposed, e.g., for placing as a hardstanding on compacted bedding, transported to the building site and placed and treated using traditional concrete technology, then the climatic conditions must be taken into consideration, since significant changes of the climatic conditions (torrential or heavy rain) in the first hours after the placing could significantly change the properties of the alkaline-activated material and consequently the requirements for this specific applications may not be achieved without proper protection.

3. Research background

The research task to find an alternative to ordinary Portland cement, by using waste products that burdens the environment, is a long-standing project of the Glass and Ceramics Institute, ICT, in Prague. The research has confirmed good results achieved with chemical reaction of the fly ash - the waste product of coal electrical power generation and heating industries. The research dealt mostly with the physical-mechanical properties of the activated fly ash amongst which are: the strength characteristic; volumetric and length changes; and resistance to chemicals and weather. Since very promising results have been achieved in a laboratory environment it became compelling to initiate testing of the alkaline-activated materials in a real life environment, with the aim to find a practical use for activated fly ash in the building industry.

This was the reason why cooperation between ICT and CTU in Prague, Faculty of Civil Engineering, Department of Construction Technology started in 2003. This cooperation could lead to finding and consequently trying the most optimal technology for this very specific material.

The overwhelming majority of research projects dealing with the utilization of the chemical reaction carried out worldwide and in the Czech Republic are mainly focused on activating basic substances like metakaolin or slag while the annual production of several million tons of waste fly ash is waiting for its use.

Until recently fly ash has been used, only, as: the inert admixture for fly ash concrete; or as the stabilization component for the road base; or as material used for recultivation of the terrain. Reutilization of this waste only uses a small percentage of the total production and therefore the effort to reuse this waste on a large scale will alleviate the disproportionate load that this waste exhorts on the environment.

As the start of the alkaline-activated material production on a large scale is concerned, it is first of all necessary to unequivocally answer three basic questions that are – the total financial costs to produce $1m^3$ of the chemically activated fly ash; the impact of the product on the environment; and its long-term durability. The question of long-term durability (25+ years) could not be verified so far because of the short period of the products existence, but accelerated laboratory tests (OECD 1992) are pointing to satisfactory results. In the past, various building products were produced that were cheap but were very inconsiderate towards the environment and consequently in the future as this question becomes an ever more important political issue, price should not be the only and decisive factor, as it is at present. The development of the alkaline-activated materials have, so far, stood up to the range of problems, e.g., the choice of suitable components for the mix. This means not only the choice of a suitable filler, but also of the chemical reaction activator, the intensificator of the solidification, additives and admixtures, the mixing ratio of these, and the influences on the resulting physical-mechanical properties, procedures for dosing and mixing the individual components, handling of the mixtures and its following placement in the environment modeling real climatic conditions to which the product will be exposed. These questions are still being intensively worked on and many of them have not been satisfactorily answered yet. However this inorganic polymer is ready for specific building applications due to its achieved stable high strength and its resistance to a range of chemicals.

In connection with the research it is necessary to say that though the alkaline-activated fly ash is a relatively young material and therefore it is not sufficiently well-tried and vetted, there are already many applications that have been tested in a laboratory environment and in real life. This is the case of mainly non-load bearing products in civil engineering, e.g. production and bedding of lock pavement in outdoor environments, where the general behavior and impact of the weather is being tested in-situ. The pavement strip of 12 meters length is laid using the same technology for transport, placement and handling as in case of common concrete.

Fig. 2. Application of block pavement from alkaline-activated fly ash on sand bedding

Roads or pavement strips made from the chemically activated materials have two indisputable advantages when compared with common concrete. The first one is the greater resistance towards freeze-thaw cycles. Previous trials have shown only a negligible deterioration of the surface after several tens of cycles. Another advantage is the already mentioned resistance to chemicals, specifically salt products that are commonly used on roads in winter.

Small prefabricated units, including components of various shape and size, made from various fly ashes, from different localities, have been tried and tested under common climatic conditions.

There is also the question of surface applications systems that mostly protect the base on which they are placed against chemical, physical and weather action. The alkaline-activated fly ash example could be a thin-layered surface application that has shown excellent cohesion with the base, reliable protection against acidic environments, fire (see figure 3), etc.

Fig. 3. Fire resistance test

Another example is the possible application of a thin chemically activated material overlay to cover a mature cementoid concrete slab containing broken pieces and holes.

However, the main aim of the research remains to force the fly ash to undergo a chemical reaction and to function as the binder. The main effect when dealing with a non-tempered inorganic polymer concrete is fast start of the chemical reaction which is one of the basic conditions for the practical use in building or other industries. It is known that larger amounts of water, therefore higher water content, markedly lowers the resulting strength similarly to cementoid concrete. We use a range of search and testing methods in an effort to find the optimal composition and representation of the elements in the mix.

4. Conclusion and Further Research

The above shows that presently we can regulate the toughness, elasticity and strength of the activated fly ash as well as regulating some of the chemical reaction processes by the amount, composition and ratio of the individual activators. To suit required properties it is also possible for specific applications to choose from various sorts of fly ash from different localities. For example, by using brown-coal fly ash that requires a higher water coefficient, we achieve an inorganic polymer concrete of a fluid consistency with slow increase of the initial strength. On the other hand if we use black coal fly ash as the binder, we obtain a concrete of a wet consistency that will reach higher initial and long-term strength. The strength and hardness of the samples is related to the possibility to evaporate water. In the case of Portland cement, the residual water, present in the pores and in hydratation products, is the water that has not been used during hydratation. There are no hydration products in the chemically activated materials and the residual water (water not used for the chemical activation) stays in the material as water poorly bounded. Therefore when the material is placed in an environment with lower relative humidity, the drying up process will start with the residual water diffusing in the form of water vapour towards the surface, whilst the water is easily vaporized from the surface. Diffusion of the water from the centre is more difficult and a slower process than evaporation from the surface and consequently the hardness (strength) nearer to the surface is greater than in the centre.

Unresolved research tasks include specifically: the shortening of the manufacturing process; removal of the tempering period; and possible applications in other than the building industry. Special attention is currently given to ways of lowering the technological complexity especially when producing larger volume components. Cooperation was established with some building companies dealing with production and handling of concrete to assist in the verification when producing larger volume components.

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Theme 7:
ICT and Technology

A State-of-the-Art Review of the Application of GPS Technology in Surveying

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Abstract:
Global Positioning System (GPS) is an innovative type of technology which can be used to increase efficiency, productivity of the Surveying discipline and to produce more accurate results. GPS technology is becoming a very popular and effective tool for surveying purposes. Many organisations are introducing and implementing GPS technology for surveying and other various purposes. In developing countries like Libya this technology has not been adequately implemented. The aim of the research is to develop framework in order to improve the use of GPS surveying technology by the Libyan Public Surveying Sector The main objectives of the research are to identify the extent to which GPS Surveying is used in the Libyan Public Surveying Sector, to identify the factors that affect the use of GPS surveying technology, to develop a framework for the adoption of GPS surveying technology, and to make recommendations for the effective use of GPS surveying technology in the Libyan Public Surveying Sector. This paper focuses on a review of literature of the development of GPS technology and the wide variety of applications to which it has been applied across the world. Work being undertaken to evaluate the appropriate implementation of GPS surveying technology by the Libyan Public Surveying Sector will be addressed.

Key words:
Global Positioning System, GPS Surveying, Libya, Technology, Theoretical Framework

1. Introduction

Global Positioning System (GPS) is an innovative type of technology that is being used in surveying and construction. GPS Technology has been identified as the important solution for use in Surveying rather than traditional surveying using Theodolites and Electronic Distance Measurement Instruments (EDMI).GPS is changing the face of all surveying applications. Currently, surveyors and engineers use GPS Techniques to increase their efficiency, productivity, and to produce more accurate results. Surveying is the first and foremost step taken before embarking on any construction projects or identifying geographic boundaries. Traditionally surveying has been performed by highly qualified personnel and is a very tedious and labour intensive effort, also there are considerable costs associated with conventional surveying technology. Its methods are time-consuming and often require multiple trips to the same site to gather data and to ensure the collected data is accurate. Crews are not always able to work under certain weather conditions, such as extreme temperatures, rain, or snow.

Global Positioning System (GPS) Technology and Geographic Information System (GIS) Technology are very powerful for surveying and mapping. However by integrating GPS and

GIS Technology the benefits are multiplied several times over. Global Positioning System (GPS) Technology is becoming a very popular and effective tool for surveying purposes. Many organisations are introducing and implementing GPS Technology for survey and other various purposes. In developing countries like Libya this technology has not been adequately implemented.

This research is concerned with adoption of Global Positioning System (GPS) Technology in the Libyan public surveying sector. The purpose of the research is to learn about GPS implementation and identify the factors affecting the use of GPS Technology. This is in order to achieve effective adoption and implementation of GPS Technology and to gain the potential benefits from employing this technology. Results of this research will be beneficial majority of Libyan public organisations survey currently implementing GPS Technology or planning to employ the technology in the future. The findings will help to improve GPS management strategies and provide guidance for better involvement of current and prospective users of GPS Technology in Libyan environment. This paper focuses on a review of literature of the development of GPS technology and the wide variety of applications to which it has been applied across the world. Work being undertaken to evaluate the appropriate implementation of GPS surveying technology by the Libyan Public Surveying Sector will be addressed.

2. Global Positioning System (GPS)

The Global Positioning System (GPS) is a satellite based navigation system that was developed by the U.S. Department of Defense (DoD) in the early 1970s. Initially, GPS was developed as a military system to fulfil U.S. military needs. However, it was later made available to civilians, and is now a dual-use system that can be accessed by both military and civilian users. GPS provides continuous positioning, velocity and timing information, any where in the world under any weather conditions.

2.1. Overview of GPS

GPS is a constellation of 24 operational satellites providing the most accurate navigation service in the world. This constellation, known as the initial operational capability (IOC), was completed in July 1993. The official IOC announcement, however, was made on December 8, 1993. The satellites (also known as Space Vehicles) are in precise orbits 20,000 km above the earth's surface. Each makes one earth orbit every 11 hours and 58 minutes. There are six orbits with at least four to ten satellites visible anywhere in the world. They are spaced 600 apart and inclined about 550 from the equator, the semimajor axis of a GPS orbit is about 26,560 km (El-Rabbany, 2002).

2.2. The different GPS components

As it is quite common and can be found in the literature, for instance (Hofmann-Wellenhof, et al, 2001) the system of GPS consists of three segments: the space segment comprises the satellites, the control segment deals with the management of the operations of satellites and the user segment covers the activities related to GPS users. However, the three segments work together to provide the Global Positioning System.

Space Segment:

The space segment of GPS consists of 24 satellites fielded in nearly circular orbits with a radius of 26,560 km, period of nearly 12 hours and stationary ground tracks. The satellites are arranged in six orbital planes (each orbit with 4 satellites) in a height above the earth of 20,000 km. The inclination of these orbits is 550. The main purpose of these satellites is to send permanent radio signal, which can be detected by receivers on the earth. An internal oscillator is generating this signal with a fundamental frequency of 10.23 MHz. It has two carrier waves L1 (1575.42 MHz (19.05 cm) and L2 (1227.60 MHz (24.45 cm).

Control Segment:

The control segment of GPS consists of five tracking stations distributed around the earth of which one, located in Colorado Springs, is a Master Control Station. The control segment tracks all satellites, ensures they are operating properly and computes their position in space. The information and data from all satellites are collected at the 5 monitor control stations and sent to the master control station in Colorado Springs, where, the broadcast ephemeris in World Geodetic System (WGS-84) coordinates can be calculated and submitted to one of the ground control stations. Using a ground antenna, the coordinates and the navigation data can then be sent to the satellites.

User Segment:

The GPS user segment consists of the GPS receivers and the user community. Almost all GPS tracking equipment have the same basic components: an antenna, an RF (Radio Frequency) sections, a microprocessor, a control and display unit (CDU), recording device and a power supply. Usually all components, with exception of the antenna, are grouped together and referred to as a receiver. GPS receivers convert SV signals into position, velocity, and time estimates. Four satellites are required to compute the four dimensions of X, Y, Z (position) and time. GPS receivers are used for navigation, positioning, time dissemination, and other research.

2.3. Basic principle of GPS

The basic principle of determining the position by using GPS satellites is based on measurement of distances from the point of observations to the satellite. This is done by comparing the reading of transmitter antenna time with the receiver antenna time. The technology operates on the principle of triangulation; the position of the observer can be calculated if the difference from an observer to three known points can be measured.

2.4. GPS Reference System

Because of the satellite motion, which is referring to the gravitational centre of the central body, the satellite coordinates and also calculated station coordinates at the earth surface are geocentric coordinates. There is no datum problem occurring, because the coordinates are determined in reference system where the satellite orbit is computed. The GPS satellites are referenced to the World Geodetic System of 1984 (WGS 84) ellipsoid. WGS 84 is an earth fixed global reference frame, which is an average or conventional terrestrial coordinate system, including an earth model, which is defined by a set of primary and secondary parameters. The primary parameters define the size and shape of its geocentric ellipsoid, which are semi major axis a=6378137 and reciprocal flattening 1/f=298.257. For surveying purposes, this earth-centred WGS 84 coordinate system must be converted to a user defined ellipsoid and datum, the coordinates can be transformed into any local coordinate system having a minimum number of known points in both systems available (Elmaghraby, et al., 2005).

3. GPS Surveying

GPS use in Surveying can produce positions accurate to the nearest centimetre or millimetre levels. The primary difference between navigation and surveying with GPS lies in how ranges to the satellites are computed. All GPS surveying is done using differential techniques with a receiver at a known site (Duff& Hyzak, 1997).

3.1. Types of GPS Surveying

A good planning of GPS survey is very important to gain high efficiency of work (Kaiser, 1997). In planning a GPS survey, there are only two basic considerations in choosing a point, its location in an area of good sky visibility, and its proximity to road. The first requirement is of primary importance. The different methods of observations with GPS include absolute positioning, relative positioning in translocation mode, relative positioning using differential GPS technique, and kinematic GPS surveying technique (Mathur et al, 2002).

3.2. Benefits of GPS Surveying

GPS Surveying is increasingly becoming the primary tool for making precise measurements on the earth's surface. GPS techniques have been used in a wide variety of surveying applications. The benefits of using GPS for Surveying are associated with labour costs, time savings, and increased accuracies. For the most part, cost savings are a result of labour and time savings. Capital equipment investments, cost recovery methods, and personnel costs are different among organizations. Accordingly, cost savings in this review are considered to be the result of both personnel costs and time savings (NCHRP Reports, 1998).

3.3. Applications of GPS Surveying

GPS is changing the face of geodesy and all surveying applications. Currently, surveyors and engineers use GPS techniques to increase their efficiency, productivity, and to produce more accurate results. However, GPS can be used for many surveying tasks ranging from horizontal and vertical control network, cadastral surveying, airborne photogrammetry, dynamic positioning, hydrographic survey, road and rail survey to navigation. For large-scale applications such as engineering surveying or cadastral mapping, GPS is used firstly to establish a homogeneous and precise geodetic control network which serves as the basis for subordinate surveys and undertaking various types of projects (Nabed et al, 2002). GPS technology provides a cost-effective method for increasing the spatial integrity of Geographic Information System (GIS) information by offering accuracy capabilities to match the needs required by any GIS element. GPS technology can be used to upgrade the spatial integrity of existing data bases and provide the vehicle for building the spatial foundation of new GIS's (NCHRP Reports, 1998).

3.4. GPS Infrastructure

GPS infrastructure can be said to be essential to the growth and development of the surveying community. To gain centimetre and millimetre levels accuracy positioning in the field, surveyors in 1993 began using RTK GPS technology, which also minimized data post processing. For RTK positioning, a reference receiver (station) transmits its raw measurements or observation corrections to a rover receiver via a data communication link, whether radio or cell phone. With the introduction of RTK, GPS became a valuable tool for application other than control work, including topographic mapping, high-accuracy GIS (Geographic Information Systems) and Construction works. The most recent advancement in GPS technology, however, is scalable GPS reference station infrastructure. GPS infrastructure consists of permanent or semi-permanent GPS receivers operating continuously. Users no longer need to set up a separate base station to achieve RTK positioning; they simply use a GPS rover to connect to the established infrastructure. GPS infrastructure can range from a single reference station to a multi-station networks, for each option, GPS infrastructure offers several benefits (Pugh, 2005):

1. Ubiquitous positioning over a large area
2. Common coordinate reference frame
3. Reference station security
4. Decreased learning curve to achieve precise GPS surveying
5. Cost savings for capital projects of government or private sector
6. Reduced cost for field crews for field setup and equipment costs

4. Use of GPS for Surveying

Global Positioning System (GPS) technology has been creating a revolution in surveying and mapping around the world. It is being widely used for surveying throughout the world, and offers a relatively inexpensive alternative to conventional surveying for many uses. It is a technology that offers great potential to GIS. Users of GIS are increasing incorporating GPS into the data collection phase of their projects (Kevany, 1993).

GPS became very important not only because the military relied on it to provide navigation, but also the public sector. The industry started focusing on research and quality control. The researchers, continually thinking of new ways to improve the product, created real-time kinematic technology (RTK), which allowed for the receivers to be updated more quickly. This improved the use of GPS in Geographic Information Systems (GIS) and also allowed surveyors and engineers to more accurately determine the topography of a terrain. The industry also realized the benefit of combining GPS technology with telecommunications. This allowed GPS receivers to transmit data to a base station for analyzing. Another aspect developed was a GPS architecture that allowed the technology to be integrated into computers and other such devices. This led to increase in uses for GPS (Theiss et al, 2005).

According to El-Rabbany (2002), GPS has revolutionized the surveying and navigation fields since its early stages of development. Although GPS was originally designed as a military system, its civil applications have grown much faster. On the surveying side, GPS has replaced the conventional methods in many applications. GPS surveying has been found to be a cost-effective process, in which at least 50% cost reduction can be obtained whenever it is possible to use the real-time kinematic (RTK) GPS, as compared with conventional techniques. In terms of productivity and time-saving, GPS could provide more than 75% time saving whenever it is possible to use the (RTK) GPS method. The GPS does not require intervisibility between stations has also made it more attractive to surveyors over the conventional methods.

The Surveying industry is reaping great benefits in the use of specialized GPS systems to enhance, facilitate and speed up the acquisition of survey data (Filion, 2006). Global Positioning System (GPS) surveying is a new technology that is being used in construction. Manufacturers claim that GPS will improve productivity and reduce costs by eliminating common problems experienced with traditional surveying equipment (Rosenmann, 1998). More and more applications find the use of GPS for better and effective functioning than the conventional methods (Ganeshkumar, 1999).

According to Ali and Cross (2003), the Global Positioning System (GPS) offer several advantages over conventional terrestrial methods. Intervisibility between stations is unnecessary, thus allowing greater flexibility in the selection of station locations compared to terrestrial geodetic surveys. Measurements can be taken during night or day, and under varying weather conditions, which makes GPS measurements economical. The above advantages and the great developments in GPS data processing and receiver design enable GPS positioning to be at the centimetre or even millimetre accuracy level.

The Global Positioning System (GPS) is a rapidly evolving technology that is changing the way many surveying and navigation tasks are performed. However, it is becoming a powerful and cost-effective tool for monitoring some types of structures deformation and performance. Using GPS for surveying and structural monitoring applications due to advances in GPS receiver technology and data-processing software have made GPS a much more cost-effective tool (Duff and Hyzak, 1997).

According to Salunkhe (2003), the public sector plays a crucial role in the spread of GPS industry in India, huge public sector industries being the prime user of GPS technology. The Geographic Information System (GIS) is a major application of GPS technology. GIS is an integration of computer hardware and mapping software. A GIS map is a combination of many layers in which each layer holds different information, it consists of two types: spatial data and attribute data. Spatial data gives the actual location on the earth, while attribute data gives additional detailed information, such as name and description. GIS allows the user to store data, perform complex analysis, integration, and manipulation, and moreover, allows visualization benefits according to the positions on the earth’s surface. The author believes that there is an urgent need to take GPS/GIS beyond the surveyor, designer and engineer to different business users. This will open a wide range of opportunities to highlight the value of spatial databases.

Using GPS for Surveying is a cost-effective proposition and ideally suited for developing countries like India. Agencies embarking on large-scale surveying recognize the importance of increasing survey accuracy while reducing labour costs and improving efficiency. Surveying thousands of kilometres is a very time consuming and an expensive process. It takes many days to survey small sections of road using traditional techniques, complete road inventories may take years. One of the cutting edge technologies that can enhance the quality of survey is Global Positioning System (Nayak, 2005).

US Department of Transportation (Federal Highway Administration FHWA) recognizes the importance of increasing survey accuracy while reducing labour costs and improving efficiency. Over the past 5 years, studies across the United States have shown that GPS technology increases the productivity of conventional survey crews, reduces data collection time, improves survey accuracy, and allows crews to work under a broad range of weather conditions. Moreover, less expertise is required to operate a GPS surveying unit than is needed to operate conventional surveying technologies. Compared to conventional surveying technology, GPS is faster, requires less labour, requires less training and more accurate (FHWA Publication, 2003).

5. Theoretical Framework

A theoretical framework is a collection of theories and models from the literature (Collis and Hussey, 2003). In this section theories and frameworks that consider factors related to GPS technology and other relevant technology like GIS are reviewed in order to develop the researcher understanding of the analysis of critical success factors. Very little has been published on the subject of GPS implementation. The theoretical framework is mainly based on research conducted for relevant technology like (GIS). This research is concerned with the determinants of adoption of GPS technology. In this research the adoption is defined as successful use and implementation of GPS technology.

The concluding resolutions of the 1995 United Nations-sponsored International Seminar on Geographic Information System, City Sustainability and Environment, held in Cairo (Egypt), emphasized the study of factors that would pave the way for increased use of GIS by cities (United Nations, 1995).

Khan (1995) identified the factors that affect the adoption of GIS in urban transportation planning and management. He suggested that the following factors are related to the adoption of GIS:

1. Knowledge of GIS: the effective use of GIS technology requires services of well educated/trained people who are knowledgeable in spatial analysis and skilled in using GIS software.
2. Technological Development: improvements in technology are likely to lead to increased use of GIS in urban transportation planning and management.
3. Cost of GIS: advances in information technologies in general and data capture technologies in particular are responsible for reducing costs. With improved educational and training opportunities in the future, the cost of special training and on site consultancies may decrease.
4. Organisational Factors: it is noted that the introduction of GIS at the management level has facilitated the promotion of GIS throughout the entire organisation. GIS can contribute to better decision making in achieving organizational goals. Cooperation and data sharing among organizations are necessary for the successful implementation of GIS.

Abdelsalam and Mostafa, (2005), conducted a study in order to develop a unified spatial information infrastructure status index (USISI) that describes and evaluates the conditions of the spatial information infrastructure of developing nations. The elements of the USISI System Framework are two fold. The first describes the technical and geospatial aspects such as the status of reference frame, existence of maps, and availability of spatial DB. The second fold of the USISI deals with the institutional as well as socioeconomic parameters such as the quality of human resources; cultural awareness of the benefits of spatial information.

The framework proposed by Chatterji (1990), is considered as a combination of four basic components, all of which dynamically interact together and accomplish any technology transformation operation. Those basic components are Technoware, Humanwar, Inforware and Orgaware.

Duncan and Djaba (2005) suggested that the advent of Global Positioning System (GPS), Geographic Information System (GIS) and Remote Sensing (RS) has made the surveyors a multi-disciplinary professional. It has therefore become necessary to train such professionals to help in the developmental agenda of the developing countries for sustainable development.

Salunkhe (2003) conducted a study among different GPS vendors and users in India. He suggested that the following factors are related to GPS growth: GPS/GIS professionals, awareness among the general public, responses from the government regarding GPS policies, GPS infrastructure in the country.

Veget (2001) conducted a detailed study using three case studies in order to identify the success and failure factors from the adoption of GIS in local government in developing countries. The factors which should be taken into account are as follows:

1. The availability of professional staff with GIS knowledge and experiences.
2. The availability of computer staff.
3. The availability of good quality base maps or a sound and affordable method for map updating.
4. A more gradual introduction of spatial information technology into the organisation .
5. The need for very substantial staff development programs aimed at raising and maintaining skill.
6. The need to identify means of cost recovery and reserving finances for future systems.

Budic (1993) conducted a detailed study on four agencies in local governments in the U.S. It described the relationship between people, organizations and technology in order to identify the successful implementation of GIS technology. He suggested that the following factors are related to successful GIS implementation: human, institutional and GIS management.

Aseno (1997) developed a framework and anticipated that the potential benefits of space technology can be adequately exploited in Africa. The factors identified are reflected in their framework as follows:

1. Provide education and training facilities in space science.
2. Promote the acquisition, supply and exchange of space science data.
3. Assist the space science industries.
4. Provide facilities for research and development of space science.

This section has provided a review of the process of developing a theoretical framework necessary to reach the aim and the objectives of this research. The theoretical framework was developed after a literature review on existing frameworks and models of the critical success factors related to GPS technology and the other relevant technology like GIS.

The theoretical framework developed compromises three different sets of factors. These factors are human factors (education-training-skills-knowledge-experience), organisation factors (goals and strategy-management-cooperation and data sharing-culture), and technical factors (GPS infrastructure consists of permanent or semi-permanent reference stations).

6. Methodology

A research methodology is a systematic and orderly approach taken towards the collection and analysis of data (Collis and Hussey, 2003). This study aims to improve the use of GPS Surveying technology in the Libyan Public Surveying Sector. It needs to obtain opinions and information from Public Surveying Sector in Libya related to the factors that affect the use of GPS Surveying technology in order to achieve the effective use and adoption of this technology. A single case study approach will be adopted, and a theoretical sampling strategy will be explored and selected for appropriate selection of the case, rather than a random sampling strategy. In the public surveying sector, the Libyan Survey Department is sought as an effective case study which can be satisfied as the unique and important case and has enough criteria for the study. Therefore, in the Department, performing the case study can be effective as a critical and unique case. Semi-structured interviews will be used as the main source for data collection purposes. These types of interviews are though the best method for data collection as it involves an interaction between the interviewer and the interviewee for which the purpose is to obtain valid Information. Observation and the collection of supporting documentation will also be utilized for triangulation purposes. The interviewees are top managers, middle managers, surveyors, engineers, and users from the different departments within the Survey Department under investigation. The use of several data collection methods i.e. interviews, documents, and observation within one case study is intended to achieve the triangulation of data, in order to increase the validity of the findings and the researcher confidence in the reliability of the information obtained. For the purpose of data collection, the question schedule will be developed in English. However, because it will be used to collect information in Libya, the English version will be translated into Arabic. For the purposes of analysis, the interviews in Arabic will be translated into English.

7. Conclusion

Global Positioning System (GPS) Technology is becoming a very popular and effective tool for surveying purposes in developed countries. Many organizations are inducting and implementing GPS technology for the survey purposes in developing countries like Libya, but this technology has not been adequately implemented. The purpose of this research is to learn about GPS implementation to identify the factors that affect the use of GPS Surveying technology. In order to improve the use of GPS Surveying and to achieve the effective use and adoption of GPS Surveying technology in Libyan Public Surveying Sector. This paper is part of an ongoing doctoral research. The paper has reviewed the state of the art for the Global Positioning System (GPS) Technology in Surveying. This paper focuses on a review of literature of the development of GPS Technology and the wide variety of applications to which it has been applied across the world. This paper also presented the theoretical framework and the methodology for developing framework in order to improve the use of GPS Surveying technology by the Libyan Public Surveying Sector.

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Deriving and enhancing knowledge assets through the application of ‘soft’ systems thinking methodologies

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Abstract:
In practice, situations and issues related to the real world, arguably, cannot be successfully comprehended through the use of traditional approaches such as Systems Definition Model (SDM) and Unified Modelling Language (UML). Real life situations are characterised by complexity, ambiguity and novelty to mention but three and, hence, researchers are required to have a thorough understanding of the strengths and weaknesses of alternative approaches such as ‘soft’ systems thinking methodologies. Choosing a methodology for ‘a situation that requires attention’ needs determination of whether the situation is ‘hard’ or ‘soft’ in nature. While pure scientific approach is appropriate for ‘hard’ situations, alternative approaches can be argued to be better suited for dealing with ‘soft’ situations. Therefore, to ascertain the applicability of Action Research (AR) based approaches such as Soft System Methodology (SSM), Effective Technical and Human Implementation of Computer-based Systems (ETHICS), and Prototyping methodologies are discussed.

Knowledge assets such as intellectual property, processes, methods, and systems, which are derived or enhanced through the application of proposed simplified ‘soft’ methodology is detailed. The underpinning characteristics that allow this methodology to become easily adaptable are discussed. The proposed methodology provides users with underlying principles, processes and knowledge transfer mechanisms to deal with situations that require attention.

Keywords:
Action research, knowledge assets, research methodologies, soft system thinking

1. Background

In practice, situations and issues related to the real world, arguably, cannot be successfully comprehended through the use of traditional approaches such as Systems Definition Model (SDM) and Unified Modelling Language (UML). The focus of such tools has been somewhat formal that could facilitate Software Engineering strand. Similarly the initial goal of SDM was to create a general purpose modelling language for distributed dynamic computing. Currently it is being used as an XML based modelling platform suitable for system modelling. On the other end, Unified Modelling Language (UML) is considered as a more advanced language, possessing the ability to model distributed systems using classes, relationships, inheritance, and composition. However, scoping relationships within a context and specifying policies, which apply to instances within a context, are two useful features in modelling which are not yet supported. Despite this, the SDM can provide these features for modelling the desired state of a distributed system (Microsoft, 2007). In generic terms, UML has been considered as the industry standard for specifying, constructing and documenting software systems and the designers still require domain specific techniques for the definition of a problem situation and for a solution (Zhang, 2004). In order to address some of these issues, the Service Modelling Language (SML) provides a rich set of constructs for creating models of complex IT services and systems that have been endorsed by many leading industrial parties in recent times (Microsoft, 2007). However, utilising these traditional approaches would mean that real life, complex situations would not be able to be captured in full detail. Researchers, therefore, need to be savvy with the knowledge of alternative methodologies, which are capable of providing the 'big picture' so that the appropriate methodologies and tools can be chosen that is fit for the job in hand. Therefore, in summary, research and development associated with real life organisations or social construct, involving human beings and cultural considerations are better dealt with through alternative approaches.

This paper provides detail insights of popular alternative methodologies that assist Information Systems development process. More importantly it proposes a simplified 'soft' systems methodology by capitalising on the strengths and at the same time by avoiding the weaknesses of these alternatives which have been recognised in the literature. The paper goes on to explain how this methodology can assist for deriving an organisation's knowledge profile of the future that is embedded within the process of application of the methodology. Finally future research works are briefed.

1.1. Research methodological standpoint

Firstly, it is important to document the research methodological positioning of this paper. From an ontological position, the authors take an objectivist standing; form an epistemological position, we take a positivist view. In simple terms we have employed a pluralist methodological stance to our study.

2. What can the alternative methodologies claim that they offer?

Choosing a methodology for 'a situation that requires attention' needs determination of whether the situation is 'hard' or 'soft' in nature. While pure scientific approach is appropriate for 'hard' situations, alternative approaches are better suited for dealing with 'soft' situations. In 'soft' systems the objectives are seen as more complex, fuzzy and ill defined, and are argued to have purposes or missions instead of problems; hence traditional approaches become somewhat unsuitable. Traditional scientific research process begins with an identified problem then objectively data is gathered and analysed for the required recommendations to be made. This process has been derived predominantly from the 'hard' systems analysis methodology, which has become the norm even for research into complex situations and in many such cases this may not be the appropriate use of it. In a complex situation the problem can not be clearly seen other than a few symptoms which may have been caused by this issue (this could also be argued otherwise) therefore neither pathway could be defined to reach a solution nor a solution can be determined following a pathway derived based on this initial problem that has been identified. This methodology also dissects component parts of a 'system' or a complex situation for detailed analysis and recognition of interconnectivity with the focus of finding remedies. Many complex and real life situations have a limited scope in finding appropriate improvements through this methodology. Therefore Action Research related alternative methodologies are somewhat more favourable specifically for the analysis of humanistic, organisational and socio-sentimental matters. Authors also do recognise that 'hard' methodologies may also provide a rigorous analysis for various decision making and problem solving situations where these are appropriate in their own right. However in general, humans are more concerned and savvy in practical decision making which is analogous to what we call Participatory Research with Constant Learning (PRCL) in some ways and it is much different from the ‘hard’ analogy. Therefore more advancement of the appropriate ‘soft’ methodologies and consolidated techniques are highly valued, as noted in the soft methodology literature. Participatory Research with Constant Learning offers the practitioner with some opportunities; ability to reflect on the current circumstance, direct planning for the circumstance improvement, ability to impose and observe all the processes within a given circumstance, and ability to re-engineer processes as needed, which will empower the practitioner.

2.1. Systems thinking

Real life situations are characterised by complexity, ambiguity and novelty to mention but three and, hence, researchers are required to have a thorough understanding of the strengths and weaknesses of alternative approaches such as ‘soft’ systems thinking methodologies. There are many deficiencies in the mechanistic thinking that is based on reductionism to encapsulate a real life situation for the development of an information system. Reductionism captures descriptions of subsystems that the whole system is composed of ignoring the relationships between subsystems. Ackoff (1973) expressed the incompleteness of this method clearly as;

> “A system is more than the sum of its parts; it is an indivisible whole. It loses its essential properties when it is taken apart. The elements of a system may themselves be systems, and every system may be part of a larger system” (Ackoff, 1973).

Although the systems thinking approach was an attempt to address this deficiency much prior to the above quote. Over time, however, it has now grown into a holistic methodology which facilitates different disciplines (Wang and Ahmed, 2002). Systems thinking has been a heavily researched methodology for over 60 years since Ludwig Von Bertalanffy’s (1901-1972) initial work on General Systems Theory (GST) which proposed that 'systems' of various order cannot be understood by an investigation of their respective parts in isolation (Bertalanffy, 1968). The systems approach considers a large number of related aspects that the human brain is unable to fully appreciate at once, as a complex phenomenon. It is an attempt to manage this complexity by describing, analysing and controlling associated details with a good understanding of the whole. Therefore a system shows properties, which are properties of the whole rather than properties of its component parts. System will always be a continuous entity, which is not episodic, and by nature it is emergent and dynamic. New interactions and influences within and from outside creates these rapid changes. In working with change we are working with networks of relationships, not with mechanistic processes (Wheatley, 1999).

2.2. Which methodology to choose?

The applicability of Action Research (AR) based approaches such as Soft System Methodology (SSM), Effective Technical and Human Implementation of Computer-based Systems (ETHICS), and Prototyping methodologies are discussed below. In considering real world complexities and their unpredictability, Peter Checkland and the team from Lancaster have derived SSM by capitalising on previous systems of work, and their own real life project experiences or Action Research. Checkland (1999) provides a clear distinction between ‘soft’ and 'hard' approaches before providing the detailed explanation of his SSM. This methodology is to be used when the situation is more complex where it is even difficult to define the 'problem'. It will analyse and structure the situation so that the stakeholders can comprehend the status for dealing with the current situation. Not only can it be used for IS development related purposes but for any other organisational matters that require further improvements. This methodology recognises the validity and the importance of capturing the human interaction and for this matter a range of tools have been derived. For elaborating the domain of the problem and to ascertain who and what is 'important' the CATAWOE analysis, 'root definition', 'conceptual model', etc. are used. SSM is criticised for not having complete guidelines explaining how to build an Information System. One would also need to consider a methodology, which would be less prescriptive than a technique or a method, and provides structured approaches that requires human judgment. The purpose of SSM is to provide intellectual devices for structure exploration within the situation considered while facilitating as an exploratory learning mechanism. The argument that the SSM is difficult to implement and does not provide rigor, scope and design and for that matter Checkland's (2000) clarification provides an insight and changes of the SSM, which have gone through since its inception as a 'soft' methodology, is a useful research paper. While Checkland was more focussed on the development of philosophical nature of the methodology, concurrently, Brian Wilson of Lancaster was focussed on its practicality (Theophilou, 2001).

Another methodology, ETHICS devised by Enid Mumford of Manchester Business School takes the participative approach a step forward. It mainly focuses on the users working life, job satisfaction, etc. prior to the technological concerns and suggests the user should either participate in the design process or s/he should design the system by themselves. Although it can be used as a problem solving methodology the users' acceptance of the final system modelled will be its main focus. ETHICS has no specified techniques, but provide a framework for feasibility, analysis and design stages. Common reaction to ETHICS says it is impractical and the user can not comprehend easily for their own design work using the methodology. Mumford has shown number of successful implementations and explains that users can be trained with ease. The ETHICS method is fully described by Mumford (1983) can be accessed through her personal pages. The latest book by Mumford and Hickey (2006) shows the integration of these techniques with agile methodologies.

Prototyping is different to the above two in many ways and can be utilised for few different purposes. Prototyping as a methodology concentrates on capturing client requirements clearly and completely. In particular when the systems requirements are not clear this methodology can work as a dynamic process to gather system requirements from its users via prototypes. The prototype will be non-functional (mock-up) but user will comprehend how the system will work when it is completed as the actual system. This methodology is also being used for Quick User Interface Design for capturing the content on each screen at the initial design stage. Ideally prototyping should not take a much longer duration of the project so that the cost associated with the process is minimised. Mostly prototypes are discarded as the actual system is being built. Managing the prototyping process requires much knowledge of the complete systems development lifecycle, which assists in gaining its full benefits. Readers are encouraged to read a few more alternative methodologies to gain a better insight of the variety.

3. Simplified 'soft' methodology

There are strengths and weaknesses of most of the methodologies discussed. Due to the essence of complexity in capturing human, organisational and environmental characteristics most methodologies are unable to provide a robust and at the same time directions that are easy to comprehend by the methodology users. For example SSM can provide the user with a reasonable degree of robustness, however, based on users' prior experience and knowledge the application of such methodology could provide varied outcomes for different users. In this paper, we would derive an extension to the methodologies discussed with the focus of its usability and robustness.

3.1. *Participatory action learning*

The design of this methodology includes important elements of organisational learning namely Action Learning and Action Research process which entails 'learning by doing' or Participatory Action Learning (PAL). The application of the methodology involves a Research Practitioner and all the stakeholders of the organisation in concern. In a more favourable circumstance the practitioner could come from the senior management team and/or a member from the stakeholder group. The four-worlds concept of information modelling is detailed later to elaborate on positioning of the researcher and stakeholders in concern.

3.2. *Methodology for targeted system realisation*

The following diagram, figure 1, shows the simplified approach to the 'soft' methodology that we are proposing in this paper from here onwards. Model building guidelines detailed by Zuber-Skerritt (2002) has influenced on the flexibility of the figures derived. This cyclic process begins with an assessment of the current status of the organisation, which leads into a refinement process through Action Learning. As the latter implies the refinement could also be a cyclic process based on the envisaged systems complexity. Satisfactory refinement will lead into the implementation following any other required conditions are met, such as financial viability of the intended system implementation at the time. The implementation and change management will address the required changes to the organisation and its environment. Size of the organisation and the resource allocation for the project could define the length of time required to complete one cycle as figured below. The success of each cycle will take the organisation closer to the satisfaction of the system realisation.

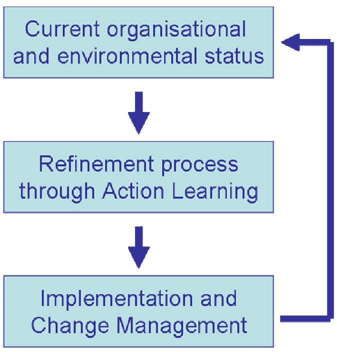

Fig. 1. Simplified 'soft' methodology for system realisation

Having explained the simplified version of the methodology let us deal now with the details through figures 2, 3 and 4. 'Preliminary research' will provide details on the necessities of any improvement to the organisation. If there are situations that require improvement the planning process begins by capturing the organisational status. The major steps involved are shown in figure 2 and listed below.

Step 1: Stakeholder analysis
Step 2: Problems / issues and strengths
Step 3: Definition of the ideal system
Step 4: Responsibilities of stakeholders or groups
Step 5: Status documentation (stakeholder engagement plan, etc.)
Step 6: Expected results / outcomes of the expected system

Although research element may impact on any of the six listed steps, more importantly step 3 and 6 are required to be well researched which is shown in the figure below. After one cycle of process the participatory researcher(s) are required to assess the expected outcomes against the 'situation improvements' sought that has been defined at an early stage. Unsatisfactory circumstances are refined by applying another cycle of the process for further improvement. This planning process ends with a well documented proposed plan for the 'situation improvement'.

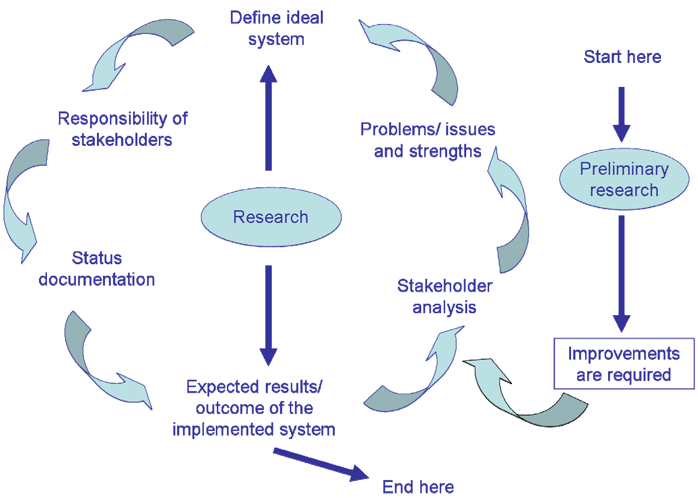

Fig. 2. Planning of the 'situation improvement'

The action of the implementation cycle begins here and it is shown in figure 3. Step 6 in figure 2 will be the starting point of the implementation cycle. The major steps are listed below.

Step 6: Expected results / outcomes of the expected system
Step 7: Document 'systems' objectives
Step 8: Define performance measures and actions
Step 9: Construct and perform actions
Step 10: Evaluation of actions
Step 11: Adjust and 'system' change management

Similar to the previous planning cycle the research element is more important in Steps 6, 9 and 11. Step 6 allows practitioners to document full objectives of the system and then to define performance measures for evaluating the fulfilment of objectives. The action planning and research process will facilitate arriving at the improved situation in a gradual manner. Required further adjustments and change management process refine the situation further such that new improvements are more acceptable to the organisation. Again at this point an evaluation is required to understand whether the expected outcome defined previously has been achieved, and if so full documentation of the evaluated model needs to be completed. Otherwise another refinement cycle would need to be engaged after the required documentation of the current 'situation improvement'. Such documentation will facilitate arriving at the new 'systems' objectives that are more mature and refined compared with the objectives derived at the initial round. At the end of the implementation process 'finalising research' will allow the investigation of future improvements or any limitations for which practitioners need to be aware. Due to the limitation of space we do not detail all the above steps in full within this publication, but readers should note the following aspects.

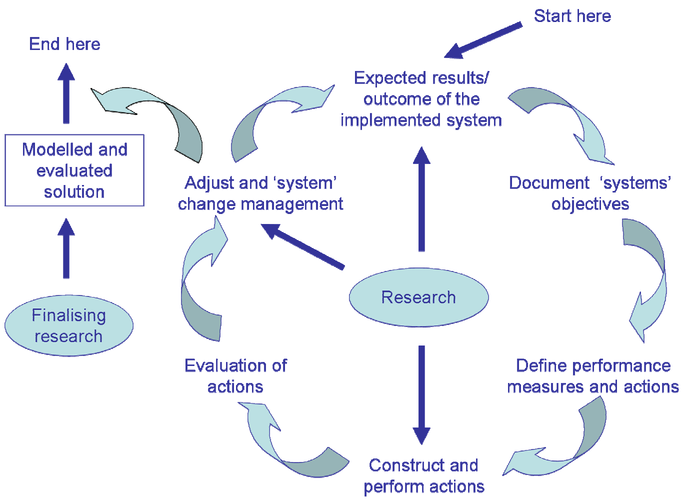

Fig. 3. Implementation of the 'situation improvement' planned

Stakeholder requirement capture: Within most organisational contexts there are multi-stakeholders pursuing a range of interests, hence very diverse requirements. A few stakeholder categories are listed in the table 1 to illustrate this diversity against their requirements types.

Table 1: The stakeholders requirements types (Toffolon and Dakhli, 1999)

Stakeholder	**Project space**	**Software product dimensions**	**Requirements types**
Customer	Problem space	• Economic • Temporal • Organisational • Functional	Cost constraints, Delay constraints, Market constraints, Efficiency constraints, Tactical/strategic constraints, Organisational constraints and priorities, Functional needs, Quality of Service needs, …
Architect	Solution space	• Organisational • Functional	Organisational context constraints, Functional constraints, Cost constraints, Delay constraints, Architecture constraints, Reuse constraints, Methods constraints, Performance constraints, …
Developer	Construction space	• Human • Functional	Functional constraints, Non functional constraints, Project's organisation constraints, Teams communication needs, Cost constraints, Delay constraints, …
End-user	Operation space	• Organisational • Human • Functional	Functional needs, Non functional needs, Organisational context constraints, …

Further, as detailed by Toffolon and Dakhli (1999) with regard to capturing such requirements the dimensions, specification, representation and agreement need to be considered. When dealing with multi-stakeholder requirements it is paramount to reconcile them through an appropriate method, such as extended investigation of conflicting requirements. The requirements elicitation was divided into two levels; intra-space and inter-spaces. The intra-space level permits taking into account the stakeholders interests and points of view while the inter-spaces level supports trade-offs and reconciliation of stakeholders points of view. Toffolon and Dakhli (1999) approach was similar to Win Win spiral model (Lee, 1996), which views stakeholders as project actors carrying out contracts related to the software system to be developed and also provides an instrument to describe stakeholders conflicting interests and points of view, hence considering all the multi-stakeholder aspects which are reconciled.

World-views of Information Systems Modelling: Groups of stakeholders who should be considered in requirements decision making can be associated into four-worlds. This makes the social prediction that different areas of expertise, different languages, and different interests exist and need to be integrated in the definition of ideal system. Researchers have argued for this four-worlds approach on pragmatic grounds: helping to determine complete agreed requirements and getting the required stakeholders involved in the process (Jarke and Pohl, 1993). Jarke and Pohl (1993) further described that it makes sense to distinguish, from a cognitive as well as a social viewpoint, between the usage world, the subject domain world, and the system world, and the need to describe their interrelationships. Then the development world has the basic task of assisting the practitioner in realising the vision in the context of the other worlds. Further to this it must also consider its internal development context of people, methods, experiences, and tools. The following is a brief description of four-worlds as described in the literature.

The **subject world** is the domain the system is intended to maintain information about and is traditionally represented within the data models. Stakeholders are the objects being represented or people who have stakes in these objects but are not direct system users. The **usage world** comprises stakeholders as owners, and direct and indirect users of the system. The relationships between users and owners can vary widely. An organisational structure often describes it, thus defining the (observed or intended) role of the information system in the work practice in or between organisations. The **system world** is often represented by technical gurus, or simply by the observed fact that the system is very hard to change, either due to its internal complexity or to its established relationships to user and developers. The **development world** is to ensure an adequate observation (cognitive aspect), participation (socio-organisational aspect), and representation (technical aspect) of itself and of the other worlds. It must proceed under consideration of resource constraints and competing role-bound and individual goals. With respect to the development world, the goal of participative design has often been cited. With respect to the system, quality-of-interaction factors such as response time, user-friendliness, and rich functionality are of interest as well as business goals such as reduced transaction costs, increased worker/ organisation effectiveness, or worker qualification (Jarke and Pohl, 1993).

3.3. Embedded action learning and action research

The process explained through figures 2 and 3 can be combined to provide the big picture of this methodology proposed. In general, the research element is a major part for deriving the planning process, implementation process and other (pre and post) processes shown in figure 4. The cyclic picture at the top (expanded in figure 2) is the process conducted to ascertain the current status and the cyclic picture at the bottom (expanded in figure 3) is the process conducted to accomplish the implementation. Strong existence of Action Learning and Action Research (ALAR) (Zuber-Skerritt, 2002) is embedded within the implementation process. McKey and Marshall (2001) described Action Researcher has having two sets of responsibilities; problem solving interest and responsibilities, and research interest and responsibilities. Similarly the figure below clearly shows the research interest of the practitioner and we have labelled the combination as ‘problem solving research’ to keep it simple. While the successful planning process by design leads into implementation process, via the Step 6 listed above, the implementation process with major planning deficiencies could lead again into the planning process for further refinement. Therefore the following entry and exit points are to be noted.

Entry: Research points to the fact that ‘existing organisational system needs improvement’
Exit: ‘Improvement strategy has been implemented’ and the finalisation research has followed

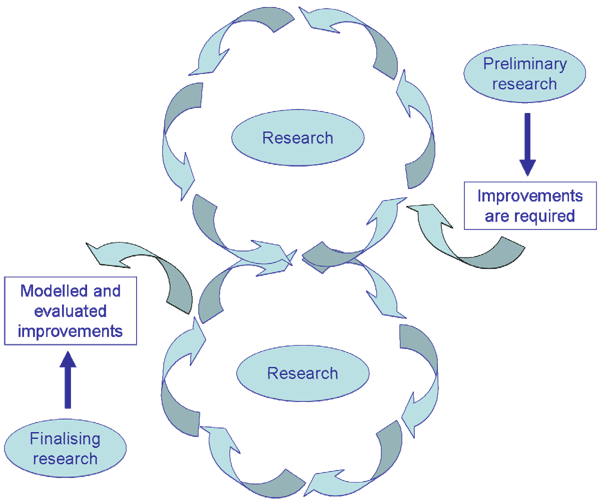

Fig. 4. Improvement via problem solving research

Practical conclusion: Given the cyclic nature of these processes, practitioners should carefully monitor the requirement of restarting another cycle and perhaps predetermined criteria for this purpose. It is also important not to exhaustively exploit available resources without justifying the causes. The practical conclusion of one cycle provides the basis for the revised actions for the next cycle and also call for further inquiry in later cycles. It will also generate information for stakeholders and researchers. The final conclusions should refer to interventions, the professional action undertaken by those responsible for the project, so that the methodology is justified. The conclusions may be of three types, (1) service activity, (2) supplementary research, and (3) appeal to other actors. The first two refer to the intervention level of the practitioners and researchers and the latter should avoid 'wishful thinking' (GTZ, 2004).

3.4. Application of the methodology and deriving knowledge assets

Although an organisation can use the simplified ‘soft’ methodology proposed to assess, implement and realise a suitable ‘system’ from which they can obtain profit, an organisation can also receive much benefits even by following the methodology partially. Due to the fact that the research practitioner engages with the stakeholders of the organisation persistently for various items (Steps 1-11 above) there will be many knowledge assets created over the process that greatly increases common understanding. There are not many processes currently being used by organisations that could create such a common understanding at a rapid pace over a considerable amount of time nor can the stakeholders realise its potential. This is where the organisations utilise external consultants to assess various aspects with regard to the organisation on an ad-hoc, basis, perhaps, when the stakeholders realise a particular process may ‘need improving or assessing’. This methodology influences the creation of such an expertise inside the organisation as a part of the stakeholder capability (or responsibility) so that the required knowledge assets can be created by themselves, with the assistance of a research practitioner who will be an insider. These assets are at high value and display the current and future of the organisation or knowledge profile of the organisation. The following table shows some of the knowledge assets that are created over this process.

Table 2: Knowledge assets for knowledge profile of the organisation

Step	Knowledge asset sought
Step 1: Stakeholder analysis	Stakeholders / Interest and roles
Step 2: Problems / issues and strengths	Bridging the deficiencies / capitalise on strengths
Step 3: Definition of the ideal system	Must have / Should have / Could have - status
Step 4: Responsibilities of stakeholders or groups	Stakeholder responsibility / Next action lists
Step 5: Status documentation (stakeholder engagement plan, etc.)	Concise memo for each stakeholder / group
Step 6: Expected results / outcomes of the expected system	Detailed ‘system’ outcomes with ‘improvements required’
Step 7: Document ‘systems’ objectives	Agreed ‘systems’ objectives and time plan
Step 8: Define performance measures and actions	Performance instruments and agreed scales
Step 9: Construct and perform actions	ALAR documentation / Action plan, etc.
Step 10: Evaluation of actions	ALAR evaluation results
Step 11: Adjust and ‘system’ change management	Stakeholder and others responsibility of CM

4. Conclusion

We believe that the underpinning characteristics of this methodology facilitate easy adaptability. In particular the proposed methodology provides users with underlying principles, processes and knowledge transfer mechanisms (Mihindu, et al, 2008) to deal with the organisational situations that require attention. The proposed methodology aims to create systems that are emancipatory. Further our expectation is that the system users’ of the organisation will be released from constraints of irrational, unproductive and unsatisfying circumstances, which may limit their self-esteem and imagination. The target would be to assist users with investigating the reality in order for them to change it and hence realise it fully. In our future work further refinement of the methodology, sample applications and case studies are to be derived. Also samples of knowledge assets are to be drafted which explain organisations knowledge profile.

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An Investigation and Identification on Functions and Features of Project Extranet in Construction

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Abstract:
Project extranet has been proven a potential technology in improving information transfer, communication and collaboration in construction. However, although many research efforts have been made on discussing its development, implementation and deployment, only very little literature was found aiming to analyze its functionality. This more or less prevents the system vendors from designing their systems clearly and simply; and prevents the end-users understanding and selecting a suitable system among all available ones.

To eliminate this obstacle, this research aims to review some existing systems, to analyze the systems' provision on functions and associated features, and to investigate the differences among systems. The result will be beneficial for the stakeholders to improve their understanding to project extranet, particularly in the functionality issues.

Keywords:
Project extranet, Functionality, Function and feature.

1. Introduction

1.1. Background

Construction industry plays an important role in the economy, as it provides buildings and infrastructure on which all sectors of the economy depend. However, it's also well-known for its notorious fragmentation and complexity and is one of the most information intensive industries (Bennett 1991, Howell 1999). Thus, the timely and accurate information transfer and communication, together with the partnership and collaboration among all partners, are crucial to the success of projects.

Project extranet, or web-based construction collaboration technology, has been acknowledged as a potential technology in improving the efficiency and effectiveness of information transfer, communication and collaboration in construction processes. According to Hamilton (2004) and many other researchers (CNPlus 2001a, Breetzke and Hawkins 2002a, NCCTP 2005, Wilkinson 2005), project extranet is defined as a network linking the various parties to a construction for the exchange and storage of project information in digital form; and for the collaborative works during construction processes. It is based on the universal Internet platform and employs integrated web-based applications and tools, to provide the communication platform and help construction collaboration more effectively. Normally, project extranet is hosted by an Application Service Provider (ASP) and the service is typically leased for a period and / or per-user / project.

Project extranet makes use of the advantages of Internet for being a global network that is not restricted by location, time or different computer operating system. The benefits from using it have been well documented, which include: no extra hardware and software investment; application and location independent (Nitithamyong and Skibniewski 2004); up-to-date information retrieval and improved communication (Bryant and Pitre 2004); cost and time effective (Tam 1999, Sulankivi 2004, NCCTP 2006); and some intangible benefits such as few claims, greater flexibility and so on (Wilkinson 2005). Because of the benefits, project extranet has been implemented in practice during the last decade and some successes have been reached in its initial stage. In 2003, Engineering News Record (ENR) in the United States reported that the number of A/E/C (Architectural, Engineering and Construction) firms using web-based systems has risen by 16% within the past two years (Hurtado 2003). In the UK, research shows up to 1,500 projects with a combined capital value of over £20 billion are already using Internet-based communication tools and there are an estimated 25,000 individual users, which is an increase of 50% on three months ago (CNPlus 2001b). This increase has been widely acknowledged and a number of such systems are reported by researchers and practitioners worldwide (Breetzke and Hawkins 2002b, Leung 2002, Alshawi and Ingirige 2003, Nitithamyong and Skibniewski 2004, Wilkinson 2005).

1.2. Research Needs and Questions

Given its short history started in late 1990s, project extranet is still a very young technology and the market is immature. Previous research has stated some difficulties and barriers such as lack of standards, over-dependent systems, resistance to change from the employees, security, and so on (O'Brien 2000, Rozell and Gardner 2000, Dawood *et al.* 2002, Becerik 2003, Nitithamyong and Skibniewski 2004, Liu and Kagioglou 2005, Wilkinson 2005). Some new topics have emerged for further studies, to ensure it can be effectively deployed and used to its potential.

Recently, some studies have discussed the importance of functionality of project extranet. Among them, O’brien (2000) suggested A/E/C firms to have a specific feature and think through how this feature would interact with the job tasks of project team members. Andresen et al. (2003) stated that there is a continuing need to improve the functionalities of project webs. Becerik (2004) also agreed that web-based project management and collaborative technology is bound to replace the old ways, but only if these tools can adequately fulfil the specific needs of users.

However, the function-related issues are not well analyzed so far because of some difficulties. At first, the existing functions and associated features vary greatly depending on the vendors’ origin, history, experience, target market and financial status. The functions and associated features are normally supplied in different combinations with different highlighted features by different vendors. It is therefore difficult to extract a standard feature list. Secondly, project extranet essentially isn’t a creative technology but only a combination or integration of several existing technologies such as web browser, Internet connection, and computer. Thus, this is difficult to clarify the differences among systems in the functional aspect. Thirdly, the functionality that systems can provide is uncertain. Intense competition often forces the vendors add new features or release new version to stay ahead of the competitors. The speed of IT development can also quickly make the feature studies “out-of-date" or very short life-span (Bjork 2003). Last but not least, previous researches (Breetzke and Hawkins 2002a, CICA 2003, Wilkinson 2005) have shown that the vendors will be reluctant to say their system does not possess a particular capacity. When being investigated, most of feature options usually get ticked by them. On this condition, it is difficult to gather the accurate result from the vendors.

The absence of in-depth analysis to the function-related issues brings about some negative results. On the one hand, some vendors are unable to clearly define and describe what they provide in the systems. The functions and features are sometimes scattered, overlapping and confusing.[i] On the other hand, the systems accumulate a large number of functions and features which somewhat are unnecessary while the most usable features might not be highlighted, or sometimes ignored at all. This situation will consequently increase the difficulties for the users to choose the right system and use the system as they planed.

Therefore some research questions can be developed as: 1. would there be a commonly acceptable function category covering fullest function list? 2. what about the availability of these functions and associated features in the existing systems? 3. Are there any systems covering the fullest functionality? 4. are there any difference among existing systems? This research will aim to answer these questions below through an investigation to the existing systems.

2. Feature and Function Definition

Project extranet is classified as a web-based information system. So, like any other information systems, it is comprised of an integrated set of features or functions. A clear understanding of the concepts of function and feature is therefore a decisive prerequisite to the function-related study.

Information system may be defined as a set of elements. It is a set of information resources organized for the collection, storage, processing, maintenance, use, sharing, dissemination, disposition, display, or transmission of information (NSTISSI 2006). The aim of an information system is to provide procedures to record and make available information, in order to improve the efficiency and effectiveness of the organization (Flynn 1998). To fulfil this aim, the system must have some different components of functions and features.

Feature has been defined in various ways. In general, feature is a service that the system provides to fulfil one or more stakeholder needs (Leffingwell 2000). It is a coherent and identifiable bundle of system functionality that helps characterize the system from the user perspective (Turner *et al.* 1999); or a prominent or distinctive user-visible aspect, quality, or characteristic of a software system or systems (Kang *et al.* 1990); or an externally desired service by the system that may require a sequence of inputs to effect the desired result (IEEE 1998).

Function is what the feature does. It is an abstraction of the main activities carried out to achieve organizational objectives. According to the definition given in Oxford English Dictionary, it is an activity that is natural to or the purpose of a person or thing. The definition further explains, in computer science, function is a computer operation corresponding to a single instruction from the user. Usually, a couple of features would be needed to fulfil a function. This also implies that a functional module may contain one or more features and provides us a basis for grouping associated features.

In project extranet, the main and purposeful function is to share project documents among project participants. This function is the core of such systems. In addition to this principle function, the latest project extranets provide many supporting functions to facilitate the information transfer and communication tasks, to streamline the work flow and to collaborate with the other partners during construction process (see details in below). Moreover, some extra functional modules, e.g. e-tendering service, are being added into the systems, which seem to be the add-ons to the end-users and add values to the existing systems.

3. Categorization of Functions and Features in Project Extranets

As aforementioned, the existing project extranets provide a large number of functions and associated features in different structures and combination. The system vendors usually have their own function matrix according to their preferences and target markets. They vary so greatly that it's impossible to generate a commonly acceptable category from the systems' provision.

Previous studies have provided some function categories (refer to Table 1). They can give a snap-shot of functionality of project extranet but are not enough for further analysis. It is firstly admitted limited by the researchers themselves (CICA 2003, Wilkinson 2005). And, the categorizations are lack of acceptable standard and therefore are only "customized". Furthermore, some categories have one or more missing or overlapping functions and features. For example, in the category made by Leung (2002), the general system module may easily be overlapping with the administration module. The category of Becerik (2004) missed the non-functional features that play the important roles to set up and administrate the systems.

Table 1: Previous Categorization of Project Extranets' Functionalities

Leung (2002)	Nitithamyong & Skibniewski (2004)	Becerik (2004)	Wilkinson (2005)
General system	Document management	Team communication and document management tools	Organisation
Document management	Project workflow	Workflow and process automation tools	Communication
Workflow management	Project directory	Process and project management tools	Management
Administration	Central logs and revisioncontrol		Collaboration
User centric workplace	Advanced searching		
Team communication	Confenrenceing and white-boarding		
ASP server performance	Online threaded discussion		
	Schedule and calendar		
	Project camara		
	File conversion		
	Website customization		
	Office access		
	Messaging outside the system		
	Wireless integration		
	Archiving of project information		
	Information service		
	Financial service		
	E-bidding and procurement		

These issues make the previous categories unusable for our research. There is neither a commonly acceptable function category nor any category covering the fullest function list. Therefore, the authors have to propose another 4 groups' category for this research, which comprises of System administration, Document management, Workflow management and Communication tools plus add-ons. This categorization is based on the tasks that all functions and associated features will fulfil in every module respectively. It tries to cover the existing functions and associated features to date. It also considers the potential upgrade that the vendors can add into as add-ons. This category including full description of all functions and associated features will be discussed in detail in the following sections, together with their adoptions in our analysis.

4. Research Method

Fieldworks, e.g. survey or interview to the system vendors, have been proven not suitable for identifying the functions and features from the vendor's perspective. The major reason is, as aforementioned, the system vendors would be reluctant to say their system doesn't have a specific function and will click most of options when investigated. As the result, the survey will normally produce an inaccurate result.

Thus, the authors have selected desktop research as the research method and so this research is mainly based on the document analysis to the available materials disclosed by the vendors. The steps include: 1. identification of functions and associate features for developing a category for this research; 2. identification of project extranet vendors for the selection of sample system; 3. investigation into the selected systems for listing and scoring the existing functionalities. 4. analysis to the results and conclude the findings.

Following these steps, the authors firstly selected some systems as the samples (refer to the following section for the sample systems and selection criteria) and then collected the materials which include vendors' web-pages, brochure, white papers, demo software, reports and some results of previous. The authors have then viewed all of the available materials, browsed the online contents and used the available demo system one by one carefully. For those vendors providing more than one product, the authors did a wider investigation among all products available. The authors have also contacted the selected system vendors by emails or filling out the request information form on the vendors' websites. However, despite several requests for information, only a couple of system vendors responded with their features lists or white papers.

The functions and features are then categorised with descriptions as below. To analyze the functionality, a scoring system showing the feature's availability has been adopted. This scoring system is based on the "Yes or No" pattern and was adopted by Raol *et al.* (2002) to analyze functionality of enterprise portal. When adopting this system, a table will be built which combines the to-be-investigated sample systems and features in a crossing way. If a certain feature is found in a specific system, a Y note will be given in the corresponding cell in the table. If this feature is not mentioned or unavailable in a system, then an N note will be given. After full investigation and all marks are completed, the total amount of features belonged to a system will be summed up and the percentage of availability for a feature will be calculated and used for the further analysis.

5. Investigation and Identification of the Functions and Features

5.1. Sample Systems Selected

In 2005, ExtranetNews (2005) listed more than 250 project extranets worldwide. Since then, some vendors have been merged or disappeared while some new ones emerged although the exact number is unknown. The market is very lively and competition is on a quite high level. Some system vendors often claim their success in their white papers or press releases, but no any single system is in a dominant position. Also, some small companies that only sell a single service (e.g. document management) are still alive, although many market leaders are providing much more comprehensive functionality or so-called full solution to the end-users.

In order to gather as much information as possible in a short time and with limited resources, the authors have decided that the major criterion for the sample selection is the functionality that the systems can be capable of providing. In another word, the samples should be those systems that indicated they provided solutions in all 4 function categories as we proposed above. Therefore the eight systems, which form a consortium in the UK (NCCTP - The Network for Construction Collaboration Technology Providers), would be the ideal samples and are all selected. As the leading systems in this area, AutoDesk's Buzzsaw & Constructware and Bentley's Viecon have also been selected. Apart from these samples, other systems are then randomly selected from the directories which include eProject, HotProject, CTSpace and The-project. However, they are all identified to have the solution in our category.

Table 2 shows a list of selected systems and their providers with the websites respectively. An abbreviation-style symbol was given to each system.

Table 2: Selected Project Extranet Providers[ii]

No.	Symbol	Product	Vendor	Website
1	4P	4Projects Extranet	4Projects Ltd.	www.4projects.com
2	ACO	Aconex System	Aconex Ltd.	www.aconex.com
3	AD	Buzzsaw & Constructware	Autedesk Inc.	www.autodesk.com
4	AS	Asite Solution	Asite Solutions Ltd	www.asite.com
5	BC	Business Collaborator	Business Collaborator Ltd.	www.groupbc.com
6	BIW	BIW Technologies	BIW Technologies Ltd	www.biwtech.com
7	CAD	CadWeb.net	Cadweb Ltd.	www.cabweb.co.uk
8	CT	CTSpace Solutions	CTSpace Ltd.	www.ctspace.com
9	CWT	Causeway	Causeway Tech Ltd.	www.causeway.com
10	EP	eProject	eProject Inc.	www.eproject.com
11	HP	HotProject	Hot Project Ltd.	www.hotproject.com
12	THE	The-Project	Sarcophagus Ltd.	www.the-project.co.uk
13	PP	ProjectPlace	ProjectPlace Int'l AB	www.projectplace.com
14	VIE	Viecon by Bentley	Bentley Systems Inc.	www.viecon.com

5.2. Features' Investigation and Identification

This section groups the functions and associated features into the proposed 4 groups' category and describes all features in detail. All feature associated with a specific function are highlighted in bold characters. Afterwards, the scoring tables are generated showing the features' availability.

System Administration

System administration includes the features occurred in the initialization stage and daily maintenance. It includes three sub-functions: 1. User management, which enables the client to manage their user group by setting a **hierarchical user profiling** and creating a **user directory or address book** to facilitate the contact among all participants; 2. Project administration, which manages project web throughout the whole process of web site utilization. The user can design its own **customized project web** by using **wizard or templates** and manage **multiple projects** in a single **project panel or dashboard**. Another useful feature is **project inbox or notice board** which shows instant message or notice to the users as soon as they log into the system; 3. System settings enable the maintenance and configuration of systems. When required, the user can set **language** options for the purpose of localization. It can also **monitor and control** the system's access, usage and health. It can set the level of **system security** and protect user's data and privacy. Some system vendors may design special features for those mobile people to access the system by using **hand-held devices**. Also, although the project extranet is mainly a web-based system, some vendors provide the user desktop or **client-end software** for their convenient and alternative use.

Table 3 shows the availability of features associated with system administration in the sample systems.

Table 3: Features Associated with System Administration

Characteristic	4P	ACO	AD	AS	BC	BIW	CAD	CT	CWT	EP	HP	THE	PP	VIE	%
User hierarchical profiling	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
User directory / address book	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	93
Project panel / dashboard	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Multi-projects support	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Customization of project web	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Project inbox / notice board	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	93
Project wizard / template	N	Y	Y	N	Y	Y	N	Y	Y	Y	Y	N	Y	Y	71
Access control / monitor	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Hand-held devices support	N	N	N	N	N	N	N	N	N	N	N	N	N	N	0
Security	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Localization / multi-languages	Y	Y	Y	N	N	Y	N	Y	N	N	N	N	Y	Y	50
Client-end software support	Y	N	Y	N	Y	N	N	Y	N	Y	N	N	N	Y	43
Feature number	10	10	11	8	10	11	7	10	9	10	9	8	10	11	
Percentage	83	83	92	66	83	92	58	83	75	83	75	66	83	92	

Document Management

Document management is the major function of project extranet and is the main benefit from using this technology for the users. It establishes a single and central location to allow the users store and manage project-related files generated by various applications, such as project photos, contracts, drawings, specifications, cost data and etc. The associated features and characteristics have been well discussed (Watson and Davoodi 2002, Asprey and Middleton 2003). In the first instance, the files' transfer (**upload & download**), **sharing and publishing**, **viewing**, **searching** and **printing** are the essentials of a document or content management system. In addition, to make the better utilization of the documents, some other features are introduced in the systems to help the users view the files in **multiple formats** remotely, either online or offline. They can then **revise**, redline, mark-up and modify the files when required. The file version will be recorded and the **history** can be retracted. **File encryption** is applied to enable the documents' security during transmitting and reviewing procedures. The files would be back-up in a second server or other storage devices, to protect them from any possible crash down or **disaster**. Information **storage and archival** allows a project team to copy the entire or part of project database to a set of storage devices or media after the completion of a project, to keep all necessary project records for any dispute and future operation and maintenance of the facilities. Also, the archived data could provide the reference for the future bidding.

Currently, the document management systems usually provide the supports to workflow management as an **integrated solution**. All files should be used seamlessly by other features such as Request for Information (RFI) and Technical Queries (TQ).

Table 4 shows the availability of features associated document management in the sample systems.

Table 4: Features Associated with Document Management

Characteristic	4P	ACO	AD	AS	BC	BIW	CAD	CT	CWT	EP	HP	THE	PP	VIE	%
File upload / download	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
File encryption	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
File sharing / publishing	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Remote viewing	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Mark-up / revise	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Notification of change / new	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Search tools	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Track record and history	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Printing-out	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Muilt-format support	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
File storage and archival	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	86
Workflow Integration	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	N	N	Y	64
Disaster protection	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	Y	Y	Y	71
Feature number	13	13	13	13	13	13	10	12	13	10	11	12	12	13	
Percentage	100	100	100	100	100	100	77	92	100	77	85	92	92	100	

Workflow and Task Management

Project workflow is a process that involves the automation of construction process and the activities among project players, e.g., the process of approving a change. Standardized workflow management is achieved through the monitoring of **project progress** and automatic completion of some specific tasks (e.g. **query management**, **change order and approval**) and timing response to the Request for Information (**RFI**) and Technical Queries (**TQ**). The benefit of workflow management can also be gained through the **real-time event management** and automatic **task reports** and **meeting minute**. To keep the work going as planned, it's also necessary to use Web-based **calendar or schedule** and **task reminders**.

Table 5 shows the availability of features associated with workflow and task management in the sample systems.

Table 5: Features Associated with Workflow and Task Management

Characteristic	4P	ACO	AD	AS	BC	BIW	CAD	CT	CWT	EP	HP	THE	PP	VIE	%
Integrated project calendar	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Progress management	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
TQ, RFI management	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y	86
Change order and approval	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y	86
Real-time event management	N	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	79
Reporting on workflow	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Feature number	5	6	6	6	3	6	5	6	6	6	6	6	4	6	
Percentage	83	100	100	100	50	100	83	100	100	100	100	100	67	100	

Communication Tools & Add-ons

Improved team communication has been proved another major benefit from using project extranet, which are achieved through online platform and with the help of some brand new or mature applications and tools, such as **email**, **instant messaging**, **discussion forum**, online **audio / video conferencing**, and etc. As a real-time appliance, **web-cam** can act as a monitor or recorder and all participants can be informed with real-time updates. These features provide supplement for and facilitate to formal communication. It is expected that wireless and mobile communication will add more values on this feature.

With the development of technologies, users' expectations to the system integration are continuously increasing. As the response to their expectations, some system vendors have developed a number of add-ons or functional modules, which are sold / leased either separately or as a bundle. Among them, **electronic tendering** function should be a potential one and the feature of recording **healthy and safety** status during construction process is also a positive response to the more and more strict requirement in law.

Table 6 shows the availability of features associated with communication tools and add-ons in the sample systems.

Table 6: Features Associated with Communication Tools and Add-ons

Characteristic	4P	ACO	AD	AS	BC	BIW	CAD	CT	CWT	EP	HP	THE	PP	VIE	%
E-mail	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
Instant messager (IM)	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	7
Discussion forum	Y	N	Y	N	Y	Y	N	N	Y	Y	N	N	Y	Y	57
Audio / Video conferencing	N	N	N	N	N	N	N	N	N	N	N	N	N	N	0
Web-Cam facility	N	Y	Y	N	N	Y	Y	N	N	N	N	N	N	Y	36
e-Tendering / bidding	Y	Y	N	Y	Y	Y	N	Y	Y	N	N	Y	N	Y	64
Healthy & Safety file	Y	N	Y	N	N	Y	N	N	Y	N	N	N	N	N	29
Feature number	4	3	4	2	3	5	2	2	4	2	1	2	3	4	
Percentage	57	43	57	29	43	71	29	29	57	29	14	29	43	57	

6. Findings and Discussion

6.1. Differences of Functions and Features – Answers to the Research Questions

The tables presented in the previous section form a basement for further studies. After checking and comparing the tables one by one, the authors have reached some results that can answers the rest of research questions.

With regard to the availability of the functions and associated features, the first impression for the authors is, of all selected systems, not anyone has had all listed features. It means no any system can be regarded as a total solution like they claimed in their disclosure materials. The thorough examination shows that only Autodesk's Buzzsaw plus Constructware, BIW and Bentley's systems can supply the most comprehensive functionality, although they are still lack of some features that may exist in other systems.

In addition, it is found that only 6 systems have more than 80% listed features in all modules excluding the communication tools and add-ons module. They are 4Projects, Aconex, Buzzsaw & Construtware, BIW, CTSpace and Viecon by Bentley. On the one hand, it implies that there exists a great difference among all available project extranets. On the other hand, this once again gives the evidence that the availability of features to all systems is not in a satisfactory level. Furthermore, we can say that the myth of total solution is not really the truth. Or, in another more gentle way as Raol *et al.* (2002) used, the term of "total solution" may not have the same definition among the different developers.

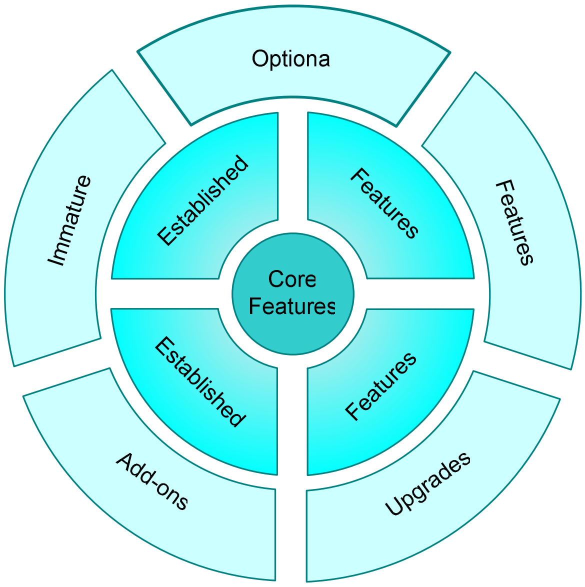
Looking into the tables, the authors have found that the extent of availability for all functions and associated features is quite different, which means the system vendors have different bias on the feature options. As the principle function, document management module has been proven a well-established one. Of 13 features associated with this function, 10 of them are produced by all system vendors, which include file upload / download, file encryption, file sharing / publishing, remote viewing, mark-up / revise, notification of change / new, search tools, track record and history, printing-out, and multi-format support.

In comparison with document management, the communication tools and add-ons module gets the lowest percentage. This means the features associated with this function are either optional or immature for an on-sale product. After looking into this module closely, instant messenger is found in only one product and audio / video conferencing has no any presence in products. Considering their popularity in personal use and entertainment, they are surely not immature but are unacceptable by the industry on the corporate level. Other less-adopted features are believed to be either immature (e.g. e-Tendering), or easy accessible (e.g. Web-Cam), or substituted by other features (e.g. discussion board and healthy files).

Another two functions are in the middle place. Of all 12 features associated with system administration, 8 are found in more than 90% systems which include user hierarchical profiling, user directory / address book, project panel / dashboard, multi-project support, customization of project web, project inbox / notice board, access control / monitor, and security. These features could be classified established and mature ones. Project wizard / template is only found in 71% of all systems, which means this feature is still needed to be further improved and wider adopted. Localization / Multi-language support and Client-end software are found in less than 50% of systems. They are therefore classified maturing features and their deployment is greatly dependent on the target market and users. The absence of hand-held devices support is an surprising finding[iii], as there have been a number of publications discussing its implementation together with wireless communication in the construction industry (De La Garza and Howitt 1998, Rebolj *et al.* 2002, Beyh and Kagioglou 2004, Rebolj and Menzel 2004, Kimoto *et al.* 2005, Aziz *et al.* 2006) and it was regarded very suitable for the mobile construction process. This phenomenon needs to be paid attention and in-depth research is required in the future.

Of all 6 features associated with workflow and task management, three have been found in all systems and another three have also got a satisfactory percentage (above 79%). So, all of these features could be classified established ones. It reflects that the concept of integrated working has been widely accepted by the industry. The workflow management and document management are now remaining a close relationship and the integration is achieved in project extranet as well.

The differences of availability for all features can lead to a hierarchical classification on them, i.e. all features could be grouped into three levels according to their presence: core features, established features, and immature / optional features. The core features include all of those that have had more than 90% of availability, while the established ones include those that locate between 70% – 89% in availability and all of the rest are put in the lowest level. This classification can then be illustrated as Fig. 1 and shows the difference among all features again.



Core	Profiling	Directory	Dashboard	Multi-project	Customization	Notice board
	Access control	Security	File load	Encryption	Sharing	Viewing
	Mark-up	Notification	Search	Track record	Printing	Multi-format
	Calendar	Progress	Workflow report	E-mail		
Established	Template	Storage	Disaster	TQ / RFI	Change order	Event
Immature	Hand-held	Localization	Client-end	Workflow	Messenger	Forum
/ optional	Web-cam	e-Tendering	H & S files	Conferencing		

Fig. 1. Features' Hierarchical Classification

6.2. Supplementary Findings

Besides the differences of all features discussed above, another finding from using the system demo is that some features are not developed as properly as they should be. As an example, localization / language option would be a serious consideration for most of system vendors if they want to develop overseas market. However, although there is some multiple language support, it seems only an advertisement. When investigating this feature, the authors tried to set up a sample project on some systems in a pure Chinese environment which the vendors claim the support exists. But the efforts failed in most of cases, because either the system only provides an English interface or produces wrong characters in the web pages. This kind of exaggeration will certainly result in the disbelief and abandonment to the implementation of such systems for the end-users.

Yet, there are also some other positive findings. At first, we find from the tables that all the systems have no significant shortage in major functions and features. For the users selecting a suitable system, it is therefore a good news as they will not fear any absence of critical features. It can surely enhance their belief in using such systems. Secondly, all systems have the same bias on document security. The related features of User's hierarchical authentication, File encryption and Security get 100% presence in all systems. This could then effectively reduce the user's worry about securing their documents and protecting their privacy. Thirdly, the usability of project extranet has been paid enough attention. In most of systems, the user can set up their own project web with the supplied wizard. Easy-to-use has often been a highlight for the vendors when marketing their system. This is also the case in compatibility issue as all systems provide multi-project and multi-format supports. Together with the service of file archival, the migration from one system to another becomes possible.

6.3. Function Overload? Suggestion for Further Study

This research has generated a complete list of features. The extent of availabilities and differences among all sample systems are discussed above. These features more or less are the components or possibly a part of further evolution of existing systems. They represent the developer's perspective in the provision of functionality. However, whether or not these functions and features are really what the users want?

Satisfactory answers to this question should be significant, as previous research has found that information systems often provide some redundant functions and features. These excessive functions will result in very loaded or complex sites which will purely discourage the users.

Hurley (1998) called this "overload", she added:

> "The overload of features and functions forces us to navigate more and more complex routes to more and more obscure asks. We are working for the technology rather than having the technology work for us."

This overload can be judged in many ways. The rule of "20/80" seems applicable to demonstrate this issue although it might be difficult to conclude a quantitative result. This rule is known as Pareto principle and it is often used to describe a phenomenon that, for many events, 80% of the effects come from 20% of the causes. In computer science the Pareto principle can be applied to resource optimization by observing that 80% of the resources are typically used by 20% of the operations (WiKi 2007). In this research, this rule may be used to describe that the 80% of users only use 20% of functionality, or 80% of all features are actually used by 20% of the users effectively.

However, this judgement needs solid evidence to validate it. So, there is another urgent need to undertake a research to analyze the functionality from the users' perspective, to make a comparison with the systems' provision. In this topic, Ruikar *et al.* (2005) have done a case study aiming to analyze users' acceptance to project extranet and found that "visionary" and "market leader" will encourage the adoption of this technology. But the users' requirements to the specific functions and features are still not disclosed. We believe the awareness to the user's exact needs must be taken into account, as the successful use of information technology requires an analysis approach which takes into account a thorough understanding of the organizational role (Shaefer 1988).

Our next research will then investigate users' real needs, aiming to find the users' attitude and expectation to the functionalities, and to find the gap between the existing functionalities and users' requirements.

6.4. Limitations

Although this research method can effectively extract the provided features from the existing systems, it has some obvious limitations.

At first, considering the amount of existing systems in market, the amount of selected sample systems is limited. Therefore the selected samples can only reflect the selected vendors' perspective and show a partial image to the researchers. This is a key limitation of this research. Another key limitation is that the information used in this research is mainly based on the disclosure materials supplied by the system vendors. Their attitude and bias on features' presence will somewhat impact on the result of this research. The authors have made continuous efforts to use the demo systems offered by the vendors, to try to find the facts that the disclosure materials don't state. However, not all systems have available demo software for this usage.

Despite the limitations stated, this research was undertaken independently and therefore the outcomes of this research are not biased in any way. The authors have paid emphasis on eliciting the existing features in a reasonable way and great care was applied in interpreting the results as well. If the further improvement on the result is required, the suggestion is testing the systems one by one with the participation of developer's software engineering or system analyst.

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[i] As an example, some vendors confused the characteristic (e.g. easy-to-use) with the systems feature.

[ii] After this paper was finished, the authors were officially informed that eProject's name has been changed to Daptive just because the original name is regarded as too specific to develop a new area. However, this research will remain the original name instead.

[iii] The authors had even written to some leading ASPs to confirm this finding but the responses are negative. All of them don't support hand-held or mobile devices so far.

Delivering Safety Training Using Virtual Classes

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Abstract:
While the delivery of virtual classes is not necessarily a new application of technology as part of learning, attempting to integrate MI into the delivery of a virtual class is a new application of e-learning. The aim of the research is to look at the application of multiple intelligence (MI) profiling within virtual classes that deliver health and safety training. It is proposed that two phases of virtual classes are developed, focusing on the risk of falls from high building structures.
The first phase of development will be tested on a target audience from the construction industry and the results and conclusions will feed into the development of the second phase. An action research approach will be used to further refine and develop each phase. An evaluation of the framework has been designed for use before and after the virtual class to measure the effectiveness of the learning that took place.
This research intends to provide an innovative training approach through developing a virtual class frame work that applies the principles of multiple intelligence (MI) to health and safety training in the construction industry. This paper looks at the methodology and approach taken in implementing a virtual class framework on a target group of construction professionals.

Keywords:
Virtual Class, Multiple Intelligence, Learning Management System, MIDAS Profiling.

1. Project Description

A network of educational institutes and training companies from Ireland, Turkey, United Kingdom, Cyprus and France have secured funding from the Socrates-Minerva Action Program to evaluate MI in an e-learning environment through deploying learning resources and evaluating the learning experience. This research hopes to provide an innovative training approach through developing a virtual class frame work that applies the principles of multiple intelligence (MI) to health and safety training in the construction industry.

2. Virtual Classes

With the rapid growth of computer networks and advances in telecommunication, distance education has become an important method for delivering education. Technology has the potential to transform the classroom experience for both teachers and pupils (Martin, 2005). A virtual classroom has been defined as: an online learning and teaching environment that facilitates the collaboration and integration of discussion forums, chat rooms, quiz management, lecture notes and assignment repositories, subscription services, relevant web links, email distribution lists and desk top video conferencing into a conventional lecture based system(Chye Seng and Al-Hawamdeh, 2001, p238).

The tools offered by a virtual class tend to fall into two categories - either synchronous or asynchronous (Davis and Wong, 2007). Synchronous communication refers to real time interaction such as voice over internet protocol (VoIP), video conferencing and virtual white boards. Asynchronous communication refers to delayed interaction which takes place over a period of time such as forums and wikis (Bower, 2007). It is suggested that a balanced use of both forms of communication is needed to achieve an effective virtual class (Davis and Wong, 2007 and Chye Seng and Al-Hawamdeh, 2001).

For educational institutions and for workplace based learning, online environments are rapidly expanding as a channel for the delivery of learning (Chye Seng and Al-Hawamdeh, 2001). The use of a virtual class offers greater efficiency in training delivery, supports a greater diversity of approaches, increases flexibility for learners and offers extensive interaction (Bower, 2006). While the use of virtual classes can enhance the conventional learning experience the most critical part of online learning is its ability to foster interaction - student to student and instructor to student (Davis and Wong, 2007).

Biggs (1999) argues that the three primary types of interaction are: learner – content interaction, learner – instructor interaction and learner – learner interaction. These interactions are a key part of any virtual class as they facilitate peer interactions, collaborative learning and peer review (Davis and Wong, 2007). The relationship between these three types of interaction is illustrated in figure 1.

Many aspects of general good teaching practice are directly transferable from traditional face-to-face teaching to virtual classes (Hawk and Shah, 2007). The way these practices are implemented can be different due to the mechanics of the virtual classroom environment (Bower, 2006). The use of virtual classes shifts the control from the instructor to the learner. As a result the online learner must be self motivated to take an active part in the online environment (Davis and Wong, 2007). As students have a more active role in the learning the instructor needs to be consciously aware of the students learning styles. This places the instructor in a position to make informed choices about course material, design, and learning processes which broaden the opportunities for effective learning (Hawk and Shah, 2007).

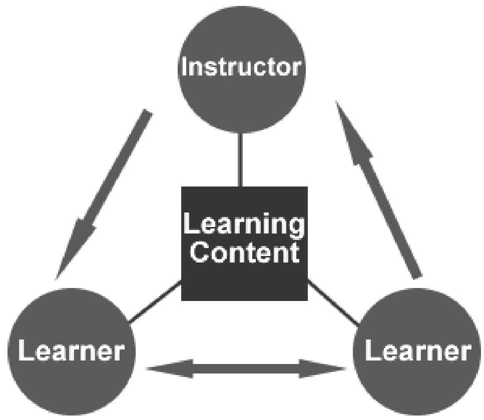

Figure 1 – Three types of Primary Interaction

3. Multiple Intelliegences

The project hopes to adapt and utilise Multiple Intelligences (MI) theoretical learning principles to create a virtual class designed for instructing health and safety principles to construction professionals (McNamee, 2007).The theory of MI was devised by Harvard University's Howard Gardner in his 1983 book *Frames of Mind* which postulates that individuals possess several independent ability areas (intelligences). According to MI, the measure of one's proficiency in a particular intelligence is the ability to use it to solve problems and fashion products that are valued in a particular cultural setting or environment (Gardner, 1983). Gardner proposes that there are eight intelligences, these include:

3.1. Linguistic intelligence

Involving the capacity to use language to express and appreciate complex meanings. For example poets, writers and storytellers.

3.2. Logical-Mathematical intelligence

Involves using and appreciating abstract relations. E.g. Scientists, mathematicians, accountants.

3.3. Spatial intelligence

Concerns the ability to perceive visual and spatial information, and to transform and modify this information, and to recreate visual images. This intelligence is strongest in artists, architects, sculptors and engineers.

3.4. Bodily-Kinaesthetic intelligence

Involves the use of all or part of one's body to solve problems, fashion products, or construct meaning. For example athletes and surgeons.

3.5. Musical intelligence

Allows people to create, communicate and understand meanings made out of sound. E.g. composers, opera singers

3.6. Interpersonal intelligence

Is the ability to perceive and make distinctions in the moods, intentions, motivations and feelings of other people and to act accordingly. For example teachers and psychologists.

3.7. Intrapersonal intelligence

Enables individuals to understand themselves and to draw on that understanding to make decisions about viable courses of action.

3.8. Naturalist intelligence

Allows people to distinguish among, classify and use features of their environment. For example farmers, gardeners and botanists. Source; (Jordan, 2003).

Typically, individuals display 'jagged' intelligence profiles that are manifested as different areas of strength and weakness and these are the reflection of the influences of inherited biology, environmental culture and life experiences (Shearer, 2007).

A key success of a educational frame work based on MI principles is the way information is presented. Gardner envisaged "entry points" which would act as "doors" to allow access to an individuals multiple intelligences. Gardner identified five multiple entry points as outlined;

3.9. Narrative

The narrative entry point deals with the 'story' that is central to the topic. Examples: case studies, narrative or themed stories, descriptive accounts

3.10.Logical /Quantitative

This entry point is focused on the numerical aspects of a topic. It typically involves deductive or logical reasoning that can often be captured by *if-then* syllogisms.

Examples: Statistics, graphs, logic reasoning tasks.

3.11.Aesthetic

The aesthetic entry point engages artistic aspects of a topic. It may also focus on sensory feature associated with the topic.

Examples: three-dimensional representations, images, videos, design activities.

3.12.Experiential

This entry point should provide students with an opportunity to engage with the topic in a 'hands-on' manner.

Examples: Any 'hands on' interaction with the subject matter of the topic.

3.13.Existential/Foundational

This entry point deals with fundamental, philosophical questions about the nature of the topic, why it exists, and/or what is its meaning or purpose.

Examples: Any questioning of the foundation or substance of a topic.

Multiple entry points are designed to serve all intelligences. This means that by presenting information through the five MI entry points, the information should be accessible by everyone regardless of their MI profile. The use of the five MI entry points provides a system where personalised instruction can effectively take place. The relationship between MI and multiple entry points with personalised instruction is shown in figure 2.

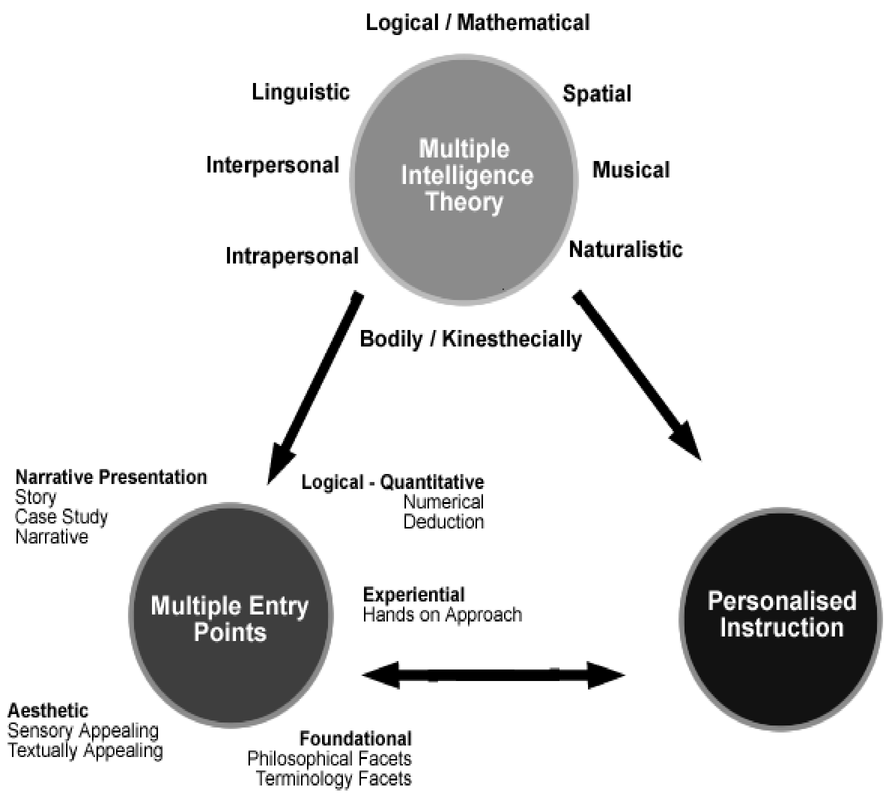

Figure 2 - Multiple Entry Points as a Part of Multiple Intelligences

When considering MI principles in creating educational content it is important to be aware of the target groups MI profile and present the information in a personalised way using as may of the multiple entry points as possible (Shearer, 2007). The use of evaluation and feed back tools are important as they can give an indication of how the learner perceives the content presentation and the instructor's role (Eom et al., 2006). In a virtual class this is particularly important due to the physical separation of the instructor and the learners.

4. Research Methodology

A case study methodology has been used as part of the empirical approach to evaluating and deploying the resources used for health and safety training in the construction area. The case study approach as a research strategy can be used in different situations to contribute to knowledge of individual, group, organisation, social, political and related phenomena (Yin 2003, cited in Wall et al., 2007).

The development and refinement of the research phases are based on an action research methodology. An action research methodology aims to solve current practical problems while expanding specific knowledge (Baskerville and Myers, 2004). Put simply action research is essentially "learning by doing". Action research has been identified as been especially useful when evaluating internet related learning, as the area is quite complex and can not be examined by quantitative methods and individual research alone (Figl et al., 2005). The cycles of action research are illustrated in figure 3. As there has been little research on the development of an educational framework for virtual classes using MI principles, the action research methodology allows for an effect model that can be refined and developed.

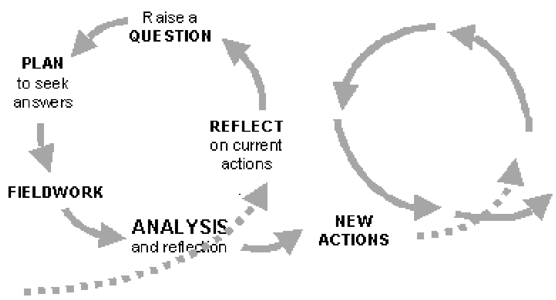

Figure 3 - The Cycles of Action Research (Wall et al., 2007)

5. Identifying the Elements of a Virtual Class.

Figure 4 attempts to illustrate the elements of a virtual class and how they interact with each other. In the centre is the learning management system (LMS) which represents the "infrastructure" of the virtual class. It is the web based interface which connects the three primary types of educational interaction: the instructor, the educational content and the learner via the learning community (Biggs, 1999).

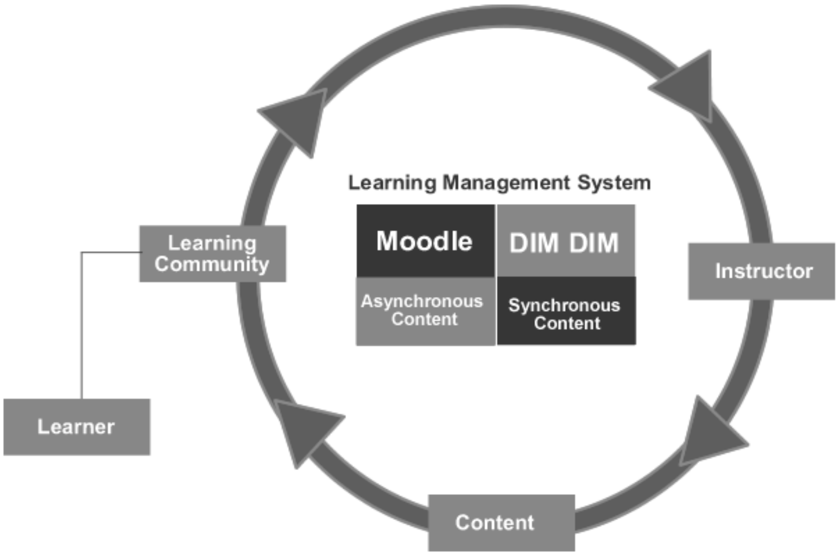

Figure 4 - The Key Elements to a Virtual Class

6. The Choice of Learning Management System

When looking at providing a virtual class an important decision is to decide which learning management system (LMS) to use. Learning management systems have been described as a virtual coat hanger (Cole and Foster, 2007). Educational content can be made available to students and their access and interaction can be controlled and monitored for assessment purposes. The LMS used is arguable the most important choice when planning a virtual class as it effects the framework and scope of the educational content that will be provided (Cole and Foster, 2007).

Online learning through virtual classes inherently places more responsibility on learners than traditional face-to-face learning systems. Learners are required to take an active role in managing the learning process (Eom et al., 2006). The effectiveness of the LMS in facilitating personalised instruction, as advocated by Gardner, plays an important part in the learners self management of the learning process. The learner-centred active learning which is an important part of constructivism, assumes individuals learn better when they control the pace of learning (Eom et al., 2006).

In the case of this research the LMS chosen was one called Moodle. Moodle is an open sources system which makes it easily adaptable and affordable. The core education philosophy behind Moodle is one called social constructionism (Cole and Foster, 2007).

Social constructionism is based on the idea that people learn best when they are engaged in the process of constructing knowledge through the act of creating an artefact for others (Cole and Foster, 2007, p10) .This definition suggests that while individuals learn better while controlling their pace of learning, the sharing with others in a social setting is a key element in the construction of knowledge. The key focus of Moodle is not simply to deliver information at the learners required pace, it is also to encourage participants in the sharing of ideas and engaging in the creation of knowledge. As the Moodle LMS is based on a social constructionism philosophy, it is a good tool for using MI principles in delivering educational content.

7. Dim Dim

In order to explore the interactive side of virtual classes the project has decided to use a web based program called Dim Dim which plugs into Moodle. Dim Dim is a web based program which allows for advanced collaboration of voice over internet protocol (VOIP), video, text and teaching mediums such as Power Point presentations. Dim Dim allows all the members of the virtual to interact in real time providing the benefits of a face-to face classroom in a virtual environment. Due to Moodle's open source design Dim Dim can be "plugged into" Moodle and be accessed as part of Moodle's content.

Dim Dim is an important tool to creating the social environment where learning can effectively take place. Figure 5 compares the features of Moodle and Dim Dim side by side. When combined they offer a powerful tool in line with the principles of social constructivism philosophy.

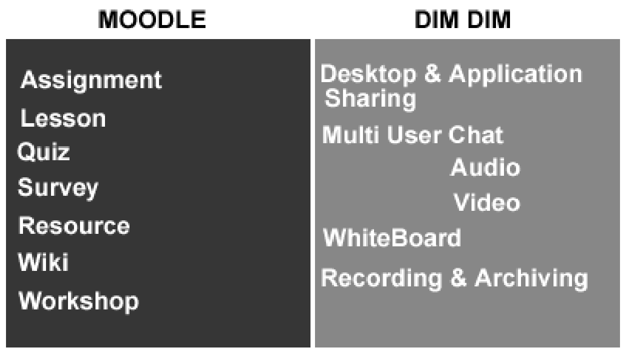

Figure 5 – Comparison of Dim Dim and Moodle Features

By using the features of Dim Dim with Moodle the virtual class has two sides. There is the static side which presents information that the learner can access at their own pace at any time that suits them. There is also the interactive side that allows learners to interact with each other and receive instruction in real time. The static and interactive sides of a virtual class are important parts of the social constructivism philosophy.

8. Content

One of the main aspects of MI in regard to educational content is that the content is presented in more then one way in order to appeal to a learners individual learning style as indicated by their MI profile (Gardner, 1983). In order to get some idea of the MI diversity of the target audience, a group of 40 construction professionals were asked to do a MIDAS test. Multiple Intelligences Developmental Assessment Scales (MIDAS) is a self completed questionnaire which provides a reasonable estimate of a persons intellectual disposition in the eight designated areas – as laid out by Howard Gardner (Shearer, 2007).

The MIDAS software for MI profiling was developed by Dr. Branton Shearer as a self assessment method of identifying the intelligence strengths associated with a group of people. The findings of the MIDAS test are not conclusive but they do provide a valuable guide in creating educational content for a target group. The results suggest that construction professionals have high levels of skill in spatial, mathematical and interpersonal intelligences. The project members considered these skills to be typical to the construction professions as well as been backed up by previous studies (Suraji et al., 2006). Based on the MIDAS profiling results and the project members understanding of the construction industry a ‘Core Graphic’ was developed to present the educational content in as visual and interactive a way as possible. In this way the health and safety content could be presented and discussed in the context of a construction site and appeal to the skill areas highlighted by the MIDAS results.

Figure 6 is a picture of the core graphic which depicts a construction site and interactively displays the health and safety hazards which exist on the site. Table 2 lists the eight intelligences and how the core graphic can be used to appeal to them (Acar et al., 2008).

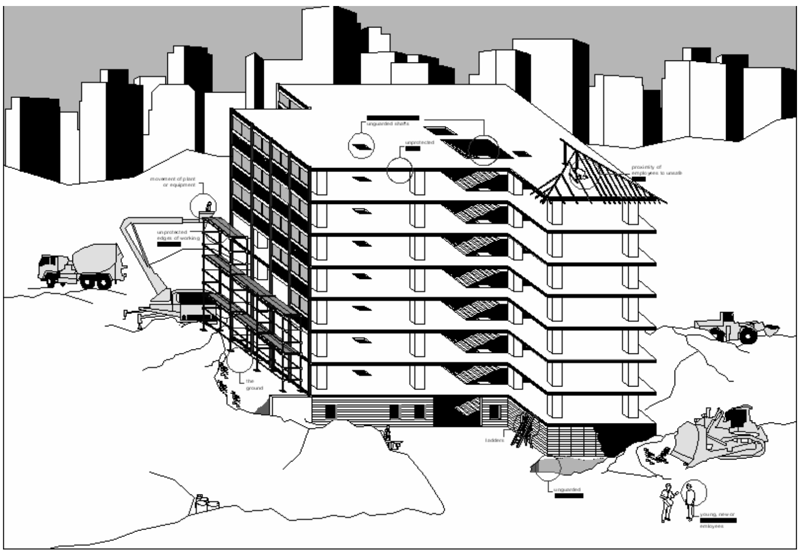

Figure 6 The ‘core graphic’

Intelligence	Examples of instructional activities
Linguistic	Writing, editing, discussion (i.e., writing a set of instructions on identifying hazards, critique written resources such as relevant safety reports)
Logical / mathematical	Analyzing relevant statistical data, creating graphic representations (charts, diagrams, etc.); devising a strategy to identify hazards of falls; conducting relevant measurements
Spatial / Visual	Matching illustrations, photos or cartoons with corresponding subject categories; creating/evaluating site layouts (i.e.'safe workplaces')
Bodily / Kinesthetic	Simulations, analysis of workpace/site ergonomics
Musical / Rhythmic	Studio visual elements, designing powerpoint presentations which incorporate music and visual elements
Naturalistic	Computer simulated spaces/environments, cities, maps, illustrations, etc.
Interpersonal	Activites that might be designed to incorporate cooperative learning groups
Intrapersonal	Activities that might be completed through reflective individual projects

Table 2 Possible instructional activities to be integrated with the Virtual Class (Acar et al., 2008)

9. The Role of the Instructor

The role of the instructor is a key part of any virtual class framework. In a study on the quality of online courses, 90% of respondents seen the interaction between the instructor and students as been essential to online learning(Young and Norgard, 2006). As a virtual class is essentially a user driven experience it would seem that the role of the instructor is to facilitate learner centered active learning. The instruction becomes communication orientated and the instructor becomes a discussion leader (Eom et al., 2006). Research suggests that the quality of discussion in a virtual class is dependant on instructor participation and leadership (Young and Norgard, 2006).

10. The Role of the Learning Community

In the educational model of social constructivism collaborative activities between learners create a greater sense of community and are associated with positive online course outcomes (Benbunan-Fitch and Arbaugh, 2006). A study on virtual classes carried out with very little learner to learner interaction reported low levels of perceived learning and grade levels among the participants (Benbunan-Fitch and Arbaugh, 2006). In order to create a collaborative learning community an active role from the instructor in creating forum topics and hosting web chats is needed (Eom et al., 2006).

11. Conclusion

Due to the number of accidents and deaths in the construction industry there is a clear need for innovative health and safety approaches. The use of a virtual class framework that utilizes MI principles is an innovative blend of technology and presentation of educational content. This approach is necessary to deal with the challenges of using information and communication technologies for educational purposes.

The action research methodology chosen for the research is effective in providing a flexible basis to evaluating the virtual class framework and making changes as needed. A key element of the action research methodology is the evaluation process used to feed into the development of the next phase of the virtual class framework. The evaluation process will be made up from the feed back from participants in pilot virtual classes and the research findings of Socrates-Minerva project members.

The key elements to the success of a virtual class is the interaction between the learners in the learning community and between the instructor and the educational content. The theory of MI allows the instructor to gain an understanding of the differences in learning style that may exist in the learning community. It also allows educational content to be presented in a way that will appeal to a group of people with different learning styles. For optimal success virtual classes need to be learner driven with the instructor taking more of a facilitation role. The use of MI principles makes the virtual class experience more learner focused which results in large benefits to the way health and safety training is delivered and the people who will take part in the training. By sharing the output of the projects development of an educational framework for virtual classes allows the wider education community to benefit from principles relevant to using information and communication technologies in education.

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Enabling Technologies for Sharing Learning Objects in Mobile Learning Environments

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Abstract:
Mobile learning which is the intersection of mobile computing and e-learning provides accessible learning resources, strong search capabilities and rich interaction anywhere anytime. Semantic Web technologies offer several benefits to new computing paradigms such as mobile and ubiquitous computing and are also a stronger approach to interoperability than standards-based approaches. Semantic Web technologies together with the ontologies provide rich medium for facilitating mobile learning via the semantic annotated learning objects and shared repositories. However, Semantic Web technologies have not yet been applied widely to deliver learning objects and support mobile learning. This paper describes SWmLOR system which illustrates the potential of using mobile devices in learning by demonstrating a mobile learning objects repository developed using Semantic Web technologies and ontologies. The paper also demonstrates the power and functionality of this system by describing a deployment scenario in an educational setting.

Keywords:
Learning Objects, Learning Standards, Mobile Learning, Ontology, Semantic Web

1. Introduction

The vision of mobile computing is that portable computation, rich interactivity, total connectivity and powerful processing. Mobile learning which is the intersection of mobile computing and e-learning provides accessible learning resources, strong search capabilities and rich interaction. Milrad (2003) defines e-learning as learning supported by digital electronic tools and mobile learning as e-learning using mobile devices and wireless transmission. Kukulska-Hulme (2002) suggests that mobile devices have to be seen as an extension to current e-learning tools rather than replacing it. Goh & Kinshuk (2004) also suggest that m-learning can compliment e-learning by creating additional channel of access for mobile users with mobile devices. An m-learning project at Ultralab is producing learning materials for mobile devices to support the learners with lack of literacy and numerical knowledge (Collett & Stead, 2002). LAND (Location Activated Nomadic Discovery) project at the Ultralab explores the possibility of deliver rich context aware information via the mobile devices (Taylor et al, 2002). Classroom experiences have also proven that mobile devices are able to support a wide range of learning activities such as brainstorming and writing.

However, the development of learning content for e-learning tends to be time consuming and expensive. Educators and curriculum developers tend to reinvent the wheel as it is continued to be difficult to produce learning materials that can be reused within different learning contexts. The learning content can be divided into small chunks of learning that are defined as learning objects. The notion of learning object came from the object-oriented paradigm of computer science where objects can be reused. According to Mohan & Brooks (2003), a learning object is a digital learning resource that facilitates a single learning objective and which may be reused in a different context. The fundamental idea behind the area concerning reusable learning objects (RLOs) is to break a larger block of electronic learning content into smaller pieces. Two of the main benefits of this modular approach are the easy updating of content, by swapping in new objects for outdated ones, and the ability to reuse content by using learning objects within other object-based content (Edmonds & Barron, 2002). A learning object repository is a collection of reusable learning objects enabling educators to share, manage and use educational resources (LOR). Learning objects and their associated metadata are located in distributed Learning Object Repositories (Najjar el at, 2004). There are many initiatives developed and continue to develop number of learning objects repositories based on various metadata standards. MERLOT is a leading edge, user-centred, searchable collection of peer reviewed, higher education, online learning materials created by registered members. However, the emerging technologies opened new opportunities in developing repositories with cutting edge technologies that can facilitate smart search and dynamic discovery of learning objects based on their associated metadata and learning contexts. Recently researchers propose Semantic Web and ontologies for improving learning objects metadata (Mohan & Brooks, 2003).

This paper first sets out to provide the overview of enabling technologies such as educational standards, Semantic Web and Ontologies. It then outlines the conceptual framework and describes SWmLOR system which demonstrates the potential of using mobile devices in learning by demonstrating a mobile learning objects repository developed using Semantic Web technologies and ontologies. It finally demonstrates the power and functionality of this system by describing a deployment scenario in an educational setting.

2. Enabling Technologies

There are number of technologies that enable the development of learning objects repository for mobile devices. However, educational standards, ontologies and Semantic Web technologies are the core technologies that enabled the development of the repository.

2.1. Educational Standards

Learning standards provide standardised data structures and communication protocols for learning materials and learning management systems (LOM, 2003). Learning standards are technical protocols, which promote easy exchange of content or data between different systems based on different technologies. Learning content has to be labelled in a consistent way to be discovered by various search engines. Therefore, there is a need for the standardising and labelling of learning objects by using metadata and packaging standards. There are however, different types of standards that exist for these purposes which can be classified into some general categories for the delivery of learning objects. Learning Object Metadata is referred as the labelling of learning objects so that they can be identified via search engines (Qin & Hernandez, 2004). There are number of standardisation bodies that are in the process of creating metadata standards for example, the IEEE (Institute of Electrical and Electronic Engineering) Learning Technology Standards committee produced a standard called Learning Object Metadata standard (LOM, 2003). The Dublin Core Metadata Initiative also developed a different metadata standard with less elements compared to IEEE LOM. The UK LOM Core is an application profile of the IEEE Standard for Learning Object Metadata that has been optimised for use within the context of UK education (UKLOM). Therefore to develop an online repository of learning objects, the UK LOM metadata elements were studied, that can be used to label each learning object, of which 44 are optional elements and the rest are mandatory. Not all these elements however, are found essential to identify learning objects via the search engine within the online repository.

Content packaging standards and specifications allow courses to be transported from one learning management system (LMS) to another. Content packages consist of learning objects and the information about how these learning objects can be put together to form learning modules. There are number of initiatives dealing with content packaging specification including IMS Content Packaging specification and Advanced Distributed Learning Initiative Sharable Content Object Reference Model (SCORM). The online repository uses SCORM that provides an API in order to hide LMSs' implementation details from SCOs and thus notably promote the reusability and interoperability of learning objects. According to Sánchez & Sicilia (2004), metadata specifications like Dublin Core and LOM see learning objects relations primarily on a syntactical level, and consequently they do not specify semantic constraints regarding the description of concrete types of relationships. Therefore there is a need for semantics within the metadata and learning objects. The next section provides an overview of the Semantic Web technologies.

2.2. Semantic Web

Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation (Berners-Lee et al, 2001). The current web, called Syntactic Web can only be accessed by humans and just provides information in a syntactic manner. However in Semantic Web concept, information is given well-defined meaning that can be accessed by both humans and machines. Semantic Web has been developing a layered architecture with the technologies and standards. These form the basic buildings blocks for the Semantic Web to support the development of meaningful web. Fig. 1 shows the latest architectural layer for the Semantic Web.

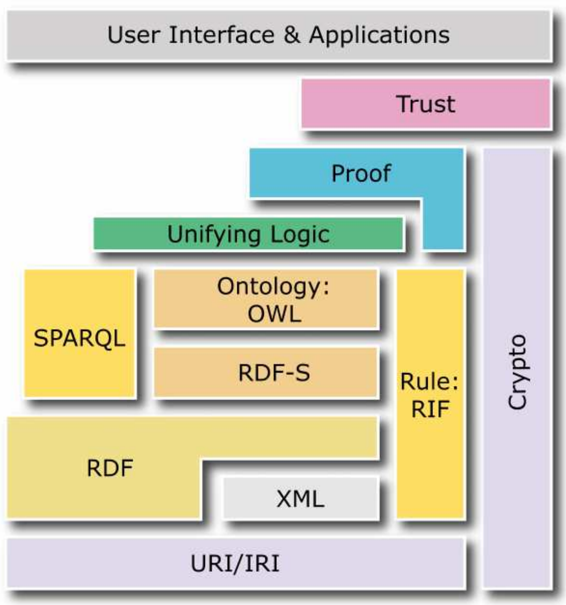

Fig. 1. Semantic Web Layer (http://www.w3.org/2007/Talks/0130-sb-W3CTechSemWeb/#(24))

Universal Resource Identifiers (URIs) can be used to identify definitions for concepts, especially useful for ontologies & metadata. Resource Description Framework (RDF) is statements linking data so as to describe things such as concepts, objects, etc. It includes standard vocabulary for describing properties and classes. XML separates data from presentation and forms a common way of structuring data on the web. It also associated with some other related standards such as Namespaces and Schemas. RDF represents metadata using URIs to identify and locate resources and information on the Web. It provides a graph model for describing and defining relationships between resources. Logic and Proof layer provide reasoning support for the ontologies and to make new inferences while SPARQL is a query language for getting information from such RDF graphs. Semantic web technologies provide means for integrating different databases and a basis for creating intelligent information retrieval systems for mobile learning objects repository.

2.3. Ontology

Ontologies are specifications of the conceptualization and corresponding vocabulary used to describe a domain (Gruber, 1993). It defines the basic concepts and their relationships in a domain as machine understandable definitions. The OWL (Web Ontology Language) is a language for defining and instantiating Web ontologies. The OWL language provides three increasingly expressive sublanguages designed for use by specific communities of implementers and users. OWL Lite supports those users primarily needing a classification hierarchy and simple constraint features. OWL DL (Description Logic) supports those users who want the maximum expressiveness without losing computational completeness and decidability of reasoning systems. OWL Full is meant for users who want maximum expressiveness and the syntactic freedom of RDF with no computational guarantees. OWL Full allows an ontology to augment the meaning of the pre-defined RDF or OWL vocabulary.

According to Dragan et al. (2004), two kinds of ontologies are needed to develop a learning objects repository. One is ontologies that describe learning object metadata and other is ontologies that describe learning object content. Although learning object metadata and content can be structured using ontologies, the mobile learning objects should be developed such a way that they can used effectively in mobile devices. As Trifonova (2003) suggests, mobile learning objects should be simple, short and domain specific. It should not be more than 5-10 minutes long as the mobile learners should be able to use their small fragments of their time for learning. The next section presents the conceptual framework addressing the challenges facing the design and delivery of reusable learning objects.

3. Conceptual Framework

Tirri (2003) sees the m-learning as a way to change the learning activities brought by the possibility to access all the information that is available through internet. The unique feature of mobile technologies is the portability. It also provides context-aware information based on the user location. Personalised services will be essential to offer unique experience for mobile users. Klopfer et al (2002) identify five properties of mobile devices that produce unique educational experiences.

- Portability – the dimension of the mobile devices in terms of size and weight
- Social interactivity – interaction with other learners for sharing information and collaboration
- Context sensitivity – mobile devices can use the context information such as location, time and environment to provide context-aware resources

- Connectivity – mobile devices can be connected to other devices and networks using wireless technologies
- Individuality – learning can be personalized to suit individuals' need and preferences

The above features make mobile computing as a powerful tool which has much to offer to support a wide range of learning activities. The online repository which serves as a portal for learning community consists of learning objects that can be searched, retrieved and delivered to other learning management systems. The aim of the repository is to develop an environment for learning objects that are interoperable, transparent and sharable by the community of educators and learners, and to be accessible anywhere anytime. Fig. 3 shows the developed conceptual framework for the learning objects repository. The framework addresses three challenges of delivering learning objects namely intelligent, dynamic and sharable. The framework demonstrates how these challenges can be overcome by using the enabling technologies such Semantic Web, ontologies and educational standards. The semantic aspects of learning objects are developed using metadata, pedagogy and ontology. Similarly, the delivery of learning objects is associated with the ontology, content package and Semantic Web. The structure of the learning objects mainly created using pedagogy, construction domains and SCORM content packaging.

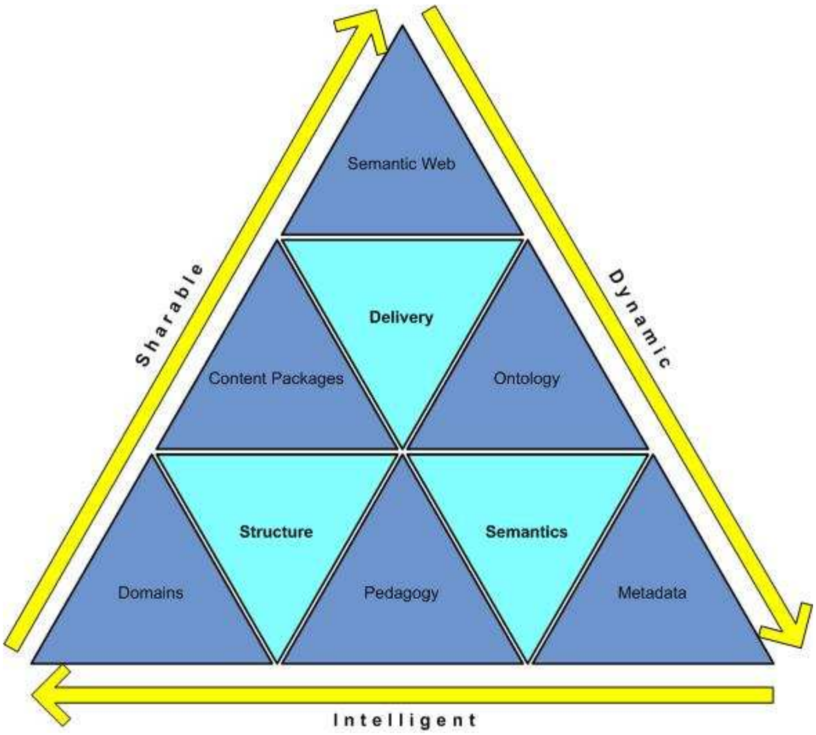

Fig. 3. Conceptual Framework

The conceptual framework is then used to develop an architecture framework for the mobile learning objects repository. The next section outlines the architecture framework of the repository.

4. Architecture Framework

Fig. 4 presents the architecture framework of the Semantic Web based Mobile Learning Objects Repository (SWmLOR). The repository is built using open source software and tools.

The core of the system is the Semantic Web toolkit called Jena. Jena is a Java framework for building Semantic Web applications. It provides a programmatic environment for RDF, RDFS and OWL, SPARQL and includes a rule-based inference engine. The repository has two separate systems that work together to function as a repository. The learning objects system is built using Semantic Web technologies and ontologies. The content packages part is built using SCORM content packaging standard.

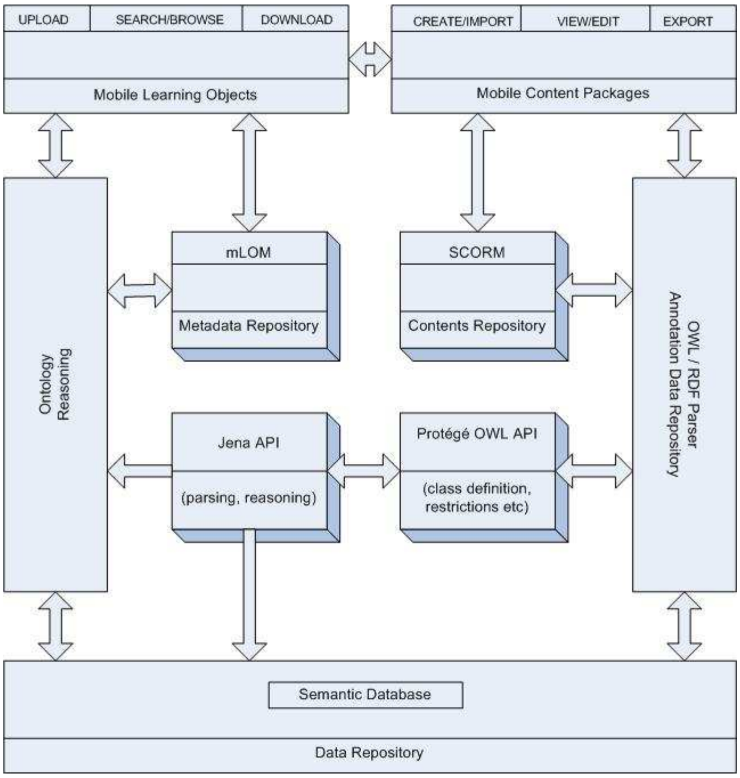

Fig. 4. SWmLOR Architecture Framework

Learning objects can be uploaded, browsed and searched within the repository. Similarly, within the repository content packages can be created using learning objects, uploaded to the repository in a zip format and exported to the learning management systems such as Blackboard. The next section demonstrates a deployment scenario for SWmLOR.

5. Deployment Scenario

Mobile Learning can be considered a lifelong activity that can take place in changing communities and mixed with everyday life situations where people repeatedly enhance their knowledge and skills (Sharples, 2000). Although mobile learning fosters an individual approach in terms of creating possibilities which fit best to the personal learning settings and preferences, it also opens possibilities for collaborative learning (Abfalter et al., 2004). Fig. 5 presents a deployment scenario for the SWmLOR. It shows that how the academics and curriculum developers can contribute and share their own learning objects to the SWmLOR which can then be accessed by mobile learners using their mobile devices. Mobile learners should be able to discover and share learning objects using wireless and mobile technologies whenever they need.

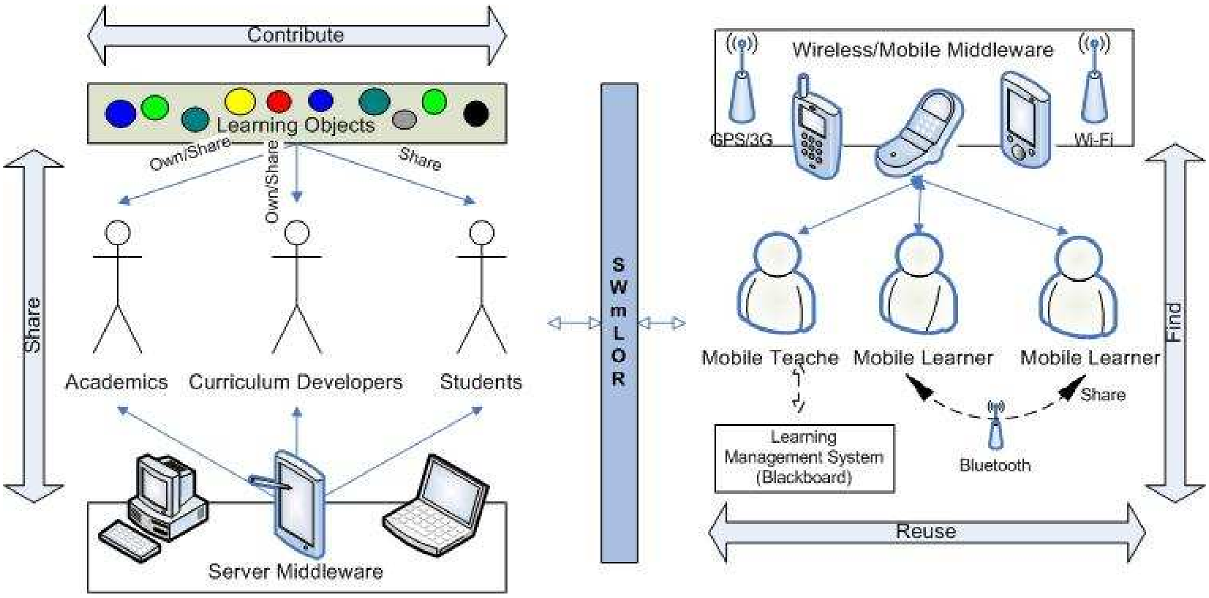

Fig. 5. SWmLOR Deployment Scenario

The next step of the research is user test with students from different courses using various mobile devices. As described in the scenario, educators should be able to submit their learning objects to the SWmLOR and students should be able to find the relevant learning objects. After the user test and evaluation, the prototype SWmLOR should be revised accordingly.

6. Conclusion

Learning objects can be used in several learning contexts and for different learners in various levels (Pitkänen & Silander, 2004). Learning Objects are more reusable if they are not heavily bound to a particular learning theory or a pedagogical model (Polsani, 2003). This paper outlined the challenges of designing and delivering learning objects in different contexts and platforms. Paper also presented the enabling technologies for developing learning objects repository for mobile devices and described SWmLOR system which demonstrated the potential of using mobile devices in learning. It demonstrated the power and functionality of this system by describing a deployment scenario in an educational setting. The learning objects repository is currently being evaluated with the aids of educators, curriculum developers and students.

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Factors Influencing Adoption and Diffusion of E-Banking Technology in Arabic Countries

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Abstract:
The adoption and diffusion of technological innovation – electronic banking technology - in the banking industry is still a relatively new area of research. To date, there have been various technology diffusion and adoption frameworks and methods of analyzing the critical factors affecting the adoption of new technologies in developed countries. However, issues on adoption and diffusion of e-baking technologies in developing countries such as Arab countries have received very little attention and there still persists an unclear understanding of the main factors contributing to the slow adoption of e-banking technology within countries in these regions. Thus, the lack of such guidelines has initiated the interest of the researcher in conducting this study. The aim of this paper, therefore, is to understand the critical factors causing the slow uptake of e-banking technology in Arabic countries. Conclusively, drawing on prior critical literature review on technology adoption and diffusion, a mixture of key critical factors has been identified.

Keywords:
E-banking, adoption of technology, technology adoption Models, adoption factors, adoption of e-banking in Arabic countries

1. Introduction

Recent advances in information technology (IT), along with the rapid advancement of telecommunication systems and emerging technologies have transformed the manner in which banking is performed (Black et al., 2001). The use of electronic banking technologies (e-banking technology) such as Automated Teller Machines (ATMs), Tele-banking, Home banking and Internet banking in the delivery of banking products and services has increasingly become an essential part of contemporary banking systems (Bitner et al., 2000; Robinson, 2000), due to the fact that banking services are almost informational (Mols, 1998; Bradely & Stewart, 2002), and thus they are easily automated and digitised (Porter and Millar, 1985).

The term of e-banking technology is relatively new (Moenaert & Lievens, 2000), and several definitions have been cited for it (e.g., Daniel, 1998, 1999; keyes, 1999; Karjaluoto et al., 2002; Nikola et al, 2002; Richard, et al 2003; Lassar, et al., 2005). Nevertheless, the majority of banking technology researchers and practitioners agree that the concept of e-banking technology refers to the system that enables banks to offer their customers access to their accounts to transact business and obtain information via electronic communication channels such as Automated Teller Machines (ATMs), Tele-banking, Home banking and Internet banking (Turban, 1999).

The need for the adoption of e-banking technology in the banking industry covers various motivations and rationales. Most banks consider the adoption of technological innovations e-banking technology as a means for better efficiency and performance, and service quality improvement (Robinson, 2000). Many banks are aware of the benefits of adopting e-banking technology, for instance, Jayawardhena and Foley (2000) argue that two fundamental reasons justifying the need of e-banking technology in banking industry. First, banks have realized the power of technology in driving down transactions-processing costs by offering e-based services. It has been proved that e-banking technology is the cheapest delivery channels for banking products once established (Sathye, 1999; Robinson, 2000; Giglio, 2002). Second, technology creates new market places and opportunities for banks. It reduces physical trade obstacles, increase market access and trade efficiency (Khalfan and Akbar, 2006).

However, technology adoption in banking industry has been widely researched in more developed countries(e.g., Liao et al., 1999; Wang et al., 2003; Gerrard & Cunningham, 2003; Liao & Cheung, 2002 and Moutinho & Smith 2000), yet there is still a lack of research relating to developing countries, particularly in Arab Gulf regions. For instance, the adoption of e-banking technology as a technological innovation in the banking industry is at present not meeting current expectations in Arabic countries (Khalfan & Alshawaf, 2004), due to various factors, and therefore there is a paramount need to identify the critical factors preventing the adoption and diffusion of e-banking in those countries. Thus, the lack of such guidelines has initiated the interest of the researcher in conducting this study. Accordingly, to address this research gap, the aim of this paper, therefore, is to highlight the critical factors causing the slow uptake of e-banking technology in Arab Gulf regions by reviewing the role of existing technology adoption frameworks in explaining the factors influencing e-banking technology in banking sector.

2. Research Methodology

Since the aim of this paper is to highlight critical factors influencing the adoption of e-banking in Arab countries, the overall research methodology will be based on a critical literature review. Reviewing the literature is vital in respect of any research study, since it allows the investigator to discover what work has already been undertaken and published in the subject area being pursued, and hence, it gives a clear direction for the researcher to follow.

In exploring the literature, the review covers the body of knowledge related to banking development in developing countries, and bank's progress in advanced countries. As a result it will provide information regarding how banking technology has been adopted and developed in these differing environments, what technology adoption frameworks have emerged as good strategies to follow, and what pitfalls have been experienced by countries during their banking developments. From this information, it is possible to identify aspects of a better technology adoption framework, and to determine how effective this framework might be in the Arabic context.

3. Liturture Review

3.1. Technology Adoption

Technology adoption is the process through which organisations or individuals decide to make full use of an innovation in their daily businesses (Khalfan and Akbar, 2006). Therefore, e-banking technology as a process innovation (Liao et al, 1999) could be studied from the perspective of the adoption and diffusion of information technology innovations.

Prior technology diffusion literatures have been well documented in the literature and ended up with a core set of theoretical frameworks. Thus, reviewing these frameworks may aid our thinking of understanding e-banking technology adoption issues in an Arabic banking environment.

3.1.1. Technology Adoption Frameworks

Technology adoption frameworks are information system theories that have been used in studies of innovation diffusion and adoption, and provide a theoretical base for examining the factors contributing to technology diffusion and adoption in organisations (Davis et all, 1989). These models include the technology acceptance model (TAM) proposed by Davis (1986); the diffusion of innovations theory proposed by Roger (1983); the theory of reasoned action (TRA) proposed by Ajzen (1975) and the theory of planned behaviour (TPB) proposed by Ajzen (1991).

The following sub-sections will look into the characteristics of the most popular frameworks. Their objectives and weakness are discussed.

3.1.1.1 Diffusion of innovation theory (DIT)

One of the most widely recognised technology adoption frameworks of today is the innovation diffusion theory (Liao et al. 1999). Developed by Rogers in 1962, it has since been used to date to explain the process of innovation diffusion and adoption. Rogers's theory is divided in three elements (see Figure 3.1): a characteristic of an innovation, individual's characteristics, and communication channels. Innovation characteristics play an important role in the diffusion of technologies. It includes relative advantages (which refers to the extent to which the innovation is perceived as superior to all other options), compatibility (refers to the compatibility of the innovation with the value, needs and experiences of adopters), complexity (refers to difficulty to understand and use the innovation), observability (refers to the benefits that can be perceived from the innovation) and triability of an innovation (refers to the possibility to perform the innovation before its actual use.

Adopter's characteristics also play a crucial role in the diffusion of any technological innovation (Rogers, 1995). Rogers identifies five categories of technology adopters, differing in terms of their adoption rate. These categories are as follows:

- Innovators: are the first adopters who want to try the new technology, no matter of how rash or risky is the technology.
- Early adopters: are those who are interest in the technology itself with positive attitude.
- The early majority: are a group of people who their decision period is longer than innovators and early adopters.
- The late majority: are people who are cautious to adopt technology till the technology had been adopted by others.
- Laggards: are those who have negative technology attitude and are the last to adopt the technology.

Furthermore, Rogers (1995) argues that communication channels, through which innovation is adopted, are also critical factor in the diffusion of innovation. According to Rogers, potential adopters are influenced by two types of communication channels: mass media channels and word of mouth channels.

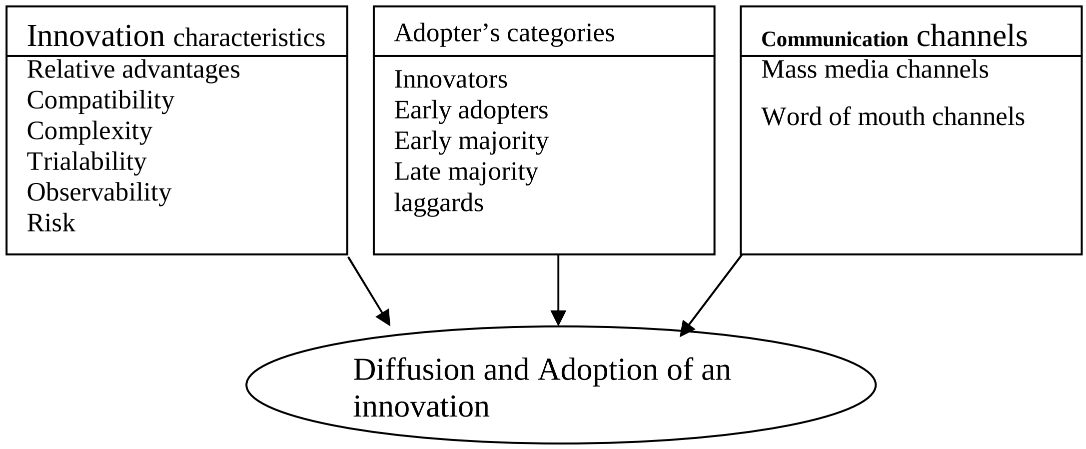

Fig 3.1: Diffusion of innovation Theory adapted from Rogers, (1995)

3.1.1.2 Technology Acceptance Model (TAM)

One of the most utilized and cited model in studying information technology diffusion and acceptance is the Technology Acceptance Model (TAM) (Davis et al., 1989). TAM was developed by Davis in 1989 and its goal is to provide a basis for tracing the impact of external factors on user's attitudes and attention to accept new technologies (Davis, 1989). The TAM suggests that when users are presented with a new technology, there are two main factors that influence their behavioural intentions to use it, namely: 'perceived usefulness' (PU) and 'perceived ease of use' (PEOU) (see Figure 3.2). Perceived usefulness (PU) was defined by Davis (1989) as the degree to which individuals believe that using a particular system would enhance their job performance" (p.320) whereas perceived ease of use (PEOU) refers to the degree to which individuals believe that using a particular system would require no effort" (p.320). According to Davis et al. (1989), PEOU and PU have a capability to determine the actual use (usage behaviour) of the new technology.

It has been found that TAM's ability to explain attitude towards using a particular information system is better than TRA and TPB theories (Mathieson, 1991) because TAM has the ability to consistently explain a significant amount of the variance in usage intention and behaviour. For instance, TAM was found successful in predicting the application of several information technologies such as microcomputer word processing software, general information systems, computer spreadsheets (Mathieson, 1991).

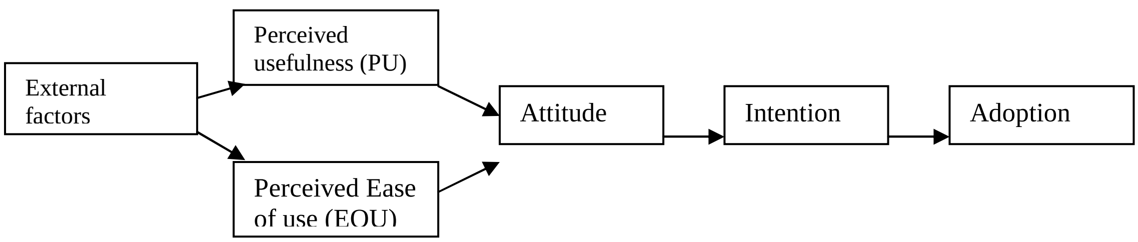

Fig. 3.2: Technology Acceptance Model (TAM) adapted from Davis, et al., 1989)

3.1.2 Critique of technology adoption frameworks

There have been numerous attempts to provide an analysis of adoption frameworks for gaining technology adoption. However critics of most theories and models of technology adoption and diffusion argue that although such frameworks are undoubtedly valuable, their adoption is often constrained by the following:

- They are all simple frameworks and they tend to focus on behaviour intention of technology adopters to perform a technology and pay little attention on the impact of organisational and environmental factors on the adoption of technology (Prescott and Conger, 1995).
- The majority of the studies relating to the technology diffusion and adoption have been conducted in developed countries and, therefore critics (e.g., Aladwani, 2001; Khalfan, et al, 2002; Kamel & Hassan, 2003) argue that these studies are less predictive when tested in developing countries such as Arabic countries. They argue that the existing technology adoption frameworks are developed and invented in Western societies. This means that they are designed to serve the purpose of such societies. Accordingly these frameworks may not be applicable to determine technology adoption in non-Western countries such as countries in Arab reigns.

3.2. Adoption of E-Banking in Banking Industry

In recent years, the increasing application of e-banking technology in the banking industry has covered a wide spectrum. According to Moenaert & Lievens (2000), the study of adoption of technological innovation in the banking industry is a relatively new area of research, they assume that research in this field did not commence until around the mid 1980s. Black et al (2001) suggest that the technology adoption frameworks are the starting point of any study which investigates the adoption of e-banking technologies.

Drawing on prior literature on technology adoption frameworks, several authors have used the above technology adoption frameworks to investigate factors affecting the adoption of e-banking technology in banking industry. Liao et al. (1999) investigated the adoption of e-banking in Hong Kong by using the framework of the theory of planned behaviour (TPB), which assumes that adoption is determined by intention to perform the innovation. However, the authors found that the framework is partially applicable to the context because its variables were found to be weak and limited. Wang et al. (2003) tested also the applicability of the technology acceptance model (TAM) to e-banking in Taiwan and found evidence that perceived ease of use, perceived usefulness, and perceived credibility of e-banking technology all had a significant positive effect on people's intention to adopt e-banking.

In another study in Singapore bank customers, Liao and Cheung (2002) used the TAM model to predict the adoption of e-banking and found that individual perceptions regarding accuracy, security, transaction speed, user-friendliness, user involvement, and convenience were proved to be an effective way of attracting and retaining bank customers. Parallel findings came from Moutinho and Smith (2000) who studied the behaviour of bank customers in the UK towards automated banking services concluded that ease of banking and convenience were the two important factors in adoption process. Mattila et al. (2003) tested the characteristics of adopters of diffusion of innovation theory found that household income and education had a significant effect on the adoption of e-banking among mature consumers in Finland, whereas perceived difficulty in using computers combined with the lack of personal service in e-banking were the main barriers to adoption. In Turkey, Polatoglu and

Ekin (2001) listed nine factors that, according to the authors, influenced the diffusion of e-banking. These were: “relative advantage”, observability”, “trialability”, “complexity”, “perceived risk”, “type of group”, “type of decision”, and “marketing effort”.

To sum up, although some of these frameworks provide insight into factors influencing adoption of e-banking technology, however, the adoption rate of e-banking differs from one country to another, especially less developed countries because different countries have different factors that facilitate or hinder the adoption process (Shao et al, 1996).

3.3. Adoption of E-Banking in Arab Countries

The adoption and diffusion of e-baking technology in the Arab regions in comparison to other countries in North America, Europe, and other developing countries is still at its very early stages (Rasmy et al., 2005). Danowitz *et al*., (1995) noted that there were lower levels of e-banking adoption in the Arab of the Middle East than might be expected, especially in comparison with other comparative developing parts of the world such as Eastern Europe. e-banking adoption in the Arab countries at this stage has not been fully researched by academia or practitioners in the region. Many countries in these regions are still lagging far behind the developed countries in terms of the adoption of e-banking technology, and many banks in these regions are not yet ready to accept it. the lack of basic infrastructure, sufficient funds, top management support, the low level of computer literacy, level of education, lack of skills and expertise in the filed ad resistance to organisational change have all been considered to impede the adoption of e-banking technology within these countries (Alshawaf, 2004). The following sub- section will look into the most important factors influencing the adoption of e-banking technology in Arab countries.

3.3.1. Factors influencing the adoption of e-banking in Arab countries

Several research studies which identify critical factors affecting the diffusion and adoption of e-banking technology in developing countries in general, and specifically Arab counries (e.g., Karjaluoto et al, 2004; Chan & Lu, 2004; El-Adly, 2003; Jaruwachirathanakul & Fink, 2005; Polatoglu & Ekin, 2001; Kamel & Hassan, 2003; Khalfan & Alshawaf, 2004; Aladwani, 2001; Sathye, 1999) have been conducted.These factors have been classified in three groups: cultural factors, technological factors and organizational factors.

- **Cultural factors**

The influences of cultural factors tend to play an important role in the diffusion and adoption of e-banking technology. These factors is related to social issues such as, customer’s perception and beliefs towards technology, customer’s awareness and education and language compatibility. Customer’s perception is proven to be a crucial factor in shaping behavior towards technology diffusion (Davis et al, 1989). In the context of banking industry, many studies have focused on the analysis of customer’s perception such as perceived relative advantages and perceived risk of e-baking technology. Relative advantages of e-banking technology refer to cost and time savings, conveniences, transaction speed and an accuracy of information (Polatoglu & Ekin 2001). Whereas perceived risk of e-banking refers to lack of security and privacy over the internet (Chan and Lu, 2004). Language emerges also as a cultural factor influencing the adoption of e-banking technology. In the Arabic context, the importance of language for example, found, during the mid-1990s, as a significant barrier in spreading any ‘Western-developed technologies’ in non-English countries (Al-Abdul-Gader, 1999).

- **Technical factors**

Technical issues such as availability of a basic technological infrastructure could be very significant in successful diffusion of advanced technology in banking industry (Mougayar, 1998). e-banking needs information and communication technologies, mainly: computers, Internet, local area networks (LANs) and ATMs, etc. Mougayar (1998) stated that e-banking expansion is likely to be facilitated within a geographic area when a solid telecommunications infrastructure is in place. Therefore, e-banking expansion is likely to be impeded when such condition are not met. Several researchers (e.g, Khalfan et al, 2006; Al-Abdul-Gader, 1999 and Aladwani, 2001) assessed the introduction of e-banking facilities Arabic banks and pointed out that lack of adequate technological infrastructure is seen as one of the problems faced by developing countries in building e-banking solutions.

- **Organizational factors**

This refers to organizational issues such as managers' perception, bank's knowledge and awareness of new technology, resistance to change, lack of financial resources and skilled personnel (Gerrard & Cunningham 2003). Mols (2001) argues that managers' attitude is the most important factor influencing the adoption rate of e-banking system. In the Danish experience, for example, Mols (2001) pointed out that top management support is the most important factor driving the introduction and exploitation of e-banking. Another organizational factor is a resistance to change. Resistance to accept new technologies can often emerge during the organizational change (Mol, 2001) because first, the bank's employees may feel threatened if the adoption of e-banking technology makes their job redundant, and a second is managerial fears about losing control. Knowledge and awareness of perceived usefulness and ease of use of e-banking technology is seen as a major obstacle towards the adoption, especially in Arabic countries (Aladwani, 2001). Banking literatures suggest that if banks are unaware of the benefits of e-banking technology, this will act as a constraint, and essentially prevents e-banking from being adopted (Kelegai & Middleton, 2004). Thus, there is an important awareness role that needs to be exerted to diffuse the use of e-banking technology among banks. Banking literatures in developed world also show that Lack of financial resources and skilled personnel as important barriers to technology diffusion and adoption (Prescott and Conger, 1995). These barriers within Arabic context were also recognized by Aladwani, (2001) who state that the lack of skilled personnel and sufficient funds seem to be very strong factors in slowing the adoption rate of e-banking technology in Arabic countries.

4. Conclusion and Future Work

This paper has reviewed the relevant literature on diffusion and adoption of technology in general and more specifically technology adoption in banking sector. The general finding of these paper show that to date there have been various technology diffusion and adoption frameworks and methods of analyzing the critical factors affecting the adoption of e-banking technology and these frameworks all have their relative benefits and limitations, as discussed in section 3.1. Yet, a framework that could investigate how certain factors could have a different influence on adoption and diffusion of e-banking in developing countries, particularly Arab Gulf regions has not been established. In general, e-banking adoption in the Arab regions at this stage has not been fully researched. Many countries of these regions are still lagging far behind the developed countries in terms of the adoption of e-banking, and many banks in these regions while they are convinced that e-banking reduce costs significantly and brings many advantages are not ready to adopt it. A mixture of critical key factors such as lack of basic technological infrastructure , low level of computer literacy and education, lack of technology awareness among bank customers, shortage of IT skilled personnel, technology investment costs and IT language differences have all been found to make e-banking unattractive in developing countries.

Finally this paper can be considered as an attempt to highlight the factors that have been responsible for the slow uptake of e-baking applications in the Arab Gulf regions, but further research is required to empirically test the validity and reliability of Western-developed technology adoption frameworks in explaining the adoption of e-banking technology in Arabic countries.

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Global eReadiness – The alignment of National Policies to Organisational Strategies

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Abstract:
Electronic readiness (e-readiness) presents an indication, measurement or "benchmark" for the capacity of nations (countries) to participate in the global digital economy. In this context, an advanced state of national e-readiness is needed for economies to expand nationally and internationally; and for businesses to readily compete in the open market. It is therefore imperative that organisations align their business strategies with e-readiness strategies in this respect. This paper investigates the initiation, developments and practice of e-readiness of nations, and presents a case for possible adoption for the Construction Industry and organisations within.

Keywords:
Construction; E-readiness; ICT strategies; Organisational strategies

1. Introduction

Globalisation has fundamentally altered the world economy, and has created winners and losers. Reducing inequalities, both within and between countries, and building a more inclusive globalisation policy is the most important development challenge (UN, 2008). In this context Information and Communications Technology (ICT) innovations are increasingly having important implications on business and socioeconomic development due to their role in introducing and diffusing the concepts of knowledge sharing, community development and promotion of equality. The implications can be felt at the individual, organisational and societal levels. While the basic needs of humankind have long been food, clothing and shelter – the time has come to add '*information*' to this list (UN, 2007). The implications on developing nations could be remarkably effective if these technology innovations are properly introduced and managed. However, if the implementation process is not well supported and controlled, the result could be an increasing digital divide between the developed and developing worlds (such divide also exists within nations, especially among developing nations). It is therefore important to avoid the fact that ICT could be marginalised in the development process. Thus, there is an urgent need to show that ICT can generate the wealth of the enterprise, which in turn pays for socioeconomic development at large. In this context, ICT can help deliver the productivity gains that would have been unthinkable many years ago.

ICT should be looked at as a platform for development within a macro perspective that addresses different individual, organisational and developmental needs. Therefore, over the past two decades, numerous studies have underlined the importance of coordination for the formulation of national ICT strategies. The need for resources mobilisation, proper environment, legislations and regulations, amongst other elements is important for building and sustaining an outcome-driven ICT infrastructure. For societies to develop, grow, and benefit from the ICT evolution, nationwide introduction, adoption, diffusion and adaptation of technology should take place, something that is hardly seen in developing nations where most of the technology implementations and infrastructure are focused. All these elements identify the importance of developing national ICT strategies. These strategies aim to build capacities to use ICT in the socio-economic development, help provide clear strategic objectives and guidelines, as well as national initiatives and action plans to help each country take an essential step in this field.

Countries around the world are recognising the importance and need of a national ICT strategy. All these strategies are well documented – from the less developed countries, such as the Azerbaijani Decree for the adoption of National Information Communication Technologies Strategy 2003-2012 (NICTS, 2008), and the Mauritius National ICT Strategic Plan 2007-2011 (NICTSP, 2007); to the more technological advanced nations such as the Japanese Science and Technology Basic Policy Report (CSTP, 2005) and the European i2010 (EC-ISM, 2007). Other national initiatives such as the Malaysian E-Tendering Initiative (Lou, 2007) and the American FACNET (Alsagoff *et al*., 2006) demonstrate the importance and power of national policies where ICT is concerned.

There are a number of challenges facing national development plans when it comes to ICT, including electronic readiness, policies and regulations, infrastructure development and deployment, legal framework, universal access, literacy, language, culture readiness, appropriate business models for public-private partnership, transparency and governance, intellectual property rights, privacy, and security amongst others. It is important to address the issues faced by developing nations in striving to develop and grow, whilst capitalising on the opportunities enabled by emerging ICT.

2. Electronic Readiness (E-Readiness) for Nations

The question of how e-strategies could be designed and implemented, and their role in broader national development strategies, has received growing attention in the international forums where the issue of the global digital divide is being addressed. The convergence of e-readiness and other initiatives of the international community seem to indicate that there is agreement about the priority attention that ICT policies should receive in poverty-reduction strategies. Success stories about how particular communities, enterprises or governments in developing countries have used e-commerce to create new economic opportunities are continually emerging.

For a start, there is no single accurate definition for e-readiness; different groups describe it differently. To provide a holistic overview, a few thoughts are outlined here to help prompt this discussion. The World Information Technology and Services Alliance (WITSA) states that an e-ready country requires consumer trust in e-commerce security and privacy; better security technology; more trained workers and lower training costs; less restrictive public policy; new business practices adapted to the information age; and lower costs for e-commerce technology (WISTA, 2004). While the United Nations appraise e-readiness as the public sector e-Government initiatives of member states according to a weighted average composite index of e-readiness based on website assessment; telecommunication infrastructure and human resource endowment (UN, 2005). The community assessment of e-readiness by the Center for International Development, Harvard University (2007) describes an e-ready society as one that has the necessary physical infrastructure (high bandwidth, reliability, and affordable prices); integrated current ICTs throughout businesses (e-commerce, local ICT sector), communities (local content, organisations online, ICTs used in everyday life, ICTs taught in schools), and the Government (e-Government); strong telecommunications competition; independent regulation with a commitment to universal access; and no limits on trade or foreign investment. On the other hand, the Technology CEO Council (2005) views an e-ready community as being equipped with high-speed access in a competitive market; with constant access and application of ICTs in schools, Government offices, businesses, healthcare facilities and homes; user privacy and online security; and Government policies which are favourable to promoting connectedness and use of the network. E-readiness can also be defined as the aptitude of an economy to use Internet-based computers and information technologies to migrate traditional businesses into the new economy, an economy that is characterised by the ability to perform business transactions in real-time – any form, anywhere, anytime, and at any price (Bui *et al.*, 2002). A brief synopsis of these reports and definitions can be seen in Table 1.

Table 1: Various definitions of e-readiness

REPORT	**DEFINITION OF E-READINESS**
Economist Intelligence Unit (2007)	E-readiness is the "state of play" of a country's information and communications technology (ICT) infrastructure and the ability of its consumers, businesses and governments to use ICT to their benefit. When a country does more online – or, as is increasingly the case, wirelessly – the premise is that its economy can become more transparent and efficient.
Center for International Development, Harvard University (2007)	Readiness is the degree to which a community is prepared to participate in the Networked World. It is gauged by assessing a community's relative advancement in the areas that are most critical for ICT adoption and the most important applications of ICTs. When considered together in the context of a strategic planning dialogue, an assessment based on these elements provides a robust portrayal of a community's Readiness. The value to a community of assessing its Readiness lies in evaluating its unique opportunities and challenges.
Asian Pacific Economic Cooperation (APEC) (2000)	Readiness is the degree to which an economy or community is prepared to participate in the digital economy. Every economy, regardless of its level of development, presents a readiness profile on the global stage, composed of its national policies, level of

	technology integration, and regulatory practices. Readiness is assessed by determining the relative standing of the economy in the areas that are most critical for e-commerce participation.
McConnell International & World Information Technology and Services Alliance (WITSA) (2000)	E-Readiness measures the capacity of nations to participate in the digital economy. E-Readiness is the source of national economic growth in the networked century and the prerequisite for successful e-business.
The World Information Technology and Services Alliance (WITSA) (2004)	The report of the survey states that an 'e-ready' country requires consumer trust in e-commerce security and privacy; better security technology; more trained workers and lower training costs; less restrictive public policy; new business practices adapted to the information age; and lower costs for e-commerce technology.
United Nations (2008)	This UN report assesses e-government readiness of Member States, according to a quantitative composite readiness of e-readiness based on website assessment; telecommunication infrastructure and human resource endowment.

In spite of all the differences in definitions and opinions, this paper takes the position of e-readiness as "measure of the degree to which a country, nation or economy may be ready, prepared or willing to obtain benefits which arise from the digital economy". E-readiness reaches its optimal level when the economy is able to create new business opportunities that could not be done otherwise.

3. International E-Readiness Assessments, Reports and Rankings

Today, there are various e-readiness assessments, reports and rankings available to the public; formulated through quantitative and qualitative research by numerous Governments, private and non-profit organisations. Each report is often the product of different methodologies, and divergent definitions of e-readiness. Therefore, the findings of the various studies are not consistent with each other. Nonetheless, every e-readiness assessment, report and ranking are meant to guide nations by providing benchmarks for comparison and gauging progress, and can also be useful for judging the impact of ICT, to replace exaggerated claims and anecdotal evidence with concrete data tool. IN this context, a study conducted by bridges.org (2005), reported that a total of 1506 e-readiness assessments have been conducted and a total of 188 countries have been assessed by at least one tool. The report further states that a total of 68 countries have been assessed between five and ten times by different organizations, while a further 69 countries have been assessed over ten times. Only four countries have never been assessed: North Korea, Tuvalu, Monaco and Nauru. Thus, e-readiness assessments, reports and rankings can be divided into two main categories: those that focus on basic infrastructure or a nation's readiness for business or economic growth (e-economy), and those that focus on the ability of the overall society to benefit from ICT (e-society). The e-society tools incorporate business growth and use of ICT as part of their larger analysis, and consider business growth necessary for society's e-readiness. E-economy tools also include some factors of interest to the larger society, such as privacy and universal access. Rough categorisations for e-economy include APEC (2000), McConnell (2000) and EIU (2007) reports; e-society include CID (2007) and UN (2008) reports. For example, the Center for International Development (2007) model looked at how information and communications technologies (ICTs) were used in society, while the APEC (2000) method focussed on government policies for e-commerce. A brief synopsis of the reports and associated measuring tools can be seen in Table 2.

Table 2: Various reports and measuring tools for e-readiness

Report	**Measuring tool**
Economist Intelligence Unit (2007)	There are nearly 100 separate quantitative and qualitative criteria, which are scored by EIU country analysts and organised into six primary categories – Connectivity and technology infrastructure (20%), Business environment (15%), Social and cultural environment (15%), Legal environment (10%), Government policy and vision (15%) and Consumer and business adoption (25%). These are, in turn, weighted according to their assumed importance as influencing factors.
Center for International Development, Harvard University (2007)	The Guide requires significant participation and interpretation on the part of its users. It examines 19 different categories of indicators, ranking each by levels of advancement in Stages One through Four. The categories fall within five groups – Network Access, Network Learning, Networked Society, Networked Economy and Network Policy. The categories are linked, each driving the others, such that a community cannot concentrate solely in one area, but must pay attention to each, noting where it might be able to capitalise on synergies among the categories.
Asian Pacific Economic Cooperation (APEC) (2000)	APEC presents a readiness profile on the global stage, composed of its national policies, level of technology integration, and regulatory practices. Six broad indicators of readiness – Basic Infrastructure and

	Technology, Access to Necessary Services, Current level and type of use of the Internet, Promotion and Facilitation Activities, Skills and Human Resources, and Positioning for the Digital Economy – for e-commerce are developed into a series of questions that provide direction as to desirable policies that will promote e-commerce and remove barriers to electronic trade.
McConnell International & World Information Technology and Services Alliance (WITSA) (2000)	The ratings combine a dynamic evaluation of the relevance and accuracy of available quantitative data with an understanding of myriad cultural, institutional, and historical factors relevant to the actual situation in each country. The ratings measure status and progress on five interrelated attributes; Connectivity, E-Leadership, Information Security, Human Capital, and E-Business Climate.
United Nations (2008)	This UN Index is a composite index comprising the Web measure index, the Telecommunication Infrastructure index and the Human Capital index. The Web Measure Index is based upon a five-stage model, which is ascending in nature, and builds upon the previous level of sophistication, of a state’s online presence. The telecommunication infrastructure index is a composite weighted average index of six primary indices based on basic infrastructural indicators, which define a country’s ICT infrastructure capacity; and the data for the human capital index relies on the UNDP ‘education index’ which is a composite of the adult literacy rate and the combined primary, secondary and tertiary gross enrolment ratio with two third weight given to adult literacy and one third to gross enrolment ratio.

In Europe, the e-Europe Action Plan, endorsed by the member states of the European Commission in June 2000, encouraged small and medium enterprises (SMEs) to go digital through a coordinated networking activity for the exchange of knowledge on best practices, e-commerce readiness, and mainstreaming e-commerce into their business strategies. In addition, the Action Plan envisaged that by 2005, Europe would have a dynamic business environment with a public policy to provide added value in the area of legislation affecting e-business (Commission of the European Communities, 2002). By the end of 2003, the European Union member states had established a European e-business support network, federating existing European national and regional players in this field with a view to strengthening and coordinating action in support of SMEs in e-business. The Commission was further expected to foster geographical and sectoral clusters of SMEs working online to encourage innovation in e-business, sharing of good practice and promoting guidelines and standards (Commission of the European Communities, 2002). This initiative has been extended with the introduction of the European i2010 (EC-ISM, 2007).

From an e-readiness ranking perspective, the pervasiveness and coverage of reports have been all-encompassing – see Table 3. Thus, from Table 3, it can be seen that there is no shared congruence of agreement between the findings.

Table 3: Selected e-readiness rankings

	Economist Intelligence Unit (2007)	United Nations (2008)	AT Kerney (2006)	ITU (2008)	Waseda University (2007)	World Economic Forum (2007)	World bank (2007)
United Kingdom	7	10	12	12	9	9	9
Ireland	21	19	4	26	-	21	14
France	22	9	23	-	12	23	20
Denmark	1	2	5	2	-	1	2
Finland	10	15	13	8	7	4	4
Sweden	2	1	10	1	10	2	1
Singapore	6	23	1	14	2	3	-
United States	2	4	3	11	1	7	10
Malaysia	36	34	19	46	15	26	40
Total countries assessed	69	182	62	178	32	122	137

4. E-readiness for Construction Organisations

ICT holds tremendous potential for improving construction businesses. It has become widely accepted that ICT can play a vital role in expanding the construction business especially by the emergence of the Internet. While the industry is facing globalisation and an expanded knowledge-based economy, the capability of ICT is undeniable for achieving competitive advantage (Adriaanse and Voordijk, 2005; Cartelli, 2007).

Today, ICT is becoming an important element of any organisational infrastructure, particularly to address construction business improvement. For small businesses, standalone applications such as e-mail, presentations and report writing are seen to be essential components for running any business. For larger organisations, the picture is more complex where ICT infrastructure plays a key role in supporting core business functions. However, there is ample evidence that ICT has failed to bring about a competitive advantage to organisations in spite of the large investments over the past decade, and a large percentage of systems have failed to achieve their intended business objectives. Recent studies in the in the area of 'IT failure' have shown that 75% of IT investments did not meet their performance objectives (Alshawi, 2007). Such projects were abandoned, significantly redirected, or even worse, they were 'kept alive' in spite of their failure. The cost of funding such projects and the missed opportunities of not benefiting from their intended capabilities constituted a tremendous loss for organisations. This dissolution in the strategic benefits of ICT is currently forcing many construction organisations not to invest in IT for competitive advantage, but for the reasons of bringing efficiency and effectiveness to business processes.

Technical problems were almost never the reason that new IT systems failed. Human problems were often to blame. People typically resisted adopting new systems, often because the cost (the effort) outweighed the benefits. One of the primary explanations for the extent of project failures and the size of ultimate write-offs was the presence of agency problems (Mahaney and Lederer, 2003), and especially the escalation of commitment on the part of the managers (Keil, 1995). Escalation is generally defined as continued commitment of resources after receiving negative feedback about a project.

The notion that business strategy and IT strategy should be aligned and, therefore, that business users should be involved in the design of enterprise systems has been widely accepted. However, doing this has proven very difficult, for several reasons (Mahaney and Lederer, 2003; Kaplan and Norton, 2004). For one thing, IT leaders struggle to truly understand the business context. What's more, business leaders do not invest without tangible justification. Managers sacrifice individualism, thus ignoring competitively powerful capabilities that a system could make possible, as developing them would add to the time and cost of carrying out an already expensive, time-intensive project. Therefore, many organisations across the world are increasingly adopting various ICTs to identify, acquire, organise, disseminate and apply information for informed decision making – e-readiness is one of them.

E-readiness is also fast becoming an important enabler for today's organisational goals and also national competitiveness – its effective implementation is even more challenging. E-readiness strategies have become an important part of strategic planning at the level of states, regions and individual organisations. Practically all developed countries have elaborated programmes and action plans related to ICT production and use in most important areas.

5. Conclusion

In the past, ICT was prompted as being vital for organisations to gain competitive advantage; this was a misnoma. The next paradigm looked at the soft issues of people and process in the organisation; yet still, ICT still failed. Today, the focus is on the e-readiness of organisations. The ability for the organisation to accept and implement ICT is now essential for organisation. In short, how ready are we?

Understanding e-readiness can enable organisations to enter new markets – aware of both the revenue potential and the possible bottlenecks to growth. Similarly, governments are also realised the usefulness of assessments as a tool for benchmarking and prioritising action. Detailed national level analysis and organisational peer reviews creates an opening for business, government and private organisations to come together to improve national overall ability to participate in the digital economy. This therefore demonstrates the critical importance for national e-readiness to be integrated and linked with organisational e-readiness strategies.

From this mantra, it is cleared that change is needed to create an environment that fosters innovation, clarifies communication and truly integrates design, manufacturing and construction processes. ICT technologies and knowledge-rich environments offer real opportunities, and the potential to realise this integration and offer and arrangement in which there is a single contracting entity from which participants provide their expertise. It is imperative to implement the right ICT solutions for the right processes, to the right degree with the right timing. Striking the right balance is a goal which all organisations and countries are striving to achieve. To strike this balance, national leaders and industry chiefs need to continuously assess the position of their organisations. Every country is different; every organisation is different; and every country the organisation operates in is also different.

Now, there are various reports looking into national (country) e-readiness, and ranking them. Future research will look into the adoption of national e-readiness for organisational e-readiness, with focus on construction organisations. In this context, the organisational e-readiness measurements could be linked to core issues, such as, people and culture, business processes, existing technology, ICT strategy, performance measurements, and others. Measurement metrics, such as, maturity models, rankings or quantifiable indices will be essential to provide benchmarks for organisations. Ultimately, this could help determine how "e-ready" are construction organisations.

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ICT Systems and Construction SMEs – a case study of adoption and implementation

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Abstract:
Construction's Small and Medium-sized Enterprises (SMEs) are not known for their innovation, particularly where Information and Communications Technology (ICT) is concerned. Indeed, any records of such activity relate to large organisations, with the implication that SMEs *could* take a scaled-down approach, but generally *do not*. We report one phase of an *action research* project to develop a document control and management information system for a construction SME. Our own early observations are compared with the existing literature on SMEs and ICT adoption. These include the conclusion that appropriate systems cannot be just 'scaled-down' versions of those in larger organisations with the predictable cost, time and people issues, but past experience, formal and informal relationships are all the more important for the SME. The study forms part of an EPSRC CASE studentship with the wider aim of developing new models for ICT adoption within Construction SMEs.

Keywords:
Action Research, Construction SMEs, ICT Implementation, Management Information Systems

1. Introduction

The work reported in this paper is part of a research project that is monitoring the attempts of a construction SME to adopt an ICT-based Management Information System. In keeping with an *action-research* approach the researchers are confronted with a hybrid: a *project-within-a-project*. First there is the desire of the SME to adopt the new system. Within this lies the academic project that is involved with monitoring, interpreting, analysing, discussing and generalising from the experience. The thrust of the academic part of the project is to exploit the rich and plentiful evidence that will come from the immersion of the researcher and to explore ICT adoption by Construction SMEs in general. The remit of this paper however, is more narrow, as the work is in its early stages. Its aim is to review previous studies of ICT-uptake in SMEs and compare their findings with results that are emerging from the present project.

1.1. ICT, SMEs and the Construction Industry

In terms of their proliferation at least, SMEs constitute the most important section of the national economy with over 90% of companies in the U.K. employing less than 250 people. Whilst the adoption of Information and Communication Technology (ICT) is seen as a key to the modern corporate goals of *innovation*, *agility*, *knowledge management*, *e-business* and *organisational learning*, managing its adoption can be problematic in smaller organisations (SMEs) who do not have large budgets or the time to invest in appropriate resources. In the Construction Industry, in particular, where the proportion of SMEs is, if anything, above that of the UK economy in general, there are problems related to adopting ICT innovations. Most companies simply *do not do it*.

Brock (2000) in a review of ICT within small firms found that comparatively little research exists in the area of ICT within small business (as opposed to large organisations). In the SME context, he cites major concerns including; the importance of the unavailability of internal IT skills, that top management support is moderated by the owner-manager relationship and centralised decision making, lack of user participation and, in many cases, a total reliance on the external support of IT vendors and consultants. Most small firms restrict IT usage to administrative tasks; mainly their accounts. Brock (2000) concludes by stating that there is a crucial need to develop internal ICT knowledge, skills and consequences (both owners' and employees') and not to have total reliance on external vendors. This must be combined with better user-training and greater participation in the adoption and implementation process.

Research into the strategic and operational management of ICT within SMEs is also surprisingly under-developed (Cragg, 2002). Innovation and agility within organisations are increasingly cited as desired core competences which often depend on effective and creative use of ICT (Fraser et al., 2003). This is an area of developing research which focuses on people, organisation and culture as the important variables that enable or inhibit effective ICT adoption, implementation and use. More rigorous research studies such as that undertaken by Caldeira and Ward (2003) utilise in-depth case study research methods. Caldeira and Ward studied twelve Portuguese manufacturing SMEs to consider how resource-based theory could be used to explain success with the adoption and use of ICT. They used the concept of *core competences* which involves viewing the assets and resources of a firm from a knowledge-based perspective. This is combined with a framework comprised of four dimensions: internal context, external context, process and content. These key determinant factors are linked to 3 sets of associated skills and competences; technical IS/IT skills, managerial IS/IT skills and business and general management skills.

This links more generally with research into the strategic management practices of small firms. Stonehouse and Pemberton (2002) in their survey of over one-hundred and fifty SMEs found that the main business planning method in use within small firms was internal financial analysis. There was little evidence of any other methods, techniques or practices associated with strategic planning (including ICT). This is despite a lot of research evidence suggesting a strong positive relationship between overall performance of SMEs and the degree of long term planning undertaken. Southern and Tilley (2000) also comment on the dearth of research on small firm adoption of ICT, despite its fundamental importance to the global economy and major government policy initiatives. They state that a common cause of problems is the lack of understanding of small firm context and culture: many approaches attempt to apply standard IT management methods, systems analysis and development techniques within a context for which they were not originally designed. Such technologically deterministic approaches may be inapplicable to loose and unstructured organisations where there are low levels of IT skills and experience and which are highly centralised in terms of decision making – usually with power vested in the owner manager of the small company.

With the introduction of personal computers, file servers and networks, small firms have the potential to take advantage of the same technology that large business has access to, i.e. email and the development of company web pages to reach larger markets; integrated ERP systems, and electronic data interchange (EDI) that could allow small firms to link with customers and suppliers (Pollard and Hayne, 1998). However, the question still remains as to whether SMEs can utilise IT strategically; that is, in ways which give competitive advantage. There is evidence that the managers of smaller firms are understandably more concerned with operational issues than the managers of larger organisations (see, for example, Rivard, et al.1988).

The issues and problems highlighted in this general research on ICT adoption, implementation and use in SMEs are further amplified by studies carried-out in a construction-specific context. Aranda-Mena and Stewart (2004) in their review of the Australian Construction industry found that adoption of e-business technologies significantly lagged behind other service and product industries. This was due to impediments that were emphasised by the particular nature of construction. Twenty-three such ‘impediments’ were identified and these related to specific organisational types and cultures associated with construction SMEs. They included: privacy, trust, uncertainty of financial returns, lack of reliable measurement, fraud, and lack of support and systems maintenance. Lofgren (2007) also investigated e-business technology adoption focusing on mobile computing in the Construction Industry. His findings also supported the case that in the Construction Industry, despite massive efforts to improve processes with ICT, firms have not increased productivity to the same extent as other business fields. The use of ICT by contractors and site workers is seen as surprisingly low.

To summarise: the literature on SMEs generally and Construction SMEs specifically, indicates that there are significant problems associated with the management, adoption, implementation and use of ICT. These are associated with the culture, context and operational practices of small businesses – especially those with a strong owner-manager structure. New levels of ICT user knowledge, skills, competencies and technical support linked to the introduction of new production practices are essential for successful business transformation.

1.2. The ‘WestFocus’ research project

A particularly interesting piece of research into SMEs and ICT was conducted in 2006 by the WestFocus consortium, comprising researchers from seven West London Universities including Brunel, Kingston and Royal Holloway (WestFocus, 2006). Around four-hundred SMEs in the Food, Logistics, Media and Internet Services (industries that are particularly important to the economy of the area) were contacted by phone. Over fifty of these also provided follow up, face-to-face, in-depth interviews. The research aim was to identify SMEs’ good practice but also identify areas for concern. Unlike the earlier literature, some of which is cited above, the report is quite complementary about the SMEs it featured, and commented on their ‘‘enormous creativity and self-reliance’. Its main criticisms were reserved, not for the SMEs themselves, but for the ICT ‘supply-side’, and for government policy. The ‘provision of effective ICT support to SMEs’ was viewed as ‘area of market failure’; and although the support for SMEs has been ‘a key policy aim of successive UK governments’, there is implicit criticism of the effectiveness of this support, which has been ‘subject to many changes over the years with a succession of different initiatives in evidence’. Whilst it is unlikely that the report’s findings would be representative of the situation of a construction SME, there may be valuable conclusions to be drawn from a comparison of the WestFocus results, with the findings of the present study.

2. Methodological approach

The present study forms part of an EPSRC CASE studentship whose aim is explore models for ICT adoption within Construction SMEs. The vehicle for the study is a construction company with thirty employees based in the Northeast of England. The researcher has been partly based in the company for the duration of the project to-date, and is involved with the company's attempts to adopt an electronic document control and management information system. An 'action research' approach was considered to be the most appropriate for the situation within an overall qualitative and interpretivist research-based inquiry.

2.1. Action Research method

Action Research (AR) as an approach, attempts to find ways of eliminating the gap between theory and practice (see, for example, NcNiff, 1988, pp ix). Coghlan (2003: p. 452) states that AR is a method based upon 'a collaborative problem-solving relationship between researcher and client, which aims at both solving a problem and generating new knowledge.' This emphasises the strong relationship between the researcher and the practitioner. It is fundamentally different from, as an extreme, laboratory research, where the interaction between researcher and researched is rigorously minimised by careful design. AR involves the community throughout the project and is often driven by an issue from the community itself. It is a method that can be driven by a group of people requiring change whilst working with a researcher to focus on a solution to the problem. Indeed, it actually 'favours consensual and participatory procedures that enable people (a) to investigate systematically their problems and issues, (b) to formulate powerful and sophisticated accounts of their situations, and (c) to devise plans to deal with the problems at hand'(Curry, 2005: p.2). Somewhat confusingly, practitioners may use different terms to describe it: AR is also referred to as Participatory Action Research, Participatory Research, Participatory Evaluation, Emancipatory Action Research, Action Science, Action Learning, Action Inquiry, Mutual Inquiry and Empowerment Evaluation. (Whitehead et al., 2003: p.7). However, within these definitions, there are four basic themes: empowerment of participants; collaboration through participation; acquisition of knowledge; and social/ organisational change.

2.2. The Case Study Background

The construction company SMEcon (The name SMEcon has been adopted to retain the anonymity of the real company. Extracts from the company's former and current websites remain unreferenced for the same reason) has thirty employees (this varies slightly, depending upon current projects) with its head office in an industrial estate in the Northeast of England. The company provides *'professional services to the construction and property industries …* [and works] *…. with individuals, companies and organisations, providing a complete service'* [original website]. They have split the 'Property Cycle' into five sections; Develop, Design, Build, Maintain and Manage, and each of these 'divisions' can stand alone as a service or be combined in a manner that suit the client. The three owner-directors of the company each has around 20 years' experience in the industry and they formerly operated as the regional management team of a major national construction and property company. They describe themselves as having '*a wealth of experience in managing a successful regional business for a major multi-national organisation*.' However, *'the team decided to rid itself of the shackles of the plc to concentrate on using its skills and experience for the direct benefit for the people who really matter – employees and customers!'* [original website]. Their feeling was that large companies can't change quickly enough to suit client demands and other industry developments due to bureaucracy, complex reporting mechanisms and a 'lack of direct contact' with the clients, suppliers and other stakeholders [Interview with SMEcon Commercial Director, 19/03/07].

The company's structure is based upon a framework that was introduced to the team in the late 1990s. This framework, along with their individual and group experiences, gave them a clear goal as to the direction the company would go along with a clear method of accomplishing this. They are committed to the 'change agendas' of Latham (1994) and Egan (1998), as well as other more recent developments, to adopt a new way of working within the construction industry. They feel that this should give them a real competitive advantage in the industry. [Interview with SMEcon Commercial Director, 19/03/07]. These changes include the implementation of a co-ordinated project information system, quality-based tendering, committed leadership, a focus on the customer, integrated processes / teams, a quality driven agenda and commitment to people.

The company policy is described as providing *'maximum value for money to customers by combining a relaxed, friendly and flexible approach with a wealth of experience, expertise and professionalism. Our approach is to work closely with our customers to fully understand their requirements, aspirations and priorities. Information is openly shared and we encourage customers to pass responsibility to us to manage their property and construction projects, using our in-house experience and expertise.'* [original website].

2.3. The research 'problem'

As noted above, Action Research (AR) is about problem-solving through a collaborative relationship between the researcher and client. The 'problem' here is two-fold. First is the academic goal of the CASE PhD; to contribute to theoretical understanding of ICT adoption and implementation issues in Construction SMEs. The second, more pragmatic goal, involves the desire by the client, SMEcon, to support its radical business aims with the development of a modern Management Information System. The company needs information to be: readily available; in a useful format; to all that are involved; and, in a timely manner. The main purpose of the Action Research study is to begin by creating a robust new paper-based system with a view to developing it into an ICT-based system. Fundamental to this is the company's adoption, implementation and use of ICT.

2.4. An opportunity for comparison

The systematic recording of the ICT adoption process within SMEcon has permitted the opportunity for comparison with both the findings of the WestFocus project (albeit that project included no construction industry SMEs) and with the extant literature on ICT uptake by SMEs in and out of Construction. The literature findings (predominantly led by the findings of the WestFocus Report) are first presented a point at a time, followed by comparative findings from the SMEcon case study, which are indented in the text to facilitate comparison.

3. Early evidence

According to the WestFocus Project Team (2006) SMEs are starting to feel more confident in adopting more extensive ICT systems. This, according to the report, is because of: the advent of cheaper hardware and of cheaper ICT infrastructure; increasingly obviously-useful office automation suites – particularly spreadsheets; the perceived need for even very small companies to offer a web presence; supply chain pressures on small companies to support some form of eCommerce; increasingly mature packaged applications to support standard business processes such as accounting, customer relationship management (CRM), basic business intelligence, etc.; and the availability of 'out of the box' outsourced business process automation from application service providers (ASPs).

> At the start of this study (September, 2007) SMEcon already used laptops with Microsoft Office suite products generally available, along with a few more specialised software systems. These included Sage Accounting and Asta PowerProject. Both of these systems incur an annual support and licence fee.
>
> More adventurous ICT implementation was driven by the needs of SMEcon's finance function. Through purchasing the Sage package, mechanisms for data capture and reporting were required and the creation of *purchase requisitions*, *business mileage forms*, and similar reports were expedited. These data-capturing forms (MS Word and Excel-based) were initially based upon previously recognised layouts and enhanced to match the data necessary to drive the Sage software.
>
> These forms created the basis for operational and statutory data recording; from *new starter* forms to *customer questionnaires*. There is little or no automation in the company apart from one or two MS Excel spreadsheets which only work independently. They do not provide separate reports or feed information to other documents. Indeed, the majority of software used creates forms to be manually filled-in (hand-written) or emails to geographically separate stakeholders. The purchase of the Asta PowerProject software was based upon the directors' previous exposure to it.
>
> The company also has a web presence which had not been updated since the site's initial launch in 2006. It acts as a brochure, mainly giving snippets of information about the origins and ethos of the company as well as contact details. It is undergoing a major redesign at the time of writing.

The WestFocus Project Team (2006) makes some observations on specific matters relating to ICT expertise. They state that many SMEs find themselves in a difficult situation as they may not be large enough to afford to employ a dedicated ICT expert, or may lack the money even to buy advice. This, allied to their lack of experience, which in turn leads to a lack of confidence in the reliability of the advice given, exacerbates the situation that arises from their limited experience in selecting, implementing and evaluating suggested ICT solutions.

> SMEcon has relied upon the research project, and in particular the researcher, as a resource for meeting some of its ICT aspirations. Crucially, the researcher has working experience in ICT, and the firm have drawn heavily upon this expertise in updating their systems and automating some of their existing management processes.
>
> Immediately prior to this research project, the companies ICT-based systems were 'being looked after' by a small ICT consultancy. However, this ICT consultant had

become dilatory, and appeared to have reached the limit of support that it could offer SMEcon. Not long after the start of the research, another ICT consultant was appointed. The choice was based upon personal recommendation, ironically from the former ICT support company.

This type of recommendation, although highly likely to occur in large organisations, would almost certainly not have been taken up as quickly, or without other ‘sign-offs’ from senior management and budget holders. Therein lies a major perceived benefit of SMEs; the people doing the work, pay for the work. Bureaucracy, tendering, procurement ‘rules’ etc, are not the blocks to decisions often found in large companies or public organisations. However, the procurement issues in particular, may allow large organisation to truly receive the best provider of service if they use a measured competitive tendering process, whereas an SME’s approach may be more ‘ad-hoc’ and personal, increasing the risk of sub-optimal technology choice and lock-in.

It is noted that larger firms have dedicated ICT resources, internal or external, and existing procurement processes. This is not the case in SMEs and “the deployment of ICT typically depends on a single individual with vision who takes full responsibility for ICT initiatives, as well as continuing with their regular activities. They often have to rely on their own self-taught expertise and feel ill-equipped to carry out the implementation tasks required of them. They make little use of the formal methods of ICT, project management, or evaluation.” (WestFocus Project Team 2006, p2)

SMEcon certainly fits some of this observation. One person is the driving force behind the overall project and the idea of bringing in a researcher to aid the project and take an academic view of actual processes. It has also been observed that this person does not have a deep IT understanding and does not have the knowledge or experience to deal with some of the more technical issues that arise in such a project.

However, this project is not meeting all the deadlines set due to some unusual problems. The three main occurrences involved one employee leaving, taking all the electronic information without any record of it on the central files, the incumbent ICT support company ‘disappearing’ for some time without any direct contact or information and the need to bring in two other companies, SMEsup for ICT support and SMEint to provide the new document management system.. Although the dates have slipped, some project management and evaluation tools are being utilised. This is mainly through the AR study.

The WestFocus Project Team (2006) reported a ‘lack of formality’ in security issues surrounding their ICT. ‘Most did not seem overly concerned about security issues either. About 15% of the companies surveyed had systems that crashed frequently, while about 4% reported that they were concerned with poor security, while 6% reported security failures of one sort or another. Although there seems to be a certain awareness of security issues, there does not seem to be much overall concern. Whether this is due to a lack of awareness of the consequences of data loss is not clear.’ (WestFocus Project Team, 2006, p22)

Two different security issues have hit SMEcon. The first is the aforementioned employee leaving the company. He managed to work for over two years without saving any work onto the central filing system on the server. This meant that when the information was required after his leaving date, nothing could be recovered. This looks to have been pre-meditated on the part of the leaver as there is no other obvious reason for the work not to be stored centrally.

The second security issue involved back-ups. The main instigator of the whole project lost over three years of information when his laptop was replaced and upgraded. The cause of the physical loss is uncertain but does highlight the need for a robust policy on document storage. The full effect of this data loss has not been realised at the time of writing.

4. Discussion and Conclusion

The literature shows a common consensus, that SMEs, despite accounting for over half of UK employment and company turnover (and well over that proportion in terms of population) nevertheless command very little research attention in terms of their ICT uptake. In fact, the WestFocus Report found the same to be true of the attention given to SMEs by ICT providers. The report identifies the reason for this as being down to money and volume; and that hitherto SMEs simply lacked access to the money necessary for complex, dedicated ICT systems as well as to the information requiring for processing (WestFocus, 2006).

The importance is noted in the literature of an individual that drives innovation in ICT take-up. This has been clearly borne-out by the case study to date. However, that individual is not necessarily sufficiently *au fait* with the technology to ensure the right decisions. He/she relies heavily on personal recommendations, even (in the case of SMEcon mentioned earlier) where the recommendation comes from a contact whose own performance has been less than satisfactory.

Matters concerning security appear to be treated in a cavalier and haphazard way. Accidental breakdown, and even (apparently) deliberate sabotage of the SMEcon's ICT system were both encountered.

In summary, the systemisation of SMEcon's management information systems and the subsequent attempts to automate them, have involved a huge learning curve and the divisions and gaps within organisational information flow are only now being highlighted. SMEcon's directors are now implementing a measurement system to feed into formal reports that are discussed at monthly management meetings. These are still in their infancy but the gaps in their ability to capture useful, timely information are becoming obvious. The administrative burdens of Quality Assurance and other aspects of Business compliance are being recognised as the process of extending the coverage of management information and ICT adoption continues.

Future research will be focused on prototyping an intranet system that integrates with a Management Information System focused upon the company's requirements. The academic part of the CASE PhD will evaluate adoption and implementation models in SMEs and evaluate them within the research filed.

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The study is part of an EPSRC industrial CASE student project with a wider aim of developing new models for ICT adoption, implementation and use within Construction Sector SMEs. The names of those involved are anonymised to for confidentiality.

Influence of input parameters in different prediction methods for railway traffic noise

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Abstract:
The measurement of the equivalent sound pressure level L_{Aeq} (noise level) from railway traffic is an expensive and long-term matter. For easier determination of noise levels special software (for example CadnaA, LimA, Hluk+, etc.) is used. The software allows determining the levels of traffic noise in studied localities objectively and reliably. It is important to know all the parameters which are significant.

The next part of the article describes statistical evaluation of different software programmes and methods – CadnaA (Önorm, Shall03) and Hluk+ (Czech methodology) used for the prediction of noise impact from railway traffic. The results obtained by these methods are different, provided the same computation characteristics are set. The accuracy of results proportionally depends upon the quality of input data.

Keywords:
Railway traffic, noise control, statistical evaluation

1. Introduction

Due to the necessity of determination of long-term equivalent noise levels such measurements are time-consuming, and in the case of large-scale projects, e.g. for noise maps, practically unfeasible. For this reason, methodologies for the determination of equivalent noise levels by computations have been developed based on parameters which may define the current and prospective condition.

Among the basic model programmes for the calculation of noise levels and elaboration of noise maps applied worldwide the following may be named:

- Cadna A,
- SoundPLAN,
- LimA,
- Predictor.

These programmes serve for the prediction and evaluation of noise emissions e.g. from road and air traffic, industry etc. and further for the design of anti-noise measures (e.g. noise barriers). All the above-mentioned programmes work with a2D or a 3D model respectively, which is necessary for the determination of accurate noise level values at a certain height. Each of these programmes incorporates a combination of valid computational methodologies used in selected countries. The German programme CADNA A (Computer Aided Noise Abatement), for example, works under standard conditions with the following methodologies for the calculation of noise levels from railway traffic:

- Shall 03 – DIN 18005 (Germany),
- CRN – Calculation of Railway Traffic Noise (Britain),
- Nordic Prediction Method (Scandinavia),
- ÖNorm S 50011 (Austria),
- Semibel (Switzerland).

The recommended methodological instructions for the calculation of traffic noise in the Czech Republic have presently been implemented only in a single programme (CADNA A).

1.1. Objective of Paper

The objective of this paper is a presentation of the possibilities of a statistical comparison of different computational methodologies or software applications – Cadna A and Hluk +. These software applications serve for the prediction and evaluation of noise situations due to traffic in outdoor spaces, in this case particularly due to railway traffic. The software Cadna A incorporates several computational methodologies, however, only two methodologies Önorm (Austrian methodology) and Shall03 (German methodology) were selected for statistical evaluation. The software Hluk + incorporates only one Czech computational methodology.

Due to the fact that on-site measurements of noise emissions tend to be highly complex and demanding by their nature, statistical evaluation was selected in the initial phase. Potential measurements are considered if suitable conditions are provided for them.

2. Input Data

An earlier research project - Noise study of the surroundings of a railway track of corridor III ČD, section Černošice – Srbsko, i.e. Štulíková, (2004) served for the selection of a specimen of 15 calculation points (situated predominantly in Černošice municipality), showing the greatest differences in the distance from the track axis and the height above (or below) the rail surface (Fig. 1). Identical configurations of the terrain, speeds and traffic volumes were gradually loaded into the Cadna A software (using Őnorm and Shall 03 methodologies) and Hluk+ (Czech methodology of railway traffic noise calculation).

The calculation of noise levels of railway and road transport was simulated in CADNA/A (version 3.3.107) and Hluk + (version 6) software.

For an objective and reliable determination of the levels of traffic noise in the studied localities, all the parameters which are significant must be known. To these parameters for railway traffic belong: the number of trains, the number of wagons in trains (or the length of trains), the speed of trains, types of trains (passenger, freight trains, etc.) and technical situation of rails. Then, it is necessary to know the characteristics of urban planning concepts in the studied regions. It is crucial to know how far from the noise sources the facing buildings studied are situated, their dimensions, their surface and their segmentation. This is connected with the knowledge of morphological and hydrological conditions. Some of these parameters are not entirely known. That is why it is necessary to make a reconnaissance of the studied regions to collect the missing information.

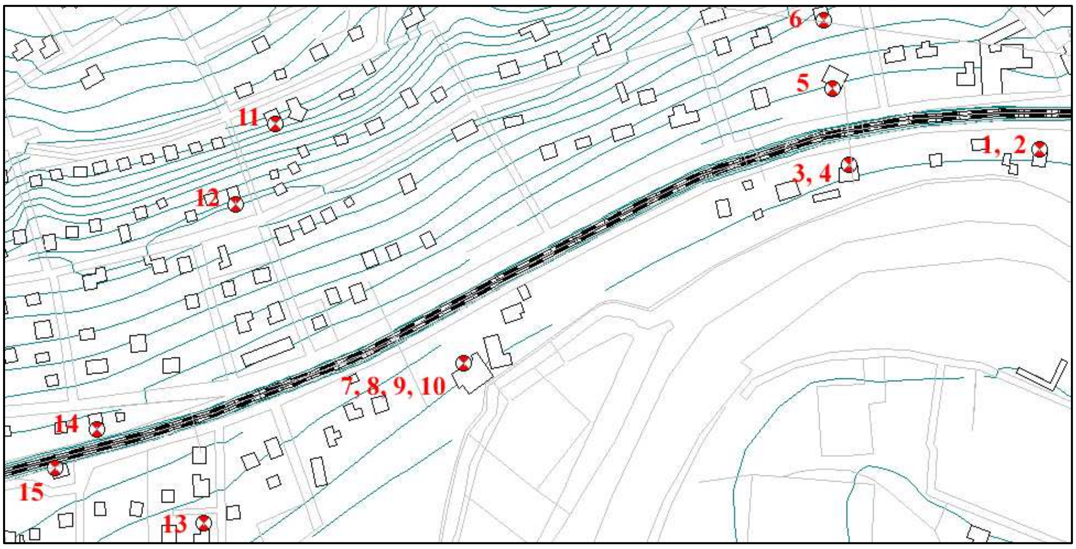

Fig. 1. Calculation points locations

Urban documents and cadastral maps were rendered by ČÚZK (Czech Surveying and Cadastral Institute). The maps were obtained in a digital form and had to be adjusted by the AutoCad software. These digitalized maps are imported for both software applications as initial input data.

The railway traffic volumes were provided by the Czech Railway Track (ČD) management. 24-hour traffic volumes and speeds of railway traffic are visible in Table 1.

Table1: 24-hour volumes of railway traffic on line Prague – Beroun (2007).

Track section	*Type of trains*	*Direction Prague – Beroun*				*Direction Beroun – Prague*			
		Number of trains		*Length of train [m]*	*Speed [km/h]*	*Number of trains*		*Length of train [m]*	*Speed [km/h]*
		day (6-22h)	*night (22-6h)*			*day (6-22h)*	*night (22-6h)*		
Prague – Beroun	*Passeng.* *Ex, IC* *Freight*	*34* *16* *13*	*6* *7* *5*	*150* *250* *500*	*90*	*22* *14* *11*	*7* *2* *5*	*150* *250* *500*	*90*

3. Statistical Evaluation

In the first phase, a model situation was selected which was the background for the calculation of noise emissions in all the three different methodologies or software applications. In choosing the situation and subsequently the calculation points a great emphasis was placed on the diversity of these points' locations (distance from the track axis, height above/below the rail surface) (see Table 2). The obtained results of the equivalent noise level (L_{Aeq} per day) were statistically investigated both by testing the differences between the two methods and by specifying the correlation coefficients of individual parameters.

Table 2: Input information for statistical evaluation of parameters

Calculation points	*Altitude [m]*			*Point distance from the track axis*	*Noise level [dB]*		
	*Point**	*RS***	*Difference*		*Önorm*	*Shall03*	*Hluk+*
1	*204,82*	*205,75*	*-0,93*	*30,50*	*65,6*	*62,1*	*64,5*
2	*207,82*	*205,75*	*2,07*	*30,50*	*66,9*	*65,7*	*65,6*
3	*204,83*	*206,02*	*-1,19*	*27,88*	*65,9*	*62,6*	*65,8*
4	*206,83*	*206,02*	*0,81*	*27,88*	*67,5*	*66,2*	*66,4*
5	*209,78*	*206,03*	*3,75*	*37,96*	*65,2*	*62,3*	*64,8*
6	*216,25*	*206,03*	*10,22*	*95,98*	*58,3*	*55,8*	*57,8*
7	*205,13*	*206,65*	*-1,52*	*47,44*	*63,3*	*60,0*	*62,4*
8	*206,63*	*206,65*	*0,02*	*47,44*	*63,7*	*60,1*	*62,7*
9	*208,63*	*206,65*	*1,98*	*47,44*	*64,3*	*62,7*	*63,4*
10	*211,63*	*206,65*	*4,97*	*47,44*	*64,3*	*63,8*	*64,3*
11	*239,72*	*206,76*	*32,96*	*209,20*	*53,2*	*51,6*	*49,9*
12	*224,54*	*206,86*	*17,68*	*158,45*	*50,3*	*49,2*	*50,0*
13	*204,70*	*207,05*	*-2,35*	*86,02*	*52,5*	*51,3*	*53,0*
14	*211,11*	*207,15*	*3,96*	*14,80*	*69,1*	*66,5*	*71,8*
15	*209,93*	*207,22*	*2,71*	*7,26*	*73,3*	*72,5*	*74,8*

* evaluated point height, ** rail surface height

3.1. Testing of differences among calculation methods

The testing of differences among computational methodologies was performed as follows (Vorlíček, 1982):

- By means of a pair test t_0 for differences L_{Aeq} of the three above-mentioned calculation procedures (methodologies) – in all cases **significant differences among the calculation procedures** were discovered, i.e. the determined values t_0 considerably exceeded the critical test values,

- The least differences discovered are between Hluk + and Őnorm; none of the differences are systematic; the highest noise level is mostly based on Hluk +.

3.2. Testing of correlations among parameters

Correlation coefficients of different parameters were determined (Vorlíček, 1982):

- correlation coefficients *r* between the distance from the rail axis and L_{Aeq} imply **a high degree of relationship,**

  Correlation coefficients are: $r_{(distance,\ LAeq\ Önorm)} = 0,88$

  $r_{(distance,\ LAeq\ Shall\ 03)} = 0,85$

  $r_{(distance,\ LAeq\ Hluk+)} = 0,91$

- correlation coefficients *r* between the height above/below the rail surface and L_{Aeq} imply **a considerable degree of relationship**,

  Correlation coefficients are: $r_{(height,\ LAeq\ Önorm)} = 0,66$

  $r_{(height,\ LAeq\ Shall\ 03)} = 0,62$

  $r_{(height,\ LAeq\ Hluk+)} = 0,69$

- correlation coefficients *r* between the distance from the rail axis (or the height above/below the rail surface) and the differences of L_{Aeq} (two methods) are very low, this correlation **is therefore insignificant** (Table 3, Fig. 2, Fig. 3),

  Correlation coefficients are: $r_{(distance,\ LAeq\ Önorm\ –\ LAeq\ Shall03)} = 0,22$

  $r_{(distance,\ LAeq\ Önorm\ –\ Hluk+)} = 0,25$

  $r_{(distance,\ LAeq\ Shall03\ –\ Hluk+)} = 0,22$

  $r_{(height,\ LAeq\ Önorm\ –\ LAeq\ Shall03)} = 0,25$

  $r_{(height,\ LAeq\ Önorm\ –\ Hluk+)} = 0,47$

  $r_{(height,\ LAeq\ Shall03\ –\ Hluk+)} = 0,12$

Closeness correlation (relationship) among investigated values is given by interval $|-1 \leq r \leq 1|$. Correlation coefficients between L_{Aeq} obtained from individual calculation procedures determined for interest sake nearly approach 1, i.e. they show an extremely high mutual relation (correlation).

Table 3: Differences in noise levels as modelled in Önorm, Shall03 and Hluk +

Calculation points	*Height above/below the rail surface [m]*	*Distance from the track axis [m]*	*Noise level difference [dB]*		
			Önorm - Shall03	*Önorm - Hluk+*	*Shall03 - hluk+*
1	*-0,93*	*30,50*	*3,5*	*1,1*	*-2,4*
2	*2,07*	*30,50*	*1,2*	*1,3*	*0,1*
3	*-1,19*	*27,88*	*3,3*	*0,1*	*-3,2*
4	*0,81*	*27,88*	*1,3*	*1,1*	*-0,2*
5	*3,75*	*37,96*	*2,9*	*0,4*	*-2,5*
6	*10,22*	*95,98*	*2,5*	*0,5*	*-2,0*
7	*-1,52*	*47,44*	*3,3*	*0,9*	*-2,4*
8	*0,02*	*47,44*	*3,6*	*1,0*	*-2,6*
9	*1,98*	*47,44*	*1,6*	*0,9*	*-0,7*
10	*4,97*	*47,44*	*0,5*	*0,0*	*-0,5*
11	*32,96*	*209,20*	*1,6*	*3,3*	*1,7*
12	*17,68*	*158,45*	*1,1*	*0,3*	*-0,8*
13	*-2,35*	*86,02*	*1,2*	*-0,5*	*-1,7*
14	*3,96*	*14,80*	*2,6*	*-2,7*	*-5,3*
15	*2,17*	*7,26*	*0,8*	*-1,5*	*-2,3*

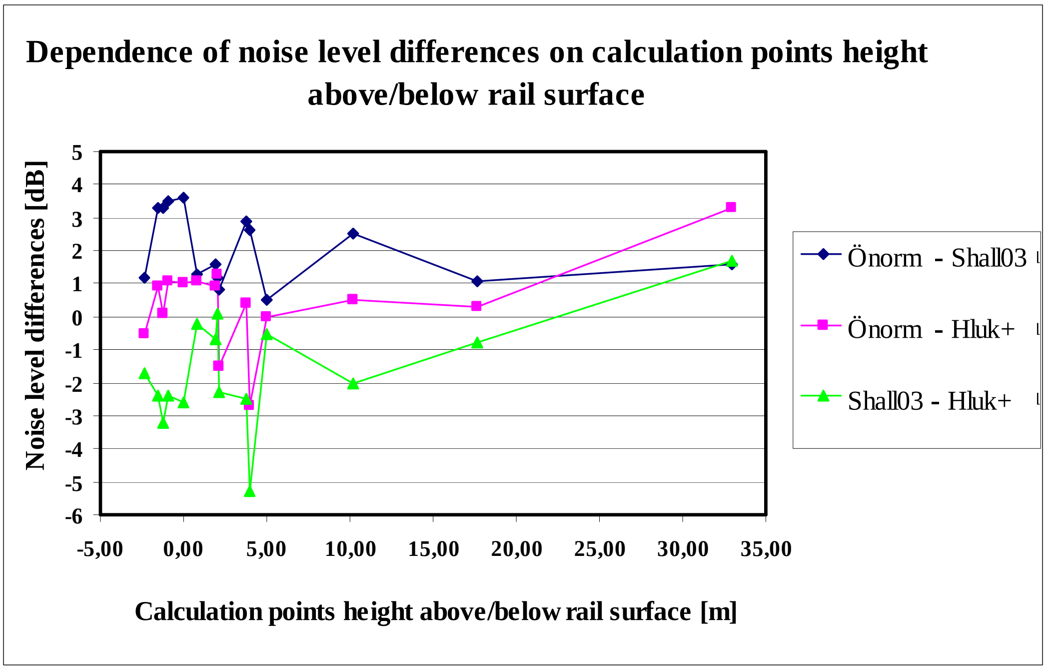

Fig. 2. Diagram of dependences of noise level differences (two methods) at different distances of calculation points from track axis

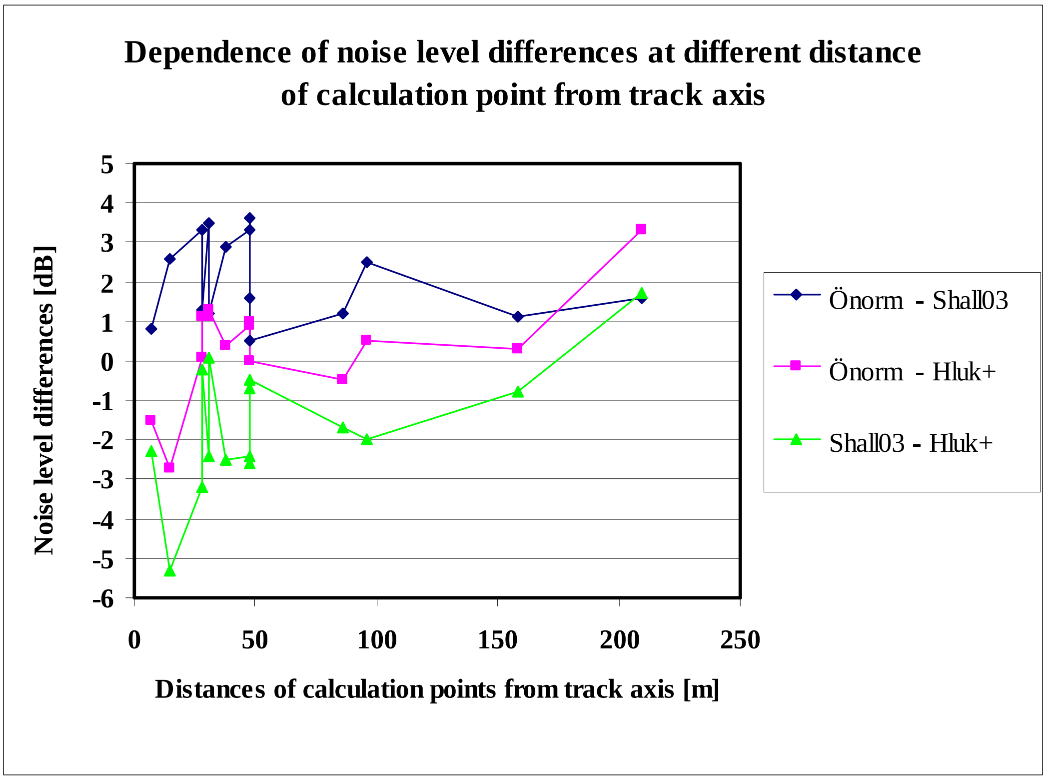

Fig. 3. Diagram of dependences of noise level differences (two methods) on calculation point height above/below rail surface

4. Conclusion

The statistical analysis failed to prove the hypothesis that prominent differences in the values L_{Aeq} obtained on the basis of various methodologies (e.g. Önorm – Shall03 etc.) depended on the distance from the track axis or the height of the calculation point above/below the rail surface. None of the methodologies, therefore, shows a systematic deviation caused by the monitored parameters.

Acknowledgements

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Patterns of Innovation and Transfer of Technologies in the Tall Building Industry

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Abstract:
The present paper investigates the innovations of the building industry, especially within the specific field of tall buildings. Several reasons are provided to awake the researcher's attention on this particular building typology. The paper explains how innovation could be helped and incremented by a clear understanding of its mechanisms (both hard and soft) and its promoters (both internal and external to the building process). Researchers and Academics are implicitly asked to deepen their attention and comprehension on tall buildings, recognizing their ever-growing influence on the dynamics of building innovation.

Keywords:
Building process, Innovation, Research, Tall building, Transfer

1. Introduction: nowadays idea of innovation.

"Innovation" is the successful output of an ameliorative process, meant to improve the performances of an entire building, a part of itself or its building process (Nardi 1998). The whole history of the technological development is strongly connected with the innovation, the efforts to reach it, and even the unsuccessful attempts. Several kinds of innovation could be identified in architecture.

The first "family" of innovations is the knowledge of "what to do?" (product innovation or hard innovation) and it is recognized when a new product is proposed on the market. It is also possible to recognize such family when the performances of an old product are improved or its cost decreased or when it becomes useful for another purpose different from the original one. The second kind of innovation is the knowledge of "how to do?" (process innovation or soft innovation). The knowledge of the process leads the organization of the production thanks to new targets, new roles,unusual methods to plan and control each and every single task, new means of communication and coordination (Sinopoli 2004). A brand new family that embraces many innovative products answers the question "what does it represent?" (semantic innovation). This innovation happens when an existent product meets new customers' needs and it is therefore certified as effective as a product engineered on-purpose.

Strategies to understand innovation are necessarily based on the knowledge of the process of technology innovation itself. Indeed, it is necessary to stress the attention on the great number of factors that mutate the technology features and that gradually drive the technology development. Innovation, in fact, is not just the consequence of an invention, because this may rely only, i.e. on the technical filed, whereas an innovation cannot be divided from the economic and social background and from all the other aspects that are factored in. The amount and the interconnection of knowledge develops the technologies, while the alternative choices obviously influence the future of the innovation. Each change and detail may define both the feed-back and the feed-forward of an innovation.

2. Why Tall Buildings? A key-role in the building industry

The choice of this paper in focussing the analysis on the market of tall office buildings comes from the acknowledgement of their ever growing economic and political importance.

2.1. A matter of… numbers

"There can be no denying that we are currently experiencing a boom in tall building construction like never before. Even considering the golden age of the skyscraper in New York in the 1920s and 30s, we are most likely undergoing the greatest development of high-rise buildings ever, certainly from a global perspective (…) As of October 2007, there are 35 completed tall buildings in the world that are 300 meters or above in height. At the same time there are over 55 such buildings currently under construction" (Oldfield 2007). Since a few decades tall buildings are being constructed in all the major cities of the world, including many historical cities once considered off-limits.

2.2. A matter of… marketing

Many tall building projects of rely on massive economical investments and the building becomes a manifesto itself: it plays a key role in supporting the image of a city or an entire country even. Buildings are now named "Taipei 101", "Burj Dubai", "Chicago Spire" whereas in the past they were more likely named after their main tenant's name as in the cases of "Sears Tower", "Pirelli" or "Equitable Building". This means that their potential target of customers is spread to attire users from the entire world, attracted by the positive economical or living aspects of the city or country they are built in. Despite a growing number of super-tall buildings are inspired by a multi-purpose construction (both for economical and technical reasons), offices still represent the largest part of the market.

2.3. A matter of… money

Tall buildings represent great opportunities for the construction industry. Engineering and building a super-tall skyscraper requires an investment of hundreds of millions of US Dollars, ranging on an average of 750 million of US Dollars for major ones. In the last decade, the cost of construction of the ten tallest office building in the world , summed up more than the entire value of the construction industry in the Czech Republic in 2005 (source of data: www.mpo.cz - Ministry of Industry and Trade of the Czech Republic) . The cash flow generated by the raw construction of a tall building is mainly divided among site preparation, structures and cladding (Kalita et al. 2007). If one considers these values, it is easy to agree with the fact that the construction of a tall building generates the critical economical mass for promoting an innovation and research process by its own.

2.4. A matter of… people

The innovation process happening in the tall office building industry is strengthened by the wideness and multi-cultural melting-pot of expertises involved in the design process. The complexity of this typology and the economical drawbacks of eventual mistakes create a wider and wider board of experts required to take the responsibility of every aspect of the design and construction. By an analysis of the professionals and enterprises involved in the tallest ten office buildings of the last ten years, the number of consultants ranges from a minimum of 5 up to as many as 40 actors involved in the New York Times Building, with an average of 25 and the lower figures more likely to be found in China (source of data: www.emporis.com). The interaction among such a great number of professional skills and technical competences can be a profitable circumstance for creating new thoughts and learning from other’s experience. The consequence of this brainstorming opportunity fed up by millions of dollars is a strong and fast innovation process for the building typology, its building techniques and materials.

2.5. A matter of… needs

The changing of the user’s needs in the office typology drove so many influences that tall office buildings can be taken as example for the whole tall building typology. In fact, while the office suites of the ancient tall buildings in Chicago and Manhattan were influenced by the natural lighting requirements and therefore limited to a depth of 8 to 9 meters (Gompert 1930), the invention of air conditioning and fluorescent lighting changed the shape of the buildings from the ’50 onwards (Willis 1995). Nowadays we can state that the shape of many tall buildings is returning to be influenced by the natural lighting and ventilation requirements, not to compensate technological lacks, but because of the need of lowering the energy demand of the buildings (Oldfield et al. 2008). According with this subdivision in subsequent “generations” of office plan configurations, it is clear that the office-tower typology has been always striving for an image of modernity, keeping itself up-to-date with the user’s need, so to cope with aggressive marketing strategies of eventual competitors. Its layout and technological features have been strongly influenced by both the ever-changing user’s requirements and the technical and normative constraints imposed on the working environment.

3. Innovators = Actors of the (tall) building process.

In constructions as complex as a tall building, users and actors of the process differ from those of other building typologies: there are several kind of both categories (Manfron 1995). Furthermore, a third category of promoters could be identified: it is constituted by the public opinion that always takes a role in the approval and even design choices of big projects. The public opinion often dialogues with the actors of the process thanks to the Authorities that define forums or other form of inquiry with the professional figures of the building process.

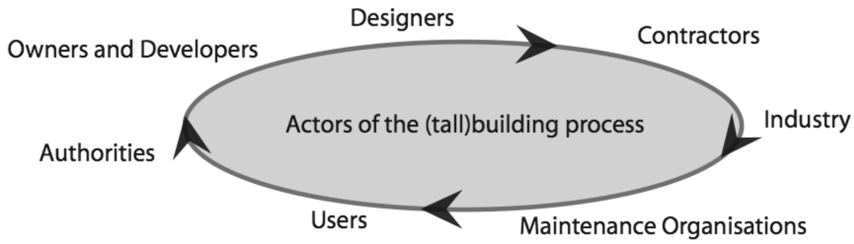

Fig.1. Owners and Developers, Designers, Contractors, Industry, and Maintenance Organizations are the Professional Figures of the Building Process. Authorities indoor needs of Public Opinion, while the Users represent both the occasional and the permanent people that use the building. (scheme reworked by the authors from CIB Report Publication 237)

3.1. Users of the building

Three categories of people are the users of an office tall building: the occasional customer of a company located in the building, the employees of the company, and the company itself, which finally pays the rental.

Innovations promoted by those categories are meant to boost of the economic value of the building rented or owned. This is possible through an enhancement of the living amenities, security (active and passive), typological updating, and better internal environmental quality.

i.e. The sensible reduction in the total weight of buildings caused by the extensive use of glazed curtain walls from the fifties onward, decreased the stiffness of the structure and tall buildings therefore became more sensible to wind forces. The comfort on the upper floors decreased and users got affected by motion-related sickness when strong winds blew. In this case the stability of the building wasn't threatened but the working condition were so poor to lower the overall comfort behavior of the building. The user's need for a more "still" building generated a process that brought to the invention and development in the late Sixties of mass-damper systems created to reduce the sway effect of the wind. This is an example where users promoted an innovation process meant to increase the value of the property.

3.2. Professional figures of the building process

The professional figures involved in the construction of a tall building can be many. Generally we can identify some actors that commonly operate at various degrees in the building process: the developer, the construction company and the subcontractors, the design team and the consultants, the funding provider. Others could take a role in specific cases.

Innovations proposed by the professional figures of the building process are meant to increase the revenue of the money invested. Given a fixed value for the rental or the sell price of the building they strive for reducing the overall building cost. Individually, they try to increase their own revenue, simplifying their operative cost, the time of construction, the use of materials, the financing procedure and so on.

i.e. The ever growing prices of the land in Manhattan created the basis for the growth of tall buildings. In fact, developers who owned a plot of land strove for building taller, consequently dividing the value of the land for a greater rentable surface, diminishing the impact of the most expansive economic factor of the entire process. In order to build taller and taller the elevator industry was forced to create safer and faster lifts improving the systems once adopted for the vertical movement of goods. The developer's strive for increasing revenues promoted an incessant research that is still going on with the creation of safer, faster and more comfortable lifts. This is an example where a professional figure of the building process promoted an innovation process meant to increase the revenue of the money paid to buy the urban plot.

3.3. The public opinion

The public opinion is a "virtual" figure acting as an external force that drives some choices of the building process. In fact, it doesn't hold any official role in the decision-making process but it can strongly influence some choices of the various actors directly involved in the building process. The public opinion acts directly against one of the actors of the process (protesting on-site or even subverting the building site) or through the political pressing. Often the action of the public opinion is even prevented by the choice to feature the building with some "external apparatus" that tend to mitigate any eventual opposition to the project.

Innovations requested by the public opinion are meant to improve the social value of the proposed project. Because they often act as "not in my backyard" movement, they are generally tended to mitigate the presence of the tall building in a given area, and therefore preserving the social value of the area interested by the project. Because of the non-professional origin of the input received, the answer is sometimes limited to mitigate the external appearance of the building. The recent debate on the sustainability promoted a new trend of innovation, enrolled by all the actors of the building process first, and subsequently became a mandatory requirement by building regulations.

i.e. When the developer of the John Hancock Center of Boston proposed the project, the massive silhouette of the building encountered the opposition of the population because of its visible presence in the skyline of the city. A new kind of ultra-reflective glazing was therefore developed to make the building to "disappear" in the sky. This is an example where the public opinion's influence forces the designer to promote an innovation process that mitigates the visual impact of the tall building proposed.

Fig. 2. The John Hancock Center of Boston seems to “disappear” in a bright sunny day. (source: www.wikipedia.com)

4. Dynamics of Innovation.

The diffusion of an innovation is strongly connected with the planning capability of the innovators and with the creation of reliable provisional models for the designing outputs. Nowadays this condition describes the real problem caused by the complexity of the productive system, and by the increased knowledge and number of information concerning the vast sort of construction solution, techniques, and styles (Del Nord 2004).

It is important to analyze the relationship between the experimental technologies and the factors that hold a key role in the success or failure of a project. Therefore, the innovation is plan-able and design-able. It is not a consequence of unforeseen events; on the contrary, it is of capital importance to understand why and how an invention may become an innovation.

The analysis is based on the interpretation of two main variables that show the complexity of the process of technological innovation thanks to their contradictions and their variance.

“Demand pull” is defined as an innovation whose idea is generated by the necessity to meet one’s need. Unlike, the “technology pushed” innovation occurs when a new idea anticipate any possible use of itself. It can take a long time before a technology evolves from the invention to the innovation stage and ultimately becomes fully commercialized. Therefore, it is important to study the relative importance of technology push and demand pull factors and, in particular, their role in the different stages of technological development. It could help to formulate better informed and targeted technology policies.

5. Learning by…

An innovation enters in the building industry following three different paths that stress the importance on the most relevant skill of the main actor of the innovation process:

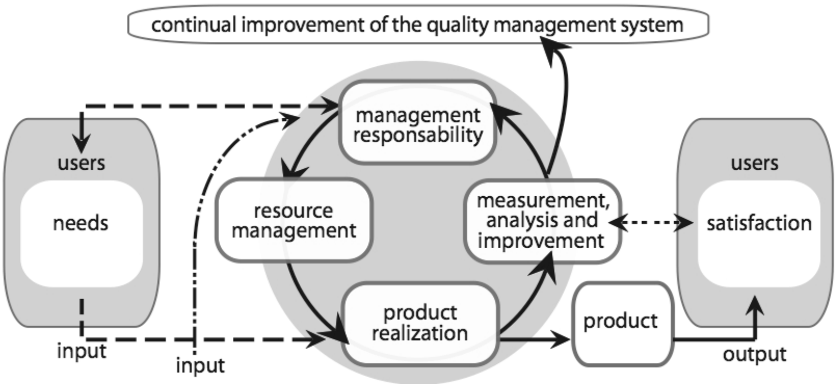

Fig. 3. The scheme shows how the different "learning by" processes may be mixed to improve the quality of both product and management system. Long dash lines represent the "learning-by research" process. Dot dot dash line represents the "learning by transfer". Dot line represents the "learning by doing". (PDCA scheme reworked by the authors and sourced from UNI EN ISO 9001:2000)

5.1. Learning-by… research

The first case, which could be defined "Learning-by research" is given by the innovation generated within the industry itself that sometimes produces brand new technologies or products that substitutes pre-existing methods or knowledge. An innovative process occurring within the construction industry generates a brand new product that meets the unanswered needs of some users. While market size and conditions are constrained, "learning-by research" will play the leading role in achieving technical progress. As a technology develops and gradually reaches maturity, the gap between the "learning-by research" innovation and the other products on the market tends to diminish (Jamash 2006). This happens because "learning-by research" is not the only source of technical changes.

5.2. Learning-by… doing

Therefore, "Learning-by doing" is called the innovation of a technology that produces an improvement of existent products. This kind of innovation generally comes from the technical changes measured in terms of the reduction of the unit cost of a product as function of the experience gained from an increase in its cumulative capacity or output. The continuous improvement of an existent technology is easier to be accepted by the market of building components and materials because the process relies on a non-stop feedback received from users by the actor of the evolution (Verganti et al 2004). Consequently, it will hardly create a shock in the market and will be more easily accepted by the general public; furthermore, due to the slow process of innovation, it will be probably comparable with other similar products of other brands.

5.3. Learning-by… transfer

The third case, that of the "Learning-by transfer", happens when an idea or a product already existent in other disciplines is adopted within the building industry. The technology transfer is usually the most viable solution for those disciplines (like architecture), which are supposed to share the same object of analysis with a wide range of other sciences, and are therefore prone to be influenced by more specific approaches to a given issue. Whenever an innovation is generated as the consequence of an efficient R&D process, it will appear as a completely new and innovative product. In a market as conservative as the building industry, a new project is likely to face great difficulties in being accepted and adopted, as many examples in the building industry can demonstrate. i.e. the technology used for air conditioning derived from the cooling methods applied in some industrial processes for ice-making machines first, and therefore for air-cooling the freshly-printed paper in printing industries. It took almost fifty years for air conditioning to become fully available for buildings but from the fifties onward it became reliable enough to be featured as a "normal" characteristic of the tall office building.

5.4. Learning-by… building tall

As previously stated, the broad range of professionals and higly-skilled figures involved in the design and building process o a tall building, represent a great opportunity for innovation by itself. The client's visions (shape, height, appearance etc.) and the constraints imposed by the environmental conditions (climate, external forces, ground resistance etc.) stress the design team to study and provide new solutions to cope with known problems (learning by research). Sometimes, even a highly engineered project faces unexpected and unknown problems. Often, the solution for these issues come from a revision of the building practices and is dealt by developers and contractors companies: their methodology relies especially on building practices and know-how, and most of the problems are solved on-site through highly-specialized building techniques, improved or modified according to the special requirements case to case (learning by doing). However, problems are sometimes apparently unsolvable within the methodology and the knowledge of the building industry and their solution is found in other disciplines (learning by transfer), thus creating a "precedent" within the architecture-related disciplines that will be able, in the future, to cope with similar issues.

6. Conclusions

The present analysis described the actors, the methods and the places where innovation happens. However, an important aspect has been intentionally omitted: the role of the Academic Research. Despite sometimes the Universities of Architecture don't have a specific role played in the innovation process, they act like an external player that influences many of the aspects previously described. It's lubricant role in the mechanism of the technology transfer is clear if one considers the key role played by the academic world in starting and alimenting the most powerful engine that promoted innovation in the recent years: the sustainability issue. The innovative and far-seeing idea of a small group of scientists, once denigrated, turned up to be the starting point of the greatest number of innovations presented nowadays.

The basic and theoretical research, conferences and written papers and an incessant mix of learning & teaching are the main ingredients of the daily work of an academic researcher. In this view we have to strengthen and improve the relations among researches tended to develop a clear thought on innovation and the way to quicken and divulge the results achieved.

This paper underlines the importance of tall buildings in the innovation of the construction industry as a consequence of:

- the number of tall buildings or super-tall buildings currently under construction or planned;

- the marketing role that tall buildings have, both for their tenants and for an entire city or Country;

- the economic importance due to the high cost of construction and the high revenues generated;

- the multi-disciplinary team that takes part in their construction;

- the change in the user's need that keep on promoting innovations and changes it the typology.

In Europe a resistance to the skyscrapers can be seen in many Countries, because they do not give an image of the city corresponding the European traditional one. On the other hand, skyscrapers may represent an optimistic vision of a future more open minded and characterized by social and economic development. One of the widest field of research that can experience further developments may be the study of more environmental-friendly design. "Towers structures require less ground area than lower buildings of the same volume, but more energy is consumed in their construction and operation. New technologies can at best ameliorate this by a few percent" (Holenstein R.). In such a way, responding to the new sustainability need, the design of tall buildings may improve the social development and the urban planing, also in Europe that is more cautious about changes or innovations.

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Taking nD modelling to the next level: Methodological issues associated with the development of a Regeneration Simulator Workbench

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Abstract:
The multi-disciplinary SURegen project is aiming to develop a digital decision support aid that will capture good practice in sustainable urban regeneration (SUR) and support regeneration training and education for practitioners. It will achieve this through the modelling of the regeneration process, the identification of key decision points and the simulation of various decision outcomes. This paper will outline the research methodology that is planned for the project as a whole and for the technical development of the digital support aid, the Regeneration Simulator Workbench or RSW, and provide justification for these approaches within the context of antecedent research projects. Based upon the experiences of these previous projects, the paper will also present some of the difficulties that can be anticipated when conducting multi-disciplinary research.

Keywords:
Decision-support tools, nD modelling, regeneration, research methodology, systems development methodologies

1. Introduction

The SURegen project, funded by the UK's Engineering and Physical Sciences Research Council's Sustainable Urban Environments 2 program to a total of £2.3 million, is a four year project that aims to address the regeneration skills gap by developing a regeneration simulation tool to enable better understanding of the regeneration process and support decision making. The project will be informed by the experiences of two recent projects in particular, the EPSRC funded *From 3D to nD Modelling* project and *Intelcities* an European Framework 6 Integrated Project. This paper will outline the contributions that nD modelling has made in influencing the conceptual approach and its implications for SURegen on the technical development, supported by some of the experiences of developing integrated systems for decision making, simulation and information provision and show how the concept of nD modelling will be developed by the project and applied at the neighbourhood scale.

1.1. Regeneration processes and challenges

The change in policy for urban regeneration in the UK since the early 1950s (Ball & Maginn, 2005) was driven in part by the realisation that mass slum clearance and property redevelopment failed to eradicate poverty and had in fact led to a loss of communities (Young & Willmott, 1957) and in many instances just moved the problem elsewhere. By the late 1970s it had become accepted that social problems needed to be tackled in the places where they existed and that housing was one issues of many. This approach is evidenced by the Government's Neighbourhood Renewal Strategy which aims to address deep seated problems by taking a longer term and more sustainable approach to quality of life issues by delivering economic prosperity, better health, safe and secure places and high quality schools (ODPM, 2003). As such, more holistic views about urban regeneration are now taken, with Roberts and Sykes (2000) describing it as a "comprehensive vision and action which leads to the resolution of urban problems and which seeks to bring about a lasting improvement in the economic, physical, social and environmental conditions of an area that is subject to change". However, there is little consensus about how to achieve lasting and sustainable regeneration or the meaning of sustainable urban development (Palmer et al, 1997): In fact, there is greater agreement that urban regions characterised by high levels of deprivation, crime, derelict buildings and disorder are clearly unsustainable (Wates, 2005; Ekins & Cooper, 1993).

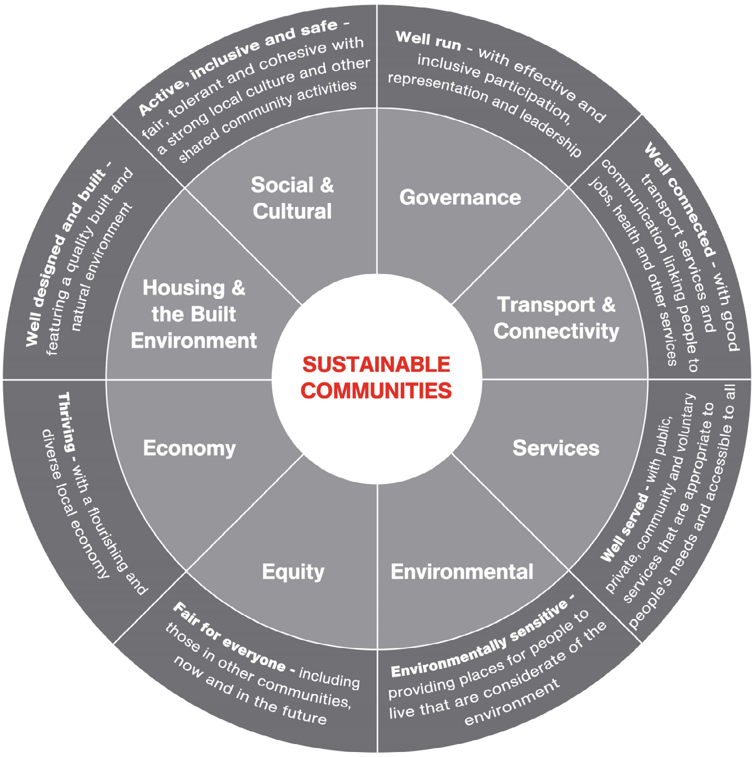

Fig. 1. RENEW NW's 'Egan Wheel' for sustainable communities (RENEW NW, 2005)

The complexity, uncertainty and ambiguity about how to deliver all these aspects in an integrated way is a huge challenge, especially in light of the skills and understanding gaps that have been identified but that such a task requires (Deakin et al, 2007; Curwell et al, 2005; Egan, 2004; Bentivegna et al, 2002). Due in part to insufficient evidence indicating whether regeneration interventions contribute to or detract from sustainability, decisions are often made without understanding of their full implications. The Egan Review (2004) confirmed the existence of a skills gap among urban regeneration professionals and the need for effective teams and interactions between the key organisations and individuals involved in the processes and across the public, private, voluntary, community and academic sectors for SUR to be successful. RENEW Northwest (2005) developed the eight point Egan wheel for sustainable communities, as shown in figure 1, and identified that the three skills gaps that need tackling are the discipline based technical skills needed to deliver SUR, the collaborative skills required to deliver integrated multi-disciplinary working between disciplines working on SUR, and the engagement and visioning skills needed to identify and achieve the goals common to professionals, elected members and the general public. The Egan Review itself concluded that to achieve measurable improvements in the communities that they serve, individual professions and disciplines could be left to deliver their own domain skills but that there was an urgent need for people with higher level generic, cross-cutting skills. The RSW is seen as a tool that, by fostering a holistic approach to consideration of all the dimensions involved in urban regeneration and their implications upon decisions, could help support the development of these skills and knowledge

1.2. SURegen project aims and objectives

The overall aim of SURegen is to explore the concept and reality of a digital tool that is able to meet the decision-making challenges that regeneration poses, to practitioner stakeholders in the first instance. The Regeneration Simulator Workbench (RSW) will hold good practice knowledge about sustainable urban regeneration (SUR) allowing it to function as a library of good practice that could be used for education and training purposes and a learning laboratory to support professionals and other stakeholders to understand not only the regeneration process and its key decision points, but also to explore some of the impacts of these decisions through the running of 'what-if' scenarios. As a multi-perspective tool providing a shared workspace, the RSW will enable regeneration team members to collaborate more effectively due to access to the following:

- Simulations of the regeneration process. In the early diagnosis and visioning phases this will allow professionals to gain experience of decision-making before they enter a live regeneration environment and allow them to transfer good practice to help fill the skills gap;
- Identification of the main regeneration process decision points. This will allow better understanding of regeneration dynamics, potential decision outcomes available at each point and some of the management and planning implications ahead of full cost implementation;
- Team building and stakeholder engagement support (including businesses and citizens) to diagnose the regeneration need, continuously develop and update the local vision and develop scenarios and indicator requirements;
- Advice about the most suitable available assessment tool for evaluating alternatives at key regeneration process decision points against the vision, scenarios and indicators appropriate to delivering the most mutually satisfactory SUR outcome.

By providing this knowledge it is anticipated that the RSW will help to close the skills gap identified by the Egan report (2004) as above in section 1.1. This will be achieved by construction of the RSW and its ontology around the core set of regeneration competencies included in RENEW Northwest's eight point development of the 'Egan Wheel' for sustainable communities.

2. Technology

Buxton (1994) describes a model as an abstract representation of a portion of a system that consists of the concepts, objects, relationships, capabilities and reactions that are important to the perspective addressed by the model, and models are used to explain the operation and underlying concepts of systems that are too complex to be otherwise understood. Visualisation and simulation technologies have been used for a number of years to present urban design plans, but current simulation models are limited in their ability to accurately predict future social, economic and environmental outcomes due to the complexity, uncertainties and ambiguities surrounding urban decision-making and the lack of applications based upon an integrated urban data model or ontology. Applying the 'MoSCow Rules' (Avison & Fitzgerald, 2006; Bell & Wood-Harper, 1998) to user requirements by prioritising them 'must haves', 'should haves', 'could haves' and 'won't haves' is one method that can help to overcome the different and potentially conflicting viewpoints of the multiple stakeholders involved in planning and help implement all their requirements in one development lifecycle. The SURegen project aims to overcome these issues by both prioritising user requirements according to the MoSCow Rules in the modelling and matching methodology and use an urban data ontology in the development of the RSW.

2.1. n-Dimensional modelling

The EPSRC funded *From 3D to nD Modelling* project outlined and developed the concept of multi-dimensional modelling based on the building scale, and demonstrated that it was technically possible to integrate the numerous data sets relating to these dimensions to model what-if scenarios even with data that was not 'spatial' or geometric in nature. An nD model is defined as the development of the conventional 3D geometric model of length, width and depth to include any and an infinite or *n* number of dimensions that might be of relevance to the design, construction, maintenance of the building, i.e. its whole lifecycle, such as crime, lighting, thermal dynamics, safety, whole life costing and accessibility to name a few. The aim was to enable seamless communication, simulation and visualisation to demonstrate fitness for purpose for economic, environmental, building performance and human usability in an integrated manner. The nD tool prototype builds on the Building Information Model (BIM) concept and is IFC based and the prototype model integrated lifecycle costing, acoustics, environmental impact, crime and accessibility data and showed how different design priorities could be tuned up or down depending on the viewpoint or individual needs of a given stakeholder. This allows context specificity to be applied to the model: for example, different design features would be 'turned up' in a model applied to a high crime area which would have different knock-on implications to the design as a whole, e.g. location of windows, opening direction of doors, use of toughened glass and CCTV and the additional cost of these etc.

The nD prototype has been developed into an nD game which has been used with school children who used it to design their ideal school (http://www.ndgame.org/) as children are schools' end users. This has demonstrated not only the validity of visualisation and simulation technologies for educational purposes but the importance of a gaming approach to help with comprehension of complex relationships between people or design entities and the ability of the model to elicit and make explicit the tacit knowledge that stakeholders may possess. A related aspect of this is the ability of such nD models to facilitate the development of holistic thinking among stakeholders involved in complex industries like construction which has a long supply chain and is characterised by mono-disciplinary thinking and working and a lack of trust, and processes such as regeneration about which there is little consensus about the decision making processes and the impacts of these. Aouad et al (2007) argue the nD concept will require a shift in mind set to enable nD modelling from traditional modelling and education is a powerful enabler in helping professionals and stakeholders become equipped with the right skills.

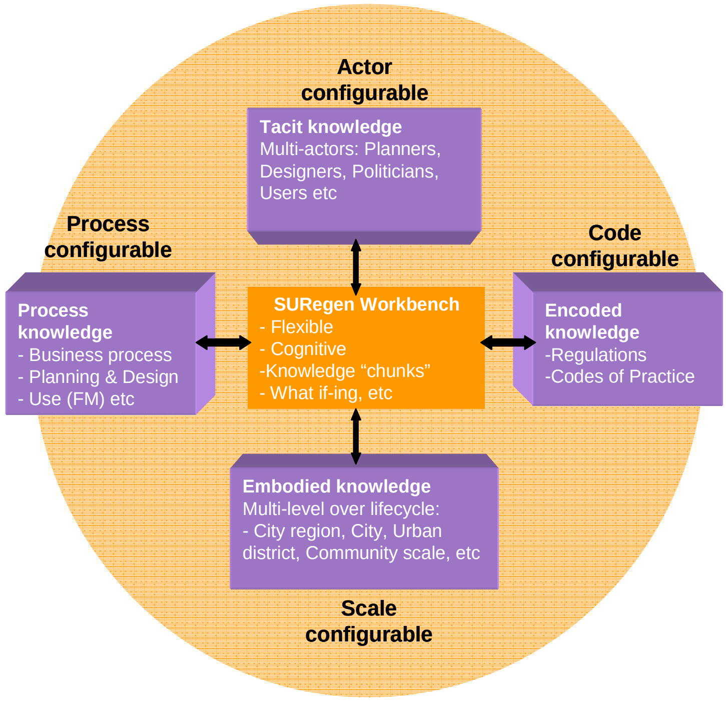

Fig. 2. Regeneration simulator concept (developed from the nD modelling research framework, Aouad et al 2007; Lee et al, 2005)

It is these very benefits that the SURegen RSW wants to realise through the adoption of the holistic nD approach and applying it at the neighbourhood renewal scale at the early stages of the regeneration programme, i.e. the point at which numerous visions are explored and key decisions are taken. Figure 2 shows the nD modelling research framework, updated from Lee et al (2005) to show the four types of knowledge that the RSW should consider and include namely knowledge that is embodied, tacit or 'embrained', process, and encoded and the ability of the user to configure the data based on their individual needs i.e. according to scale or design feature. Whilst it is not anticipated that a regeneration 'super model' able to simulate all SUR aspects simultaneously could be built during the four years of the project, the model will be able to provide more concrete information about physical, economic and social outcomes of decision making as a result of the dimensions it is able to collect data on and the ontological model underpinning it.

3. Methodology

The RSW is aimed at regeneration professionals and knowledgeable non-experts and, whilst it will focus upon housing at the neighbourhood scale, its algorithms will enable reference to higher and lower scales and dimensions such as health, education and transport in order than impacts can be understood on the immediate area and those surrounding it. In order to populate, develop and validate the RSW with its anticipated stakeholder user group, the project will need to meet the following project sub-objectives:

- Capture knowledge of SUR processes and practice from recent research projects, good practice examples identified by industrial and public sector bodies, and the experience of regeneration from case studies in Greater Manchester;

- Transform this into actionable SUR knowledge objects or knowledge ‘chunks’ which can be learned and assimilated by professionals either through the process of their development or after the event as an ‘education’ event mid career
- Map the SUR neighbourhood renew process and use this to inform an ontology to drive the data modelling
- Select appropriate simulation and assessment tools which can be used to predict the outcomes and impacts of regeneration
- Develop the system architecture to embed selected tools into the RSW’s data structure
- Construct the RSW using evolutionary prototyping to demonstrate is use in the planning and development stages of SUR and validate this with end users in the two case study areas

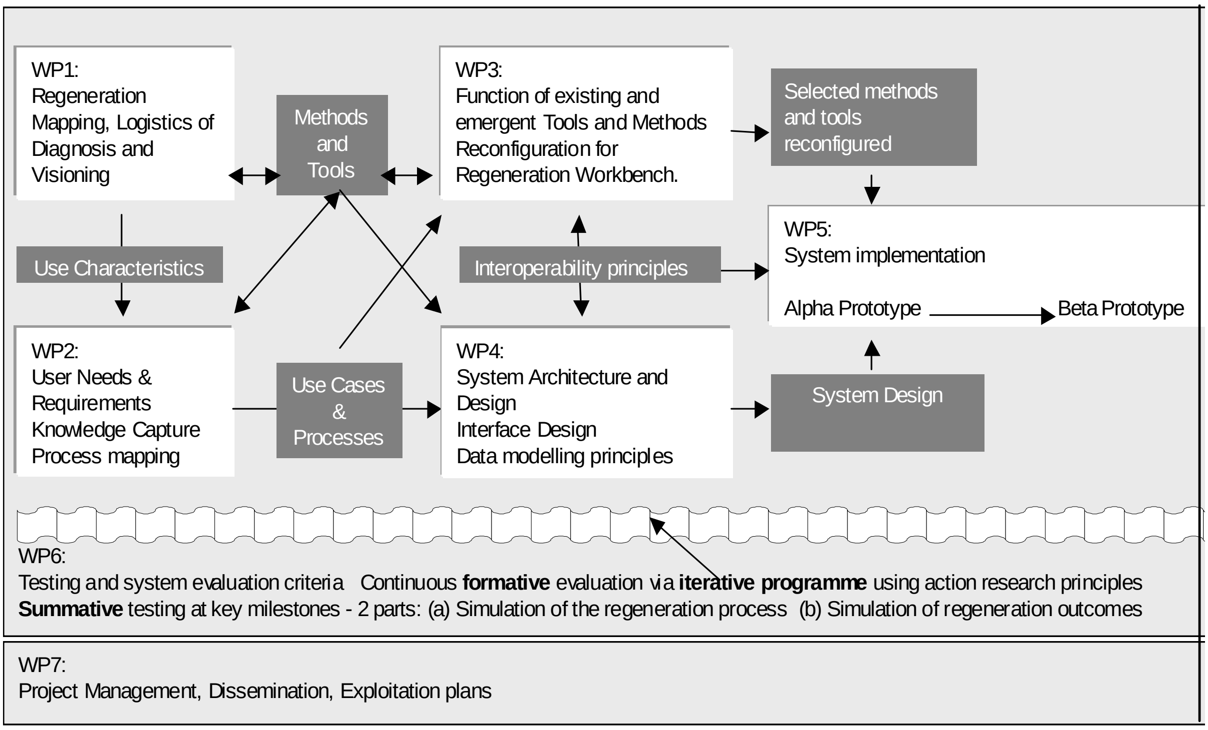

Fig. 3. SURegen project structure and knowledge flows

The four year project is divided into seven work packages as shown in figure 3. The first two years will focus upon the capture and structuring of knowledge, mainly by WPs 1 and 2, in order to map the regeneration process based upon current state of the art and theoretical underpinnings as well as the collection of user needs and requirements from the case study areas. This data will be detailed enough to allow visioning, scenario exercises and storylines to be developed and used and the data to be validated in terms of the potential functionality of a digital decision support tool to deliver socially inclusive SUR and the functional specifications to be developed into use cases suitable for the development of technical requirements. Years 2 and 3 will see WP3 identifying the issues, indicators and tools that can be employed at the key decision points in the regeneration process, as identified by WPs 1 and 2, and this will help to facilitate the identification of the applications and models required to design the RSW workspaces and interfaces, work to be carried out by WP4. The tacit knowledge that is collected and the use case storylines developed by WP2 will be used by WP4 for the system design and the development of the data structures and ontology which will drive the implementation of the RSW (to be carried out by WP5). WP6 will see the setting up and running of action learning sets comprised of regeneration practitioners who will provide knowledge of regeneration as it takes place on the ground in their case study area. This work package will also develop the RSW by validating the user requirements against the regeneration process, for their inclusion in prototypes of the RSW, and for their actual ability to support decision-making in the case study area. It is important to stress the iterative nature of the RSW development which will take place as a result of both knowledge collected by project partners from sources external to the project, through their relationships with one another, and from feedback collected via WP6 of experiences using the RSW on 'live' regeneration projects.

3.1. Technical development – RAD and modelling & matching

Whilst SURegen has not explicitly stated that the RSW development will take place using a Rapid Application Development (RAD) approach, the iterative nature of the RSW's development and the complexity and uncertainties of the data it will be using mean that there are opportunities of conceptualising it in this way. RAD is a systems engineering development lifecycle that allows faster technical development at a lower cost and with higher quality results than the traditional development lifecycle and it consists of just four stages: requirements planning phase, user design phase, construction phase and cutover phase, the change from the old to the new system. Martin (1991) argues that the ability to create and modify applications more quickly is one of the most urgent concerns for enterprises as this allows them to react more quickly to maximise competitive opportunities in the market that developing such applications enables. Additionally, the pervasiveness of computer networks and immediate availability and access to information and desk-top decision-making tools shortens decision-making times and the use of 'quick and dirty' prototypes allowing technical development to be constantly validated with users during development rather than being checked at the end of the development which traditionally could take 2-3 years. This means that incremental changes can be made to the prototypes as either requirements change or are shown to be inaccurate for some reason or as additional functionality is required. This incremental way of working also allows new components to be developed as data becomes available and for concepts/assumptions to be tested if the tool is to embody information or knowledge that may be contentious, complex or poorly understood. The RAD lifecycle does not favour one particular technique over another, but rather it advocates the use of whichever technique or techniques are most suitable to the given problem e.g. process and data modelling, CASE tools, reverse engineering etc., although it does favour methodologies that are adaptable to changing circumstances, make sense to developers, allow developers to be creative and provide guidelines for success and warn of pitfalls (Martin, ibid).

In line with this iterative development of the technical simulator itself, the methodology by which the user requirements will be collected and 'translated' into a technical specification will also be iterative in nature. A methodology for the development of complex e-planning systems called modelling and matching (Chen, 2007) will be applied which fits the characteristics of e-planning systems in the following ways: use of an incremental and complex development process, involvement of multiple stakeholders and the interoperability of applications. Chen proposes a four process framework which is underpinned by both technically objectivist or 'hard' viewpoints, and interpretivist or 'soft' viewpoints and is iterative in nature. These four processes are the modelling process during which the social context and user needs and available technologies are explored, the matching process by which the prioritised system functionality is matched to the available technologies, the iteration process and the evaluation process.

4. Conclusions

This paper has provided a description of the SURegen project and the iterative way in which it will collect user needs and data to develop and validate a decision support tool, the Regeneration Simulator Workbench, to help address the regeneration skills gap identified by the Egan Review (2004). It has shown how an RAD approach to technical development can be useful when developing tools aiming to support processes that have uncertain and complex outcomes and it has shown how a similar approach to prototyping for modelling and scenario in the nD modelling project helped to overcome a number of difficulties associated with a complex concept.

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Technology Transfer and Development in Nigeria: The Role of Non Governmental Organizations (NGOs)

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Abstract:

Ongoing improvements and the adoption of new technologies are acknowledged as major determinants of economic growth. The ability to innovate and adopt new technologies plays a vital role in the progress of any nation. This is particularly true in developing nation where sustainable development requires technological capabilities and technological innovation to better exploit existing technology and promote the adoption of new technology. To be effective in this regard requires the collaboration of all relevant institutions such as Non governmental organizations. Community based activities permeate into the activities of Non Governmental Organizations (NGO). The objective of this paper is to examine the application of technology transfer through NGO community based activities. Data used is mostly qualitative from academic journals, conference papers, government reports, development magazines and NGO websites because it suit well in understanding the dynamics of NGO activities. The study is important because of relative neglect of the specific research questions by previous researchers.

Keywords: Non Governmental Organization, technology transfer, Nigeria, capacity building, development**.**

1. Introduction

The development discourse has evolved over the years. The discourse has shifted focus over the years from that of aid orientation (Mitlin et al., 2007) to that of support of building both human and institutional capacity among many other development paradigms (Wubneh, 2003). As the development discourse evolved, so did its definition, players and institutions. The previous definition of development prior to when ideas such as modernization and human development was devised centered on economics view, which was mainly on economic development (GDP) (Bhattacharyya, 2004, Lewis, 2001). In recent years, the definition has come to mean much more than economic development as development encompasses factors such as the quality of life and embodies aspects such as economic, social, or human development (Stiglitz, 1998, Bhattacharyya, 2004). Different elements have been added to the definition of development such as community development. Community has come to be viewed as an important factor in the development paradigm. According to (Stiglitz, 1998), Much of life centres around communities, and communities are often the most effective vehicle for bringing about the transformation of society.

According to Stiglitz, 1998, Development not only transforms a society, enriches the lives of individuals by widening their horizons and reducing their sense of isolation. It reduces the afflictions brought on by disease and poverty; it not only increasing life spans, but improves the vitality of life. This definition carries much weight than just calculating the GDP of a nation. It puts into focus that there must be a transformation from old ways to something better.

Lewis (2001:17) defines development as deliberate attempts at progress through intervention. It can also refer to the efforts of people to improve their quality of life through their own efforts. Bhattacharyya, 2004 argues that ultimate goal of development should be human autonomy were the people exert the capacity of people to order their world, the capacity to create, reproduce, change, and live according to their own meaning systems, to have the powers to define themselves as opposed to being defined by others.

At the same time that the development discourse was at its peak, there was also "important players/ actors" in this discourse namely the Non governmental organization (NGO) (Korten, 1987, Mitlin et al., 2007). Among other institutions of development such as the government, financial institution, educational institution, NGOs are involved in what Lewis (2001: 18) termed "people centered development". People centered development is attained by NGOs playing a role in empowering civil society by linking local initiative back into national and structural change (Craig, 2007).

NGOs are recognized as being vital to the successful realization of development policies and projects (Edwards and Hulme, 1996, Mitlin, 1998), NGOs have comparative advantage to their government counterparts (Atack, 1999, Fisher, 1997), NGOs were seen as an alternative to development (Mitlin et al., 2007), better service provider (ref) provide services at better value for money (ref), closer to the people the work with (ref). These has also been contested and called to question over the years. Research by many development and NGO scholars counter old orthodox belief that NGOs are the answer to alternative development (Funk, 2006, Mitlin et al., 2007, Tvedt, 2006, Zaidi, 1999) NGOs have been reputed to having the same problems of bureaucracy that the state are accused of and they are criticised that they do not reach the poor people as they have been claimed to (Edwards and Hulme, 1996)

This paper examines NGOs efforts in development through technology transfer. It does this through firstly looking at the concept of Non-governmental organization and technology transfer as this forms the underpinning foundation in understanding their involvement through community based activities. In so doing the concept is linked to development discourse through issues arising from such involvement, which are capacity building, community development, sustainability and technology transfer.

For the purpose of this paper, NGOs acronym will stand for Non governmental organization and it is construed to mean independent, non profit, developmental, voluntary organization operating at the local levels that are neither government nor business that are engaged in development and poverty reduction work at local, national and global levels around the world. This definition encompasses definition from Lewis (2001) and other NGO scholars such as M. Edwards, & Fowler, A., 2002; M. Edwards & Hulme, 1992; F. W. Fisher, 1997. NGOs are heterogeneous and cannot be generalised (Edwards and Hulme, 1992, Lewis, 2001). They differ in activities and purpose but they all have certain features in common such as "Value" (Lewis, 2001).

The definition of technology as adopted in this research is the means of applying understanding of the natural world to the solution of practical problems and technology transfer as referred in this research is the "intervention" by Non governmental organisation with the aim of accelerating the flow of technologies to local communities. The underpinning point of this definition is flow of know-how from nongovernmental organisation to local communities.

This paper will limit the scope of the study by exploring NGO activities in poor communities in Nigeria. As NGOs activities are numerous, and they are involved with many projects and programs, this paper is concerned only with the unmet housing needs of the people in poor communities in Nigeria. Therefore, the paper will only focus on community based projects that deal with the construction of houses, schools and hospital; in other word the built environment.

Housing need is chosen because Housing is a critical factor in determining the general quality of life for people (Majale, 2004). People with unmet housing needs tend to be socio-economically disadvantaged, experience higher death rates, poor health, and are more likely to have serious chronic illnesses.(Garner, 2006). Inadequate Housing is a major problem facing Nigeria and housing conditions is continuing to worsen due to urban population(Ogu and Ogbuozobe, 2001). In 1970, Nigeria's urban population was estimated as 16.3% of the total population. This rose to about 20.2% in 1980 (Awotona, 1990). The country's cities are said to be fast growing at double or triple the rate of national population increase. Lagos has grown from 1.14 million in the early 1960s to 6 million, and is alleged to have the worst living conditions of all African cities (Nwaka, 1992). The unmet housing needs and services have resulted in the spread of slums and squatter settlements, the outbreak of serious epidemics caused by overcrowding and poor sanitation (Nwaka, 1992). Ogu & Ogbuozobe (2001) specifies the huge housing challenge that Nigeria faces. They purported that the country's first National Rolling Plan 1990-92, estimates housing deficit to increase to between 4.8 million and 5.9 million by the year 2000. According to the authors, it has been documented by the national housing policy that an estimate of 700,000 housing units need to be built in the country each year in order to meet the housing gap by the year 2000 (Ogu and Ogbuozobe, 2001).

It is also pertinent to state that the paper does not suggest or imply that NGOs are the answer to development; rather it examines the role NGOs play in technology transfer through their community-based activities. It is also important to emphasize that other institutions that do contribute to development exists such as the state government, Universities and research institutions, financial institutions and other developmental institutions. For instance, the development of the advanced nations has been through development of both human and institutional capacity (Cooke and Leydesdorff, 2006). With the above background and the given purpose of this paper set out, this paper gives the objective of this research and then the conceptual basis of linking NGOs with technology transfer.

1.1. Research objective

The objective of this paper is to identify the roles, responsibilities and scope of work of non governmental organization and its stakeholders.

1.2. Proposed methodology

This paper is an initial part of a PhD thesis which proposes to adopt the interpretive epistemology. The researcher's decision to adopt the interpretive epistemology is because it is the better alternative epistemology suitable to address the research questions and to achieve the objective of the research. The justification for adopting this assumption is because of the nature of the study which deals with variables that are complex and difficult to measure rather than the positivist mode which deals with variables that can be identified and measured.

This research proposes to constitute of exploratory case study approach, involving five (5) detailed case studies; utilizing data consisting of the activities of NGOs involved in construction in poor communities in Nigeria and the communities that benefit from these activities. The use of case studies methods is utilised to gain understanding to this phenomenon. Hesse-Biber and Leavy (2004) stated that vivid experience often supplied by case studies is an important mechanism for the transfer of knowledge from one setting to another. Data collection is mostly qualitative from academic journals, conference papers, government reports, development magazines and NGO websites because it suit well in understanding the dynamics of NGO activities also the use of semi-structured interview is utilised to enable the researcher gain insight into this study.

1.3. Research problem

Literature on the channels of international technology transfer and their importance for the growth of any economy abound (Hoekman et al., 2005, Narula, 1997, Lee, 2006, Masten and Hartmann, 2000). However, apart from principle channels of transfer such as direct transfer of technology via international licensing agreements, foreign direct investments (FDI), and international trade, little is known about the impact and magnitude of the movement of people as a source of technology transfer. As acknowledged by some technology transfer literature, the best form of transfer is the movement of people. This statement is concurred by Bell and Pavitt (1993) who also acknowledges the contributions of technology transfer by the movement of people (Martin and Pavitt, 1993). This nature is a key characteristic of NGOs because of the large array of community based activities that they carry out and in that community based activities, experts, researchers, funders, international and bi-lateral organisations all interact, share and exchange knowledge. NGOs carry their tacit knowledge, embodied knowledge and experiences to places they seek to make a change in. Hence this research contributes to knowledge by filling the gaps in literature by bringing together technology transfer literature and NGO literature.

1.4. Justification for the research

In this paper, the author deals with a subject that, despite its importance, is rarely raised in technology transfer literature, which is NGO as a channel of technology transfer. While there have been general discussions and writings on Non governmental organisations, the role they play in technology transfer in developing countries has little writings about it. There are little writings on how NGOs contribute to technology transfer through their interaction and community based projects in communities they work with. This paper attempts to address this gap in the literature. The justifications for this research are as follows:

- Large statistical data showing research problems in terms of real issues in the region (number of poor especially in Africa increasing, lack of capacity still a major issue).

- Current debates and discussions from international agencies, non governmental organizations, and government publications (importance to move policy away from only aid provision to transferring knowhow for a sustainable development). This contemporary debate focuses on the need to integrate developing countries especially the African countries more into international trade through technology transfer.

- Relative neglect of the research questions by previous researchers

2. Literature review

The literature review sets a milieu to the NGO phenomenon and examines NGOs literature in order to comprehend and have a general insight of NGOs phenomenon. This section will review literature on NGO roles, responsibilities and scope and then links it to technology transfer.

The literature focuses on Non governmental organizations, technology transfer, and community based projects and capacity building. Community based activities permeate into NGO activities thus this is seen as NGOs promote local participation by working closely with the community groups as partners, emphasizing self help initiatives and local control of programs (Bebbington, 1997, Bebbington and Thiele, 1993, Edwards, 1999, Edwards, 2002, Fisher, 1997, Fowler, 1992, Craig, 2007, Lewis, 2001). By doing this, they are inadvertently promoting capacity development. Capacity development as defined by Godfrey et al (2002) article is the process by which individuals, organizations, institutions and societies develop abilities (individually and collectively) to perform functions, solve problems and set and achieve objectives.'' Community development promotes social inclusion and democratic participation. It is rooted in the concept of empowerment (Powell and Geoghegan, 2006). Community development can be defined as a broad based change for the benefit of all community members (Kelly and Caputo, 2006)

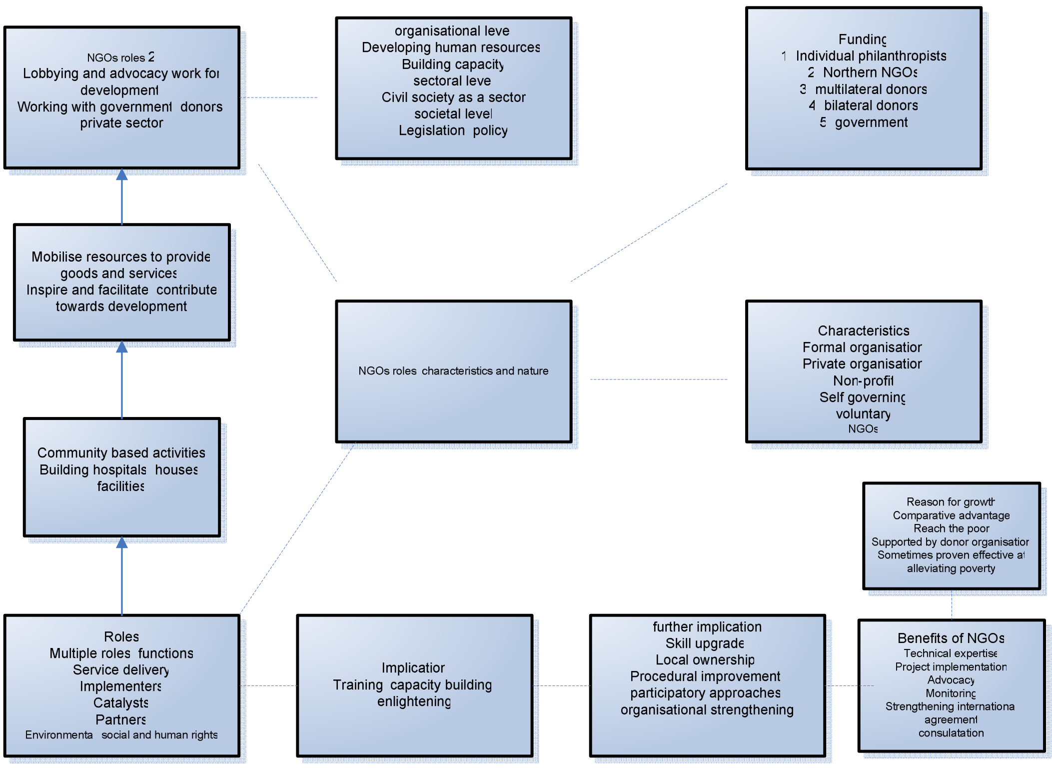

Figure 1: Characteristics and features of NGOs

The above diagram captures some of NGOs characteristics, its roles and scope.
NGOs have had their fair share of criticisms. Authors such as Tvedt (2006) have made this known in his recent work. NGOs do have their short comings. One of the arguments used to oppose the importance of NGOs to development is that NGOs are often understaffed and short of trained field workers. There are also arguments that NGOs do have negative impact on the economy of

developing countries and the same disadvantages given by NGOs about government also applies to them. However, The growth in the numbers and scope of NGOs around the world has been widely published by NGO researchers (Lewis, 2001, Tvedt, 2006, Edwards and Hulme, 1992, Fisher, 1997). In replicating the words of authors such as Fisher (1997) and Domeisen (2006), they attribute the evidence of the growth of NGOs to include the increased numbers of officially registered associations, the number of NGOs represented at international conferences, the increased amount of development funding channelled through NGOs, the attention paid to collaboration with NGOs by the World Bank and other international agencies, the highly published successes of lobbying efforts of NGO coalitions.

NGOs have been purported to have comparative advantage over government, donor agencies and private firms (Bratton, 1989, Marcussen, 1996, Edwards and Hulme, 1992). NGO activities include the delivery of new or improved services to communities which are in need, raise awareness to issues neglected by those in authority, provide emergency assistance, engage in enlightenment programmes, and different community development projects and programmes among others.

2.1. NGO roles

There are two main roles NGO plays: the service role and educational role.

The delivery of services plays an important role to NGO budgets and their basis for support from a wide range of donors. Such services include technical advice, resources for relief, development and other purposes. Educational and advocacy NGOs seek primarily to influence citizens educate populations and mobilise public opinion about the requirement for fundamental change in the global order. This may be liked to the logic of forming new policies, better decisions to help reinforce various norms promoted by intergovernmental organisations through public education campaigns. After having highlighted some of the roles, responsibilities of NGOs, the next section will examine the role of NGOs in technology transfer.

2.2. Technology transfer

The importance of understanding the application of technology transfer through Non governmental organization is paramount to the successful implementation of development projects or policies around the world and especially in developing countries. Technology has been defined in different ways by different authors from different fields. The economists' definition defers from the sociologist as well as anthropologists. Technology transfer has been defined as ''the movement of know-how, technical knowledge, or technology from one organizational setting to another (Bozeman, 2000).

After having established the basis for NGO involvement in technology transfer, it is pertinent to mention some Non-Government Organizations (NGOs) involved in the housing sector, particularly; habitat for humanity, Concern, Oxfam, Norwegian Save the Children Fund, BRAC, Orangi pilot project.

2.3 NGOs transferring technology through community based projects.

Developing countries and especially in Africa, they can impart technical and managerial skills from which local communities can benefit from. This can be seen as in the case of South America and Asia (Bebbington, 1993, Farrington and Biggs, 1990). Part of NGOs programmes in Nigeria include capacity building and sustainable development and in the area of social services where it is needed most is in housing (Awotona, 1987). The oil boom period in Nigeria brought about rapid urbanisation as well as the increase of "slums" and informal human settlements on cities(Awotona, 1990). Capacity building goes beyond individual organisations and institutions to broader systems, groups of organisations and networks (Shrum, 2000). It goes on to encourage community development which according to Kelly and Caputo (2006) emphasises as broad-based change for the benefit of all community members. The key factor in these activities is the participatory strategies utilized by NGOs in poverty alleviation as participation is the key to sustainability (KLEEMEIER, 2000). Contribution to technology transfer through community based activities could be on the individual level, organisational level and sector/network level.

3. Conclusion

This paper explored some literature on the roles, responsibilities and scope of Non governmental organisation. It confirms that NGOs' are involved in a diverse range of development activities but that a number of the projects have not really solved the issue of development (Edwards, 2000:9). The paper takes example of NGOs' activities in Nigeria to access the magnitude of technology transfer changes that could be brought by their presence. One of the more significant findings to emerge from this study is the recognition that community capacity building sets a stage for community development and that could translate to technology transfer. The paper concludes that a number of problems need to be addressed before such activities can be satisfactorily intertwined into development programmes. An implication of this is the possibility that there is a need to further investigate the nature of technology transfer by NGOs to other sectors in the country. This paper will serve as a base for future studies and further work needs to be done to establish how NGOs transfer technology in developing countries.

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The Role of the Usage of Information Technology in Turkish Contractor Firms

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Abstract:
A study has been carried out in order to determine the current extent of IT usage, main purposes, benefits, obstacles and impacts of IT in the Turkish contractor firms by making a field survey. The field survey has been conducted in which a number of large construction firms in Turkey. Their main purposes on the use of IT, benefits by using IT and obstacles to a greater use of IT are evaluated. With the help of the field survey, impacts of IT implementations and levels of them are demonstrated. It is found that IT implementations have only technical and economic effects. Although firms which compete in construction industry need to use IT strategically in order to gain competitiveness; there is not much evidence that the firms are affected strategically by using IT.

Keywords:
Information technology, field survey, Turkish contractor firms.

1. Introduction

Technology has been continuously improving, causes high business pressures that affect organizations' current and future competitiveness. These pressures cause common and rapid changes on all industries. Construction industry is also affected by these changes but shows a different improvement from other industries in terms of its nature of activities and unpredictable conditions. By means of these rapid changes, it is obvious that construction projects have gradually been more complicated and extensive, and it has been much more difficult to achieve the required aim in terms of time, cost and quality. Thus, information technology (IT) becomes an issue to cope with the change; by means of adding, developing and competing with the modern business environment. Moreover, successful IT implementations becomes into an important term for construction firms, against necessity of adaptation to the continuously changing business environment. Firms which compete in construction industry need to use IT strategically in order to keep their competitive advantage. By using IT strategically, IT can turn into a valuable tool for creating enhanced competitiveness and gaining strategic advantage for the firms.

This paper presents the results of the field survey which has conducted in a postgraduate dissertation named "Strategic Use of Information Technology on Gaining Competitive Advantage in Turkish Contractor Firms". The aim of the field survey is to highlight the importance of using IT strategically in order to gain competitive advantage for Turkish contractor firms. This paper only focus on the availability and usage of computers, purposes of using IT, benefits, obstacles and impacts of IT implementations among Turkish contractor firms. The whole field survey findings are going to be demonstrated in the dissertation as a result of it.

1.1. The Use of Information Technology in the Construction Industry

Many researchers have stated the importance of information and use of IT in the construction industry. For instance, Rivard et al. (2004) stated that "information is such an essential component of construction activities, the evolution of IT will undoubtedly have a profound impact on how organizations in the architecture-engineering-construction (AEC) industry operate". Moreover, Issa et al. (2003) emphasized that "to survive and succeed in today's business world, companies of any size, public or private, from any industry, from leaders to start-ups, feel the need and the pressure to develop strategies to catch up with IT". Before explaining the use of IT in the construction industry, it is better to define the characteristics of it; because construction industry differs from other industries in many ways.

In contrast with other industries, construction is a project-oriented industry that produces unique products. Each project based on a long process from initiation of the project, design of the project, procurement, construction, and operation of the facility to disposal of it. Secondly, the risk factor is much higher in construction than it is in other industries; because the nature of the work itself is unpredictable. In comparison with other industries, more resources are involved in performing construction activities, more interrelationships exist between construction activities and more factors relating to environment and technology may affect the work flows in construction. Moreover, each project is almost unique and there are a large number of project participants with different specialties and multiple interrelated work flows in the construction industry. This makes it complex and fragmented. In this long and fragmented process, various usage of information technology can be seen in the construction industry.

First of all is the use of computers and software like Computer Aided Design (CAD), 3D Modeling, Computer Aided Facility Management, project planning and programming software, scheduling, costing and budgeting programs. The second place it can be seen is in communications such as access of internet, web portals, shared databases and distribution of documents in digital format. By using these, time, paper and cost savings are gained and project progress speed is increased. Moreover, as construction industry is heavily information-based, IT offers great potential to improve management practices, communication and overall productivity in the industry.

IT can have different impacts which are often difficult to identify. Different applications can have different impacts on the firms. Because of the difficulties in analyzing the impacts of IT, it is necessary to define various effects of IT on the firms. There are three types of effects such as technical effects, economic effects and strategic effects. All IT investments involve both economic and technical effects. Although IT has negative economic effects such as expenditures on IT; new revenues added to the firm and cost reductions generated by the technology are the positive economic effects that occur in the firms. The technical effects refer to changes in the time required for an employee, the department or the firm to perform its task. Moreover, quality improvements, added value and less resource consumption can be said as other technical effects. Even if an IT implementation generates positive technical effects, this does not imply that the implementation is successful. The technical effects must be transformed into strategic effects in order to make an IT implementation successful. Successful implementation depends on the business strategy of the firm. One issue that arises is whether competitive advantages from IT are sustainable. If IT is going to create enhanced competitiveness and strategic advantage for the firm, then it has to create unique benefits to the firm that does not occur in any other firm. Porter (1985) claims that even if technology does not yield competitive advantage to any one firm, it may affect the profit potential in the industry.

IT can be implemented to enable internal and external improvements in the firm. Internal improvements refer to changes in the firm's value chain that improve the performance and competitiveness (Porter, 1985). Such changes can occur in projects, project process and organization. IT implementations that support the business strategy generate effects that are coherent with one of the generic strategies, cost leadership and differentiation. External improvements refer to changes that improve the firm's position in its environment in terms of customers, suppliers, new entrants and substitutes. Furthermore, external improvements can have impact on the performance and competitiveness of the firm.

1.2. Background

Several studies have been made to demonstrate the use and to determine the impact of IT in the construction industries of different countries such as in New Zealand (Doherty, 1997); Scandinavia (Howard et al., 1998); Canada (Rivard, 2000; Rivard et al., 2004); Australia (Thomas et al. 2001); South Africa (Arif and Karam, 2001); Northern Europe (Samuelson, 2002); United States (Issa et al., 2003); Austria (Mahdavi et al., 2004). It is necessary to mention how IT usage and its impact were determined in these studies.

A survey was made in order to see the extent of computer use in the New Zealand building and construction industry (Doherty, 1997). The survey aimed to measure computer usage and to assess the direction of the industry in terms of the use of computers. Another survey was made as an IT-barometer to ascertain IT usage in the construction industry in Scandinavia (Howard et al., 1998). The survey results from Denmark, Finland and Sweden were compared regarding the use of computer hardware, software and communications. The survey in Canada was developed from the IT-barometer and conducted in order to see the current and planned use of IT and its impact on architecture, engineering and construction (AEC) industry (Rivard, 2000). Results of the survey were presented including topics such as computer availability, computer usage, computer-aided drafting, networks and communications. The study in Australia aimed to examine the current usage of IT by Australian subcontractors, and to identify the potential problems for subcontractors in IT implementation (Thomas et al. 2001). Moreover, a survey was conducted to identify the extent of IT application in the building construction in South Africa (Arif and Karam, 2001). Another survey was repeated as an IT-barometer in 2000 to determine the use of IT in the Nordic construction industry (Samuelson, 2002). The purpose of the study was to create a method and perform a survey for measuring the use of IT in the construction industry. These surveys were carried out in Sweden in and in Denmark and Finland in 2001. Knowledge about access to computers, software and equipment, use of computers and software, communications, effects and strategies were gathered from the surveys. Advantages and disadvantages of IT were put forward by comparing the survey results from 1998 and 2000. Then, the results from the comparison between the countries were presented. A similar study was made in the US construction industry about e-business implementation (Issa et al., 2003). The study focused on determining the level of adoption of e-business within project management systems by general contractors. In the scope of the survey, e-business, e-procurement, e-marketplace and their practices in the US construction industry were researched. A series of case studies was made on the use of IT in the Canadian construction industry (Rivard et al., 2004). Architects, engineers, general contractors and owners were included in the scope of the study. Eleven construction projects were selected so as to define the practices and benefits of IT. Several types of technologies such as 3D, CAD, custom web sites, commercial web portals and in-house software development were found to be used in the projects. Furthermore, an inquiry was made into building product information acquisition and processing by architects and building owners in Austria (Mahdavi et al., 2004). As architects and building owners are the major participants of construction process, their habits about using IT in building product information acquisition were investigated.

There are also several studies in Turkey in order to determine the importance of IT in the construction industry by presenting different kinds of information systems. One of them is a study that aims to design a conceptual framework and develop a computerized model for recording, organizing and delivering information efficiently in order to provide effective management functions. The outcome of this study is a computer-based information system called ASAP – Automation System for Architectural Practices – that was developed to respond to the stated problem of large architectural offices (Kanoglu and Arditi, 2001). This system was developed in order to help to manage the information flow among the participants who face serious management-related problems in the design process because of a lack of an efficient information system. Another similar information system model, MITOS – Multi-phase Integrated Automation System – was designed for design/build firms (Kanoglu, 2003). An experience-based computational model was used for the estimation of the duration of construction projects, and the performance results were discussed. MITOS was developed in response to the need expressed by a large, well-established Turkish design/build firm that undertakes projects in cooperation with international partners. It is a performance-based duration estimation model integrated with an automation system model and a comprehensive model that attempts to solve the integration problem in design/build organizations.

The importance of IT in the construction industry is also emphasized by conducting several studies on the building product field. For the purposes of gathering the information on different kinds of building materials, and designing a database which will be used during the design process, a research project supported by Istanbul Technical University Faculty of Architecture and the Istanbul Technical University Research Fund was carried out. The paper was based on the findings of the research project called “Designing a Building Material Relational Database Management System for Turkish Construction Sector” (Tas et al., 2002). A survey, about the current and planned use of IT and its impacts, is conducted between demand side -architects- and supply side - building product manufacturers- in Turkey. The applied methods and frequency of usage in building product information acquisition, their characteristics, importance and point of view in building product information systems were determined (Tas and Irlayici, 2007). Moreover, the database designed aims to join the supply side and the demand side in the same environment that works on the domain of building material information in the Turkish construction industry (Tas et al., 2008). To achieve this goal the information supplied by the supply side and the requirements of the demand side were evaluated from different point of views. Different data were gathered from the both side in accordance with the type of source, level of information and frequency of updating. The data gathered were integrated into the pre-construction stage and used in the analysis of the building material evaluation and selection process as to how this information was used by the demand side.

2. Purpose and Methodology

The purpose of this paper is to emphasize the importance of the IT usage in construction firms by describing the current use of IT by evaluating main purposes, benefits, obstacles and impacts of IT in Turkish construction industry. In order to achieve this purpose a field survey is conducted in Turkish contractor firms. This paper presents the most significant results from the field survey and focuses on the availability and usage of computers, purposes of using IT, benefits by using IT and obstacles to using IT and finally the impacts of IT implementations among Turkish contractor firms.

The target of the field survey is contractor firms which are members of the Turkish Contractors Association. The Turkish Contractors Association (TCA) is an independent, non-profit professional organization based in the capital of Turkey, Ankara. The association was founded in 1952 and represents 142 leading contractor firms in Turkey. The business volume of its members encompasses nearly 70% of all domestic and 90% of all international contracting work done by Turkish contractor firms so far.

A questionnaire has been set up in order to collect data from participants of the field survey. Firstly, an attempt was made to contact the firms via telephone and electronic mail. From the 142 registered firms, 99 of them were contacted. The response rate was 35 or 35% out of the 99 contacted construction firms. However, the number of firms that are evaluated is 32. 3 of them are not included because; their responses were not find clear enough. 20 questionnaires were filled face-to-face and one-on-one with participants. The electronic mail included an explanation of the study objectives, instructions and the questionnaire itself were sent to the other participants who did not agree to a personal interview.

3. Field Survey Findings

The questionnaire is divided into three parts:

- The first part concerns the presentation of the firm. It aims to get *general profile of the firms* in terms of the number of employees, operating period and operating field.
- The second part of the questionnaire involves questions about the *usage of IT* among the firms. Their IT usage purposes, benefits by IT usage and obstacles to use of IT are evaluated.
- The last part of the questionnaire consist of questions in order to get information about the *impacts of IT* implementations and at what level the business is affected by them.

3.1. General Profile of the Firms

The firms represented in the field survey have a work force that varied from 11 employees to over 500 employees. Fig. 1 shows the size distribution of the firms according to the number of employees. It is seen that the largest group has 101 to 500 employees with 34%.

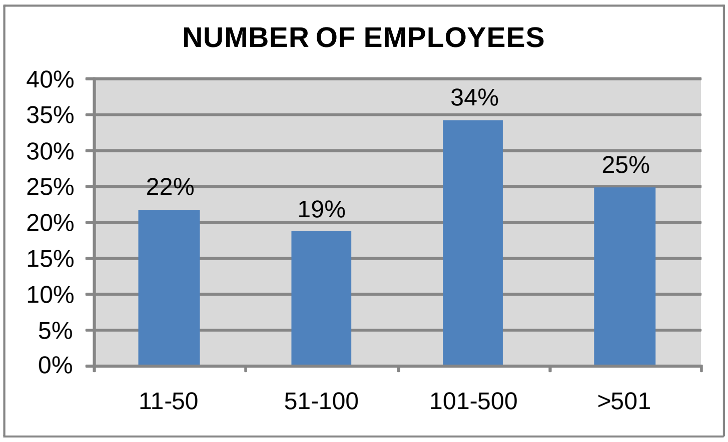

Fig. 1. Size distribution of all the firms surveyed in terms of number of employees

Firms show rather extensive dispersion about the period that they have been in operation in the industry. The oldest responding firm that is still in operation was established in 1938, and in contrast, the youngest operating one was established in 2004. Fig. 2 shows the highest percentage of firms 28% occurring at the 22-31 years category. From another perspective, the average age of the firms is calculated to be 31 years, which means that the average firm in the area was established before computers became such dominant tools in the local construction industry.

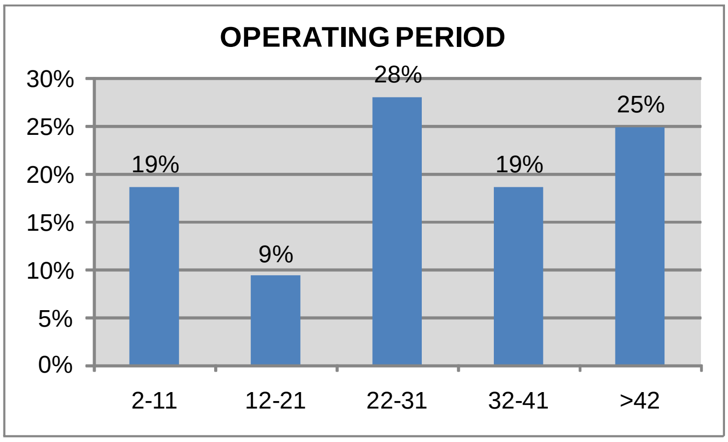

Fig. 2. Operating period of the firms surveyed

As the firms analyzed in terms of fields which they are operating in, it is seen that they are working not only in domestic, but also in international contracting works. 66% of the firms are operating in both domestic and international field (Fig. 3).

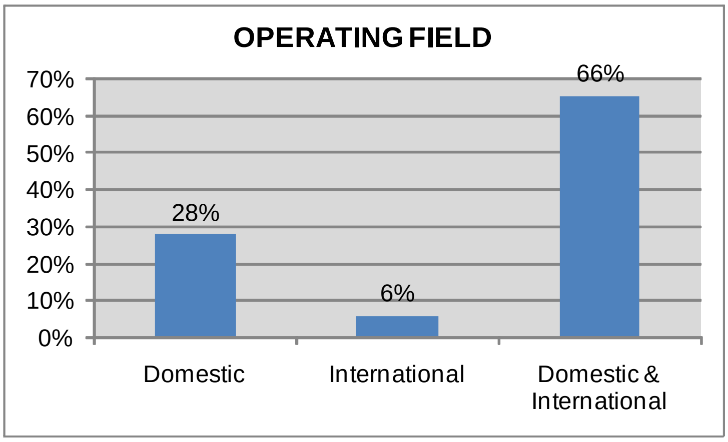

Fig. 3. Operating fields of the firms

3.2. Usage of Information Technology

In this part of the field survey areas and main purposes of IT usage, benefits by using IT and obstacles to using IT are asked to the firms. All respondents take advantages of using computers. Fig. 4 shows the type of computer platforms being used, and it indicates that both stand-alone personal computers (PCs) and networked PCs are used by the contractors. 94% of surveyed firms use networked PCs which provide an easy way to co-ordinate and exchange documents. On the other hand, 6% of them are still not networked and using stand alone PCs.

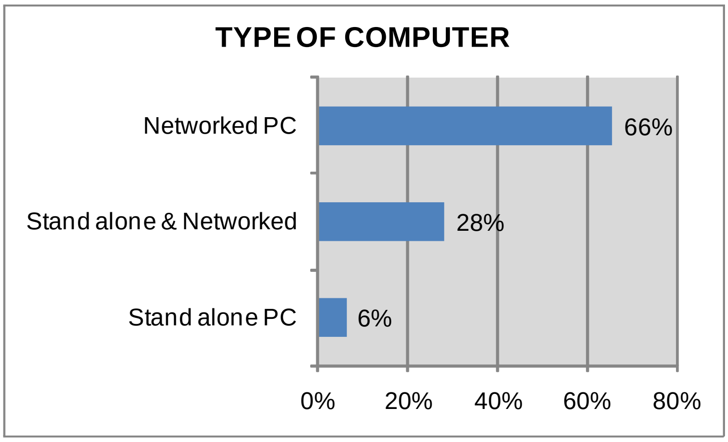

Fig. 4. Percentage type of computers among the firms surveyed

The use of computers varies but when it analyzed in the field survey, software that consists of general purpose applications are the dominant ones. The software being used by the contractors is shown in Fig. 5. All contractors with computer systems used word processing and spread sheet packages. Computer aided drafting (CAD) is also widely used by the contractors (i.e., 75%). 50% of respondents use project planning & programming software. On the other hand, the estimating packages and database systems are not as prevalent as other ones.

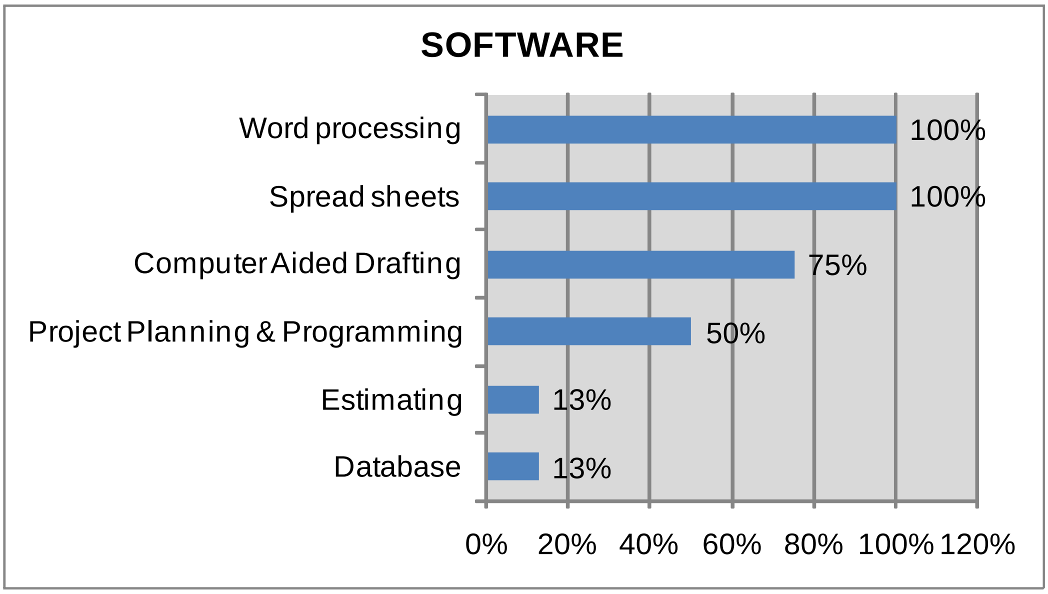

Fig. 5. Percentage use of software among the firms surveyed

Firms have different purposes on the use of IT and these purposes are shown in Fig. 6. Almost all respondents determined that they are using IT on the purpose of quick access of correct and up-to-date information. Continuous and permanent communication and providing to do activities correctly and in time are other major purposes of IT usage. Providing competitive advantage has a small percentage in purposes of IT usage with 44%. Furthermore, other purposes are keeping all records in an electronic medium and offering optimum solutions to the difficulties that have been confronted with.

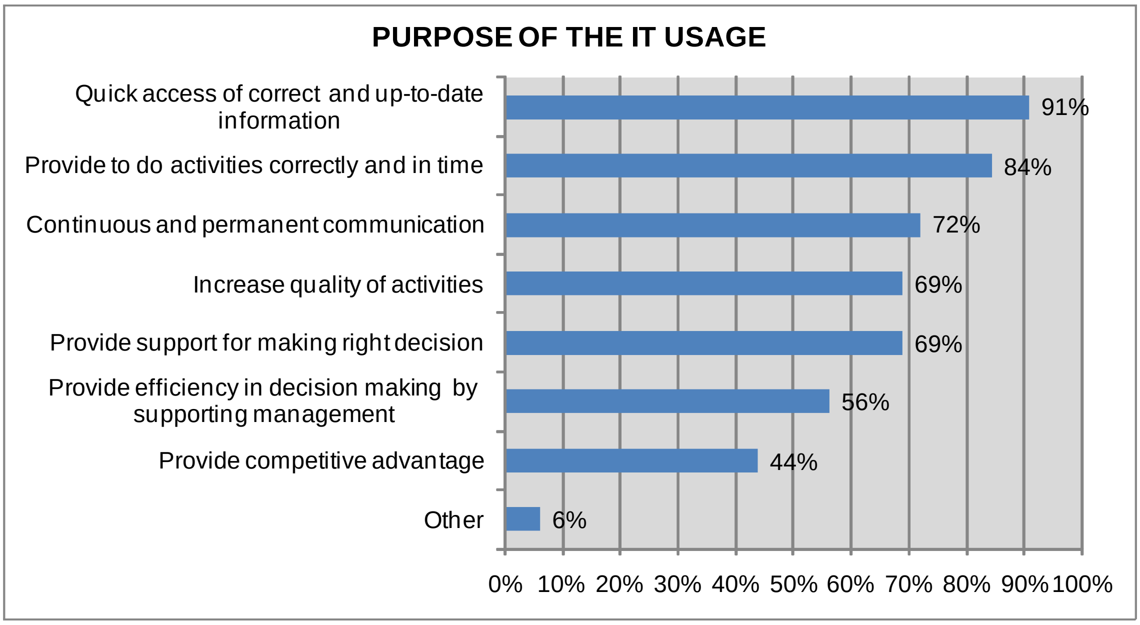

Fig. 6. Purposes of information technology usage among the surveyed firms

IT provides various benefits for the firms. Firms surveyed are asked to determine the main important benefits achieved by the adoption of IT. Their responses are evaluated together with their grades of importance on a scale from 1 to 5 and are shown in Fig. 7. The main benefits provided by a greater use of IT are quick access of correct and up-to-date information, data storage, share of information, providing better planning, controlling and management according to the respondents. Possibilty of reducing the staff and less use of paper are not considered as important benefits by most respondents.

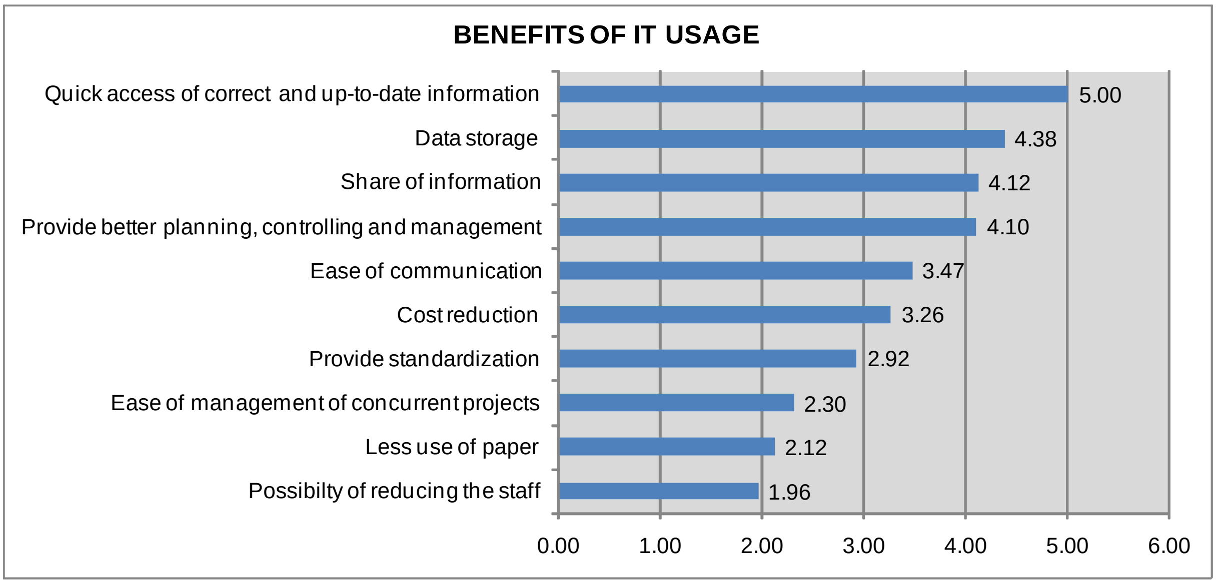

Fig. 7. Benefits of information technology usage

Although firms gain lots of benefits by taking advantantages of using IT, there are some obstacles to greater use of IT. The main effective obstacles of IT usage are evaluated together with their frequency on a scale from 1 to 5 as in Fig. 8. The two main obstacles are the continual demand for upgrading hardware and software, high cost of investments. The lack of standards and providing continuous training to employees are not considered an important obstacle to the use of IT.

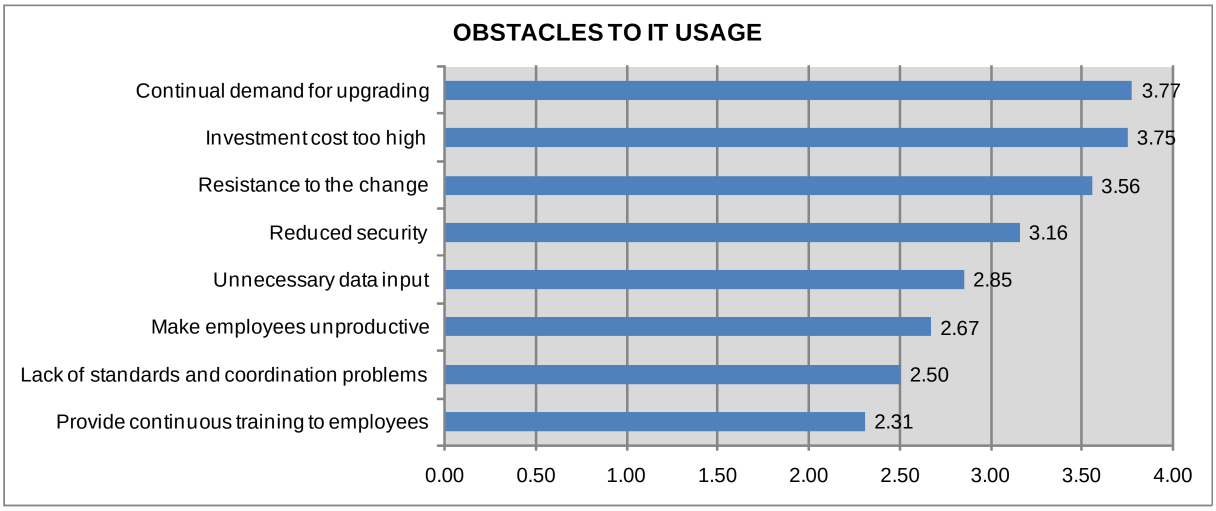

Fig. 8. Obstacles of information technology usage

3.3. Impacts of Information Technology

After determining the purposes, benefits and obstacles of the IT usage; there is a need of demonstrating the impacts of IT implementations on the firms surveyded. In order to defining these impacts, respondents are asked at what level IT implementations have impacts on the business. According to the responses IT implementations has a great impact on data collection, operational support for repetitive works and developing databases (Fig. 9). On the other hand, IT has a least impact on formulating strategies such as cost leadership, differentiation and focus; although they are really imporant so as to help gaining competitiveness for the firms.

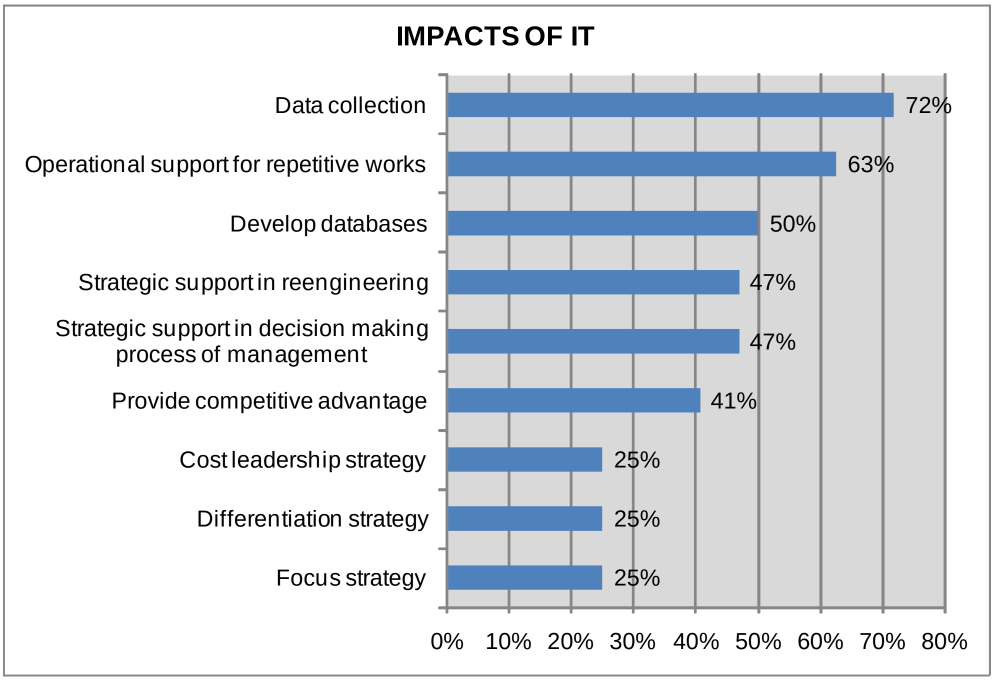

Fig. 9. Impacts of information technology implementations

4. Results

As a result of the field survey, which aims to determine the current use of IT by evaluating main purposes, benefits, obstacles and impacts of IT; it can be said that Turkish contractor firms evaluated in the field survey are the dominant and most experienced ones that operating in the construction industry regarding their number of employees and their operating periods. Furthermore, as they are operating not only in domestic but also internationally, it can also be said that they are holding the largest market share in the Turkish construction industry.

With the help of the field survey, the case for IT usage in Turkish construction firms has been put forward. All respondents take advantages of using stand-alone and networked computers that consists of general purpose applications such as word processing and spread sheet software. Moreover, the common purposes of using IT among the firms surveyed are quick access of correct and up-to-date information, providing to do activities correctly and in time, continuous and permanent communication. Firms benefit by using IT in accordance with their purposes of IT usage. Regarding these purposes, benefits by providing IT usage are quick access of correct and up-to-date information, data storage, share of information and providing better planning, controlling and management. Furthermore; continual demand for upgrading, high cost of investment and resistance to the change are the main obstacles to greater use of IT.

The impacts of IT implementations on the firms surveyed show that, IT has a great impact on technical aspects such as data collection, operational support for repetitive works and database developent. On the other hand, IT has the least impact on strategies such as cost leadership, differentiation and focus. However as being a fragemented industry, construction firms have to adapt one of these strategies in order to improve their competitive position.

5. Conclusion

In a continuously improving business environment, technological advances highly affect construction firms' current and future competitiveness. Thus, IT usage becomes an issue to cope with the change; by means of adding, developing and competing with the modern business environment.

Turkish construction firms take advantages of using IT only on technical aspects; but not on strategic ones. However, using and benefit from IT only technically are not enough to survive in the construction industry and gain competitiveness. Even if IT usage generates technical effects, it does not show that the firm can successfully compete in the industry. The technical effects must be transformed into strategic effects in order to increased performance compared to competitors. If technical effects can be transformed to strategic ones, IT will create enhanced competitiveness and strategic advantage for the firm. Using IT strategically can create unique benefits and contribute to Turkish construction firms in order to gain competitiveness in the industry.

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Theme 8:
Real Estate and Facilites Management

A Fuzzy Logic Approach to Property Searching in a Property Database

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Abstract:
Finding a place to live is an important event for everyone. There are many options the buyer has to go through. There are many estate agencies with huge amounts of properties for sale or rent. To find the right one becomes complicated, time consuming and is often frustrating. Common methods for searching based on price are not enough. They produce results that may fit a user's criteria, but tell nothing about the suitability of a particular result. The aim of this paper is to show an application of fuzzy logic theory to searching for properties. The comparison between commonly used methods using filtering by criteria and the fuzzy method will be discussed. The fuzzy approach will be presented in which the search portal could mark every available result with a score based on all of the requirements the user has and then sort the results according to that score.

Keywords:
Fuzzy logic, Searching, Property, Information systems

1. Introduction

Having shelter is the oldest need of people since prehistory. People build houses to protect themselves against weather dispositions like rain, wind, cold etc. But having a place that could be called 'home' is a psychological thing too. Everyone needs to return to somewhere where they feel comfortable and safe. It may appear that to get a home is easy, but it is not. In fact getting the right home is very difficult and it requires many things to be done before successful residence can be achieved.

Seeking a new property starts with specifying requirements for that property. There are many attributes of a property that could be specified. It includes a price, area, number of bedrooms etc. Every person has different needs and resources. The second step in obtaining the new property is to search for it. There are many possibilities of how to do the search. The first alternative is to go to a real estate agency and specify the requirements and ideas. They will then try to find suitable properties for the client. Then the client will view the particulars of the properties and could visit them and if the property is satisfactory they could start to negotiate about the price and attributes of a contract. The second alternative for the client is to search for the property by himself. There are many internet portals which offer a large number of properties from all around the country. The client enters criteria and portals gives results that fulfil them, but there are two processes that the client must go through. Firstly the results currently can only be sorted by one of the property attributes (price; area; number of bedrooms; etc.) and not by suitability for the client; and secondly is that the search engine does not weight the preference of some attributes above others. This approach is efficient and effective for those clients who know exactly what they need and no variations are possible. Those clients are able to find suitable properties quickly and then evaluate them one by one to find the right one. For others, which is the majority, this approach means a huge amount of time is spent going through results and evaluating them manually. The search cannot be narrowed without the loss of possible good matches, because all of the listed results meet the defined search criteria and if it is narrowed by including another criterion it will cut out those that don't meet this final criterion. However, not all of the criteria are 'hard' requirements. Some are mandatory, but others may be desirable, and other may be aspirational. They do not all carry the same relative importance to the client.

A way to solve this problem of relative importance is to create a search engine, which is able to search a database of properties and sort results by suitability for the individual client. The aim of this paper is to show that this could be met by using fuzzy logic algorithms in searching. The client can assign a weight (relative preference of one criterion to all others) to every criterion, which means assigning it a priority (e.g. "Three bedrooms are the most desirable, but two will be acceptable too."). This approach is able to mark every property according to an individual client's criteria and as a result the output is a list of properties sorted and ranked by overall suitability to an individual client's specific preferences. This will impose the effectiveness and efficiency of the search process for all clients.

Selection problem

The stated problem can be simplified as a selection problem from finite amount of alternatives. The decision maker wants to choose the best options from all possibilities based on the criteria. There is a finite number of attributes every option has. By evaluating of the attributes the decision maker gets suitability of how the particular option satisfies desired criteria. By evaluating every option and then comparing it to one another the best option may appear. But the comparison can be done in many ways resulting in different results. This type of problems is called multi attribute decision making.

In the property market the decision maker want to select the best property based on the expectations and requirements. The significant attributes of properties are (based on the unpublished property portals review done by authors):

- Type of offer (to sell, to rent);
- Type of property (house, flat, etc.);
- Style of property (detached, semi-detached, etc.);
- Price;
- Area (London, Prague, Munich, etc.);
- New or resale;
- Number of rooms (all types or bedrooms only);
- Area (165 sq m);
- Periphery (garden, garage, etc.).

A number of decision aids supporting selection problems can be found in the literature. The most used techniques in the field of multi attribute decision making are as follows:

- *Multi Attribute Utility Theory* (MAUT), (Hwang and Yoon 1981; Yoon and Hwang 1995; Olson 1996);
- *Simple Multi Attribute Ranking Technique* (SMART), (Olson 1996);
- *The MAUT with uncertain inputs* (ARIADNE), (Olson 1996);
- *Outranking techniques* (ELECTRE and PROMETHEE), (Olson 1996; Fülöp 2005);
- *Preference cones*, (Olson 1996);
- *Ordinal preference techniques* (ZAPROS), (Olson 1996; Larichev 2001; Dimitriadi and Larichev 2005);
- *Geometric Mean Techniques* (REMBRANDT), (Olson 1996; Van Den Honert 1998);
- *Analytic Hierarchy Process based Techniques* (HIPRE 3+), (Olson 1996; Wesseling and Gábor 2005);
- *Visual Interactive Method* (VIMDA), (Olson 1996; Korhonen, Moskowitz et al. 2005);
- *Aspiration Level Interactive Techniques*, (Lotfi, Stewart et al. 1992; Olson 1996).

Each of the groups of methods is intended for a different use. There is no single ‘best’ method for the majority of selection problems. The performance of a particular method depends on the circumstances under which it is applied. Fuzzy logic was selected for this particular purpose because it can handle selection problems without needing of specifying large amount of variables precisely. Ease of use was one of the criteria for the approach selection in order to achieve success in real application.

2. The Need for a Good Search Tool

There are a lot of properties on the market today. It means many options for a potential buyer. However finding the right one is difficult and requires a good method for searching. To be possible to search through all properties there is the necessity to look deeper at the property details and analyze possibilities of how they can be searched more effectively.

Every property has defined attributes. The potential buyer has requirements for a property specified as a list of attributes, so there is a match between input units and the units used for searching. But specifying just the attributes is not enough. The buyer has a list of attributes the property should have, but there are many properties that will suit these requirements. Something is still needed to narrow the search. The current approach is to sort the results by one of the attributes of a property. This is not narrowing of results, because there is still the same number, but it gives that particular attribute priority. The buyer may prefer a low price against the number of bedrooms etc. But this is still not a good approach. This gives priority to one attribute only. The others are still counted as the same lower priority. Moreover it doesn’t tell anything about the global suitability of the first listed property in the sorted list of results.

What it is needed is to weight every attribute the buyer cares about and based on them mark the results with a score and then sort them by this score. This approach accommodates every requirement the buyer has and is able to produce much more suitable results. Schema of this approach is shown in Figure 1.

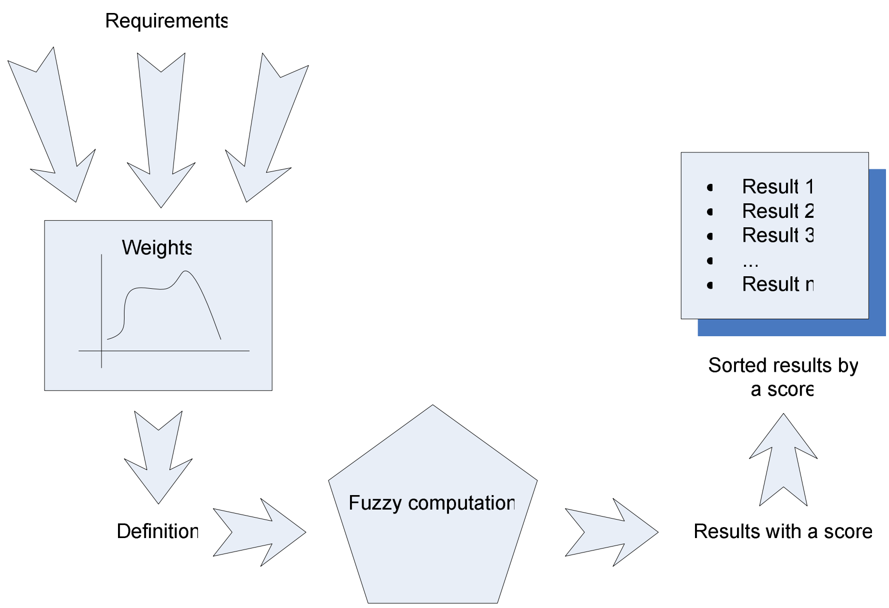

Fig. 1. Projected Approach.

3. Disadvantages of the Currently Used Approach

The contemporary approach to searching is based on hard criteria selection and then ranking by one of those criteria. This gives results that suit the hard criteria the user sets, but tells nothing about the suitability of each particular property in the list. The user must still go through the results one by one and do manual evaluation. Every good search engine has the feature of sorting the results by criteria, but they are only able to sort the results by one criterion. It means the user can only give preference to one criterion, instead of specifying a weight for every one of them. But real life is more difficult than this. The user has a whole set of preferences and another set of criteria, which doesn't matter (e.g. "I want three bedrooms no matter what, but there needn't be a garage and garden."). Those requirements cannot be taken into account in contemporary properties search engines.

Figure 2 shows that the most used approach enables the client to find the right property, but it is a matter of large amount of time and energy spent on evaluations and decisions.

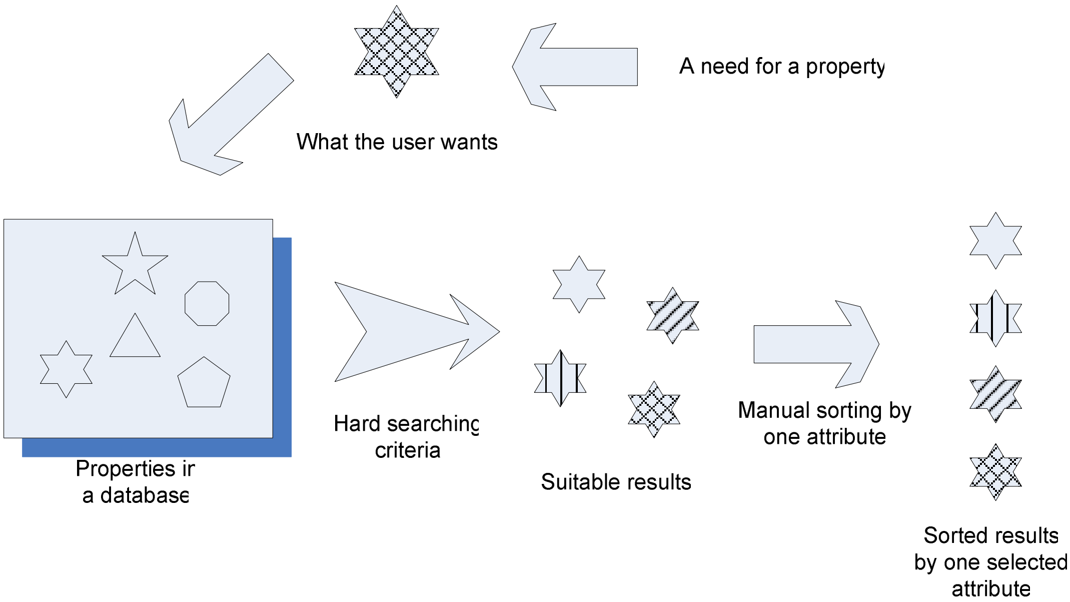

Fig. 2. Contemporary Approach to Property Searching.

4. Fuzzy Logic Could Help

Decision making is characterized by selection or choice from amongst the alternatives which are available. In the process of selection, specified goals have to be reached and specified constraints have to be kept. It can be found that the decision problems in reality are very complex and 'fuzzy'. The goals, even the constraints, may be specified in vague and ambiguous ways. The use of a traditional exact mathematical approach is not possible in most cases, or causes the problem to degrade to a simpler task, which then does not reflect the reality of when the results should be applied. Fuzzy logic can help in this matter.

Consider a decision making model consisting of a goal described by a fuzzy set *G* with membership function $\mu_G(x)$ and a constraint described by a fuzzy set *C* with membership function $\mu_C(x)$ where x is an element of the crisp set of alternatives A_{alt}.

By definition (Bellman, Zadeh et al. 1970) the decision is a fuzzy set *D* with membership function $\mu_D(x)$, expressed as the area shown under the intersection of *G* and *C*:

$$D = G \cap C = \{x, \mu_D(x) \mid x \in [d_1, d_2], \quad \mu_D(x) \in [0, h \leq 1]\}$$

It is a multiple decision resulting in the selection of the crisp set $[d_1, d_2]$ from the set of alternatives A_{alt}.

$\mu_D(x)$ indicates the degree to which any $x \in [d_1, d_2]$ belongs to the decision *D*. The function of the constraints and goals and its intersection is illustrated in Fig. 3.

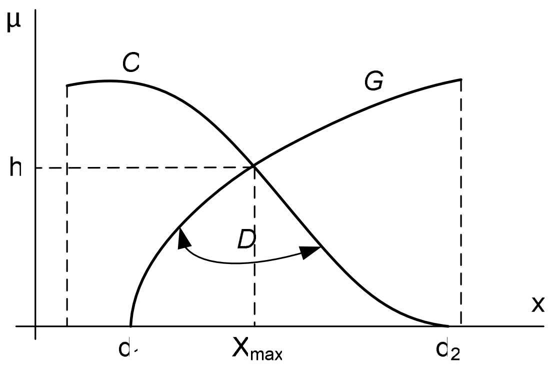

Fig. 3. Intersection of Fuzzy Constraint and Goal (Bojadziev and Bojadziev 1997)

The operation of the intersection of A and B denoted as $A \cap B$ is defined by:

$$\mu_{A \cap B}(x) = \min(\mu_A(x), \mu_B(x)), \quad x \in U$$

Using the membership function and operation intersection it gives:

$$\mu_D(x) = \min(\mu_G(x), \mu_C(x)), \quad x \in A_{Alt}$$

The operation intersection is commutative, thus the goal and constraint can be formally interchanged. Sometimes it is an advantage to consider the goal as a constraint and vice versa. Because the decision maker chooses from the crisp set of alternatives it is necessary to conduct defuzzyfication of *D*. It is natural to adopt for that purpose the value of x from the selected set $[d_1, d_2]$ with the highest degree of membership in the set *D*. It is expressed by:

$$X_{\max} = \{x \mid \max \mu_D(x) = \max \min(\mu_D(x), \mu_C(x))\}$$

x_{max} represents the final selected alternative from the crisp set of alternatives $A_{alt.}$

The process of decision making is shown in Fig. 4.

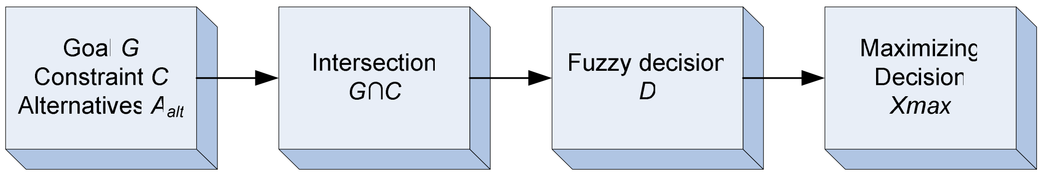

Fig. 4. Block Diagram of Fuzzy Decision Making (Bojadziev and Bojadziev 1997)

Bellman and Zadeh (1970) generalized the formulas for general use with *n* goals and *m* constraints. The decision then is:

$$D = G_1 \cap \cdots \cap G_n \cap C_1 \cap \cdots \cap C_m$$

The membership function of D is:

$$\mu_D(x) = \min(\mu_{G1}(x), \cdots, \mu_{Gm}(x), \mu_{C1}(x), \cdots, \mu_{Cm}(x))$$

And x_{max} is:

$$X_{\max} = \{x \mid \mu_D(x) \text{ } is \text{ } \max\}$$

5. Advantages of the Fuzzy Logic Approach

The proposed fuzzy logic approach when applied to real environment is able to sort the properties in a way that the user should see the most suitable property at the first position and not as a "one of many" hidden somewhere between others. In this case the probability that the client misses an ideal property is very low (it depends on how accurately the user specifies his conditions and preferences). Fig. presents this approach.

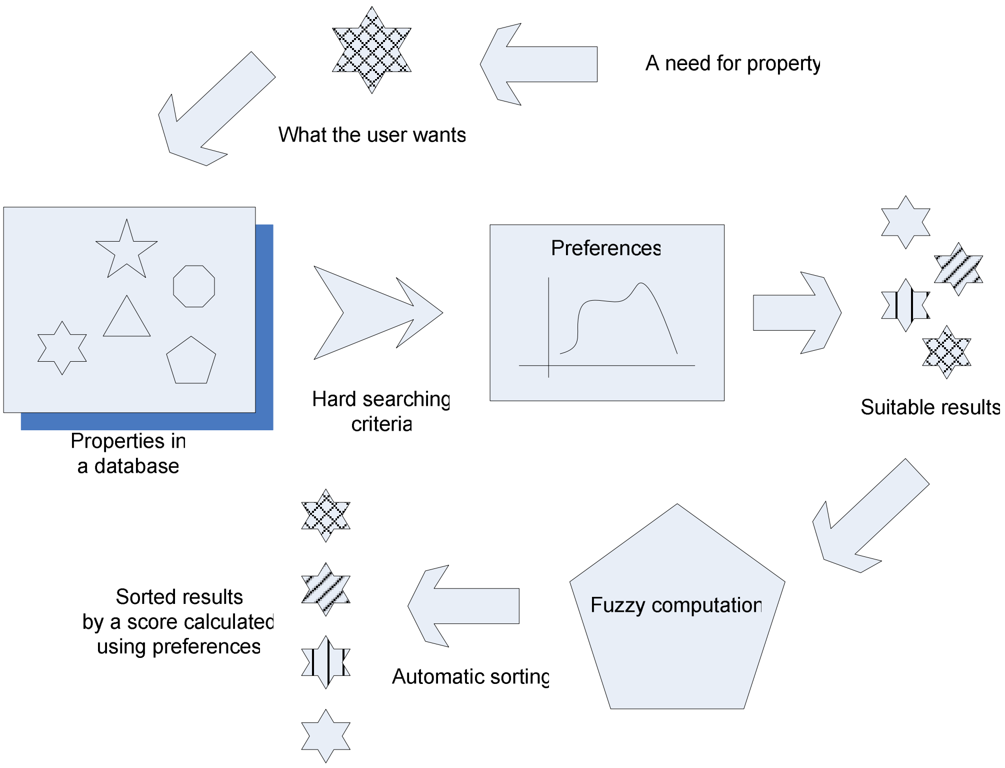

Fig. 5. Fuzzy Approach to Property Searching.

6. Conclusions

To find the right property is essential. The majority of people can afford only one property at any point their lifetime, which points out the significance of having a good search tool for that task. Moreover, no one wants to spend a lifetime on evaluating the properties manually, regardless of the inconsistency, non-completeness and non-objectivity of this process being done manually. The contemporary approach to searching through property database is not enough. To find good results the client has to spend a huge amount of time evaluating results one by one, which is frustrating and time consuming. Contemporary search systems are capable of sorting the results only by one attribute. This requires further manual evaluation, incorporating user's preferences.

The search system with the use of fuzzy logic has been presented. It is capable of giving a list of properties sorted by suitability based on the totality of the client's preferences. The client sets attributes of a property and preferences of these attributes. The system calculates a score for every property that suits the basic hard requirements and then sorts the properties by that score. The score means suitability for the individual client based on his preferences. The client will get the list of the best properties from available options. The lower the position the property is on the list the less suitable. This approach is timesaving and it eliminates the possibility that the client misses a good property, which is very possible in the contemporary approach.

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Affordable Housing Provision in Nigeria from a Policy Perspective: Literature review and synthesis

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Abstract:
Demand for affordable housing in Nigeria is soaring due to massive shortage of new low cost housing units on the market as a result of inadequate housing finance and the Government tactical withdrawal from direct housing provision. Worst hit by the housing needs is the low-income groups who cannot afford out-right purchase of houses. This has brought about a paradigm shift in the Nigerian Housing Policy focus to a public-private participation concept. This concept provides for the private sector as the engine room and leading agent of development with government providing enabling environment. This policy shift formed the basis of the current housing reforms of 2002 to enhance the development of the sector and make housing available to the people. This paper presents an overview of Nigeria housing development programmes of the latest National Housing Policy and positions the affordable housing provision reforms within it. The effects on the overall sustainable development of Nigeria are discussed and some conclusions drawn.

Keywords:
Affordable Housing Provision, Housing Sector Reforms, Public-Private Developers

1. Introduction

Housing is one of the most important essential human needs after food as given by the Maslow's hierarchy of needs (Maslow, 1970). The house that an individual lives in is the symbol of their status; a measure of their achievement and social acceptance; the corner stone of an enjoyable environment and healthy living. Housing can also be used as the barometer to measure the wealth of a nation. Unfortunately, decent housing has over the years remained elusive in Nigeria especially to the low-income people who constitute an estimated 90 percent of the nation's total population of 140 million (FGN, 2002; Census report, 2006).

In spite of the activities of both public and private sectors in housing delivery (Agbola, et al., 2000, Ajanlekoko, 2001) the problem of non-availability and non-affordability has continued to persist. This has been attributed to poor implementation of Nigeria's public housing efforts. However, as potential solution to this inadequacy and consequent waste of resources there have been various initiatives and several reviews to housing programmes and policies since the birth of first democratic government in Nigeria untill the present, with a view of finding opportunities for appropriate actionable strategies towards facilitating more affordable homes for low income people.

2. Research Focus and Approach

The aim of this research is to evaluate the affordable housing delivery system in Nigeria and to assess the extent to which this impacts on the supply and demand of affordable housing in Nigeria. In order to achieve this, the study seeks to assess both public and private sectors housing experiments in Nigeria to determine the extent to which they have enhanced housing affordability among various groups in Nigeria especially the low-income people. The need to examine and document the activities of housing providers in Nigeria is crucial since it forms the pivot of the new National Housing Policy in Nigeria. In determining the extent to which the Policy outcomes have been in tandem with the Policy objectives, this paper carried out an in-depth document review on the past and present National Housing Policy as past of its literature review and presents its findings. The assessment revealed that there is a gap between the Policy objectives and Policy outcomes. The findings provide a basis for further research which shall be accomplished by a quantitative approach with the use of questionnaire and hypotheses to validate the research aim and objectives. The researcher is at the moment on field survey to collect data.

3. Nigerian Housing Development

For about 25 years, global development policies and practices have been fundamentally affected by a transformation in attitudes and approaches regarding the roles of the public and the private sectors. The earlier focus of policies and practices were on the public sector. The shift in focus moved gradually from this extreme to shared responsibilities between the public and private sectors. The rationale for the policy shift according to Barylisa (2006) is a response to perceived failures in the public sector, coupled with a growing prominence and refinement of theoretical arguments highlighting inefficiencies in the public sector and the superior performance of private ownership. Therefore, privatization became part of a global ideological shift in emphasis towards a more efficient and market-driven economic policies. This gave birth to the emergence of public-private participation concept as a reform in the Nigerian housing sector policies. This concept makes the private sector the engine room and leading agent of development whiles the government only provides the enabling environment. The various stages of reforms witnessed in the Nigerian housing sector so far are analysed below.

4. Nigeria Housing Sector Reforms

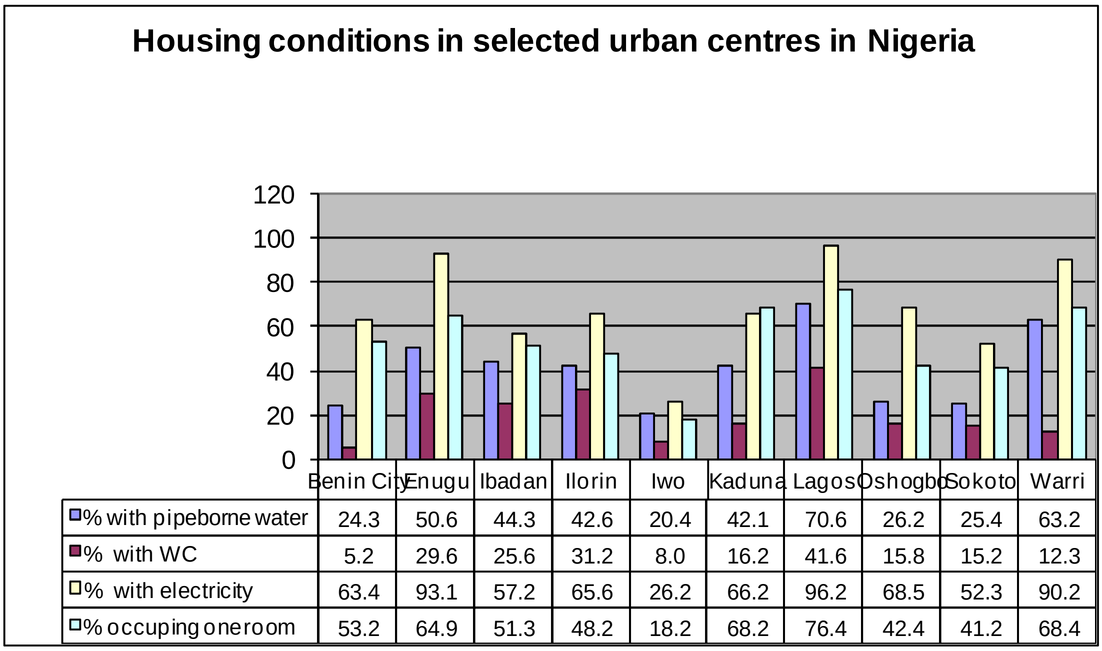
The housing sector in Nigeria has had three major national housing policies since the political birth of the nation forty-seven years ago. These are discussed as follow:

4.1. First National Housing Policy

The first national housing policy was in 1982 during the administration of President Shehu Shagari who ruled Nigeria between 1979 and 1984. With the ravages of the Nigerian civil war (1967-1970) still fresh in mind, the policy aimed at solving the quantitative housing problems occasioned by the heavy losses of housing units in the eastern region of Nigeria. According to the UN estimates of the time (1983), while Nigeria needed to provide 1,000 units of housing for a 10,000 of its population, it was providing only 2 and 3 units. In addition, available evidences in the literature (Okupe, 2000; Ajanlekoko, 2001; FGN, 2001; Jakande, 2004; Akewusola, 2006; Ozigbo, 2006, Reis, 2006) point to the fact that the policy achieved very little. One of the reasons among others identified for low performance was that the political landscape was so inhospitable that the policy stood little chance of success.

According to Agbola (2007) it could be said that Nigeria had the money but not the institutional framework, manpower and process-details of making a housing policy effective.

The implications of this were overcrowding in the existing habitable accommodation, overstretched of existing facilities and consequently massive growth in the squatter settlements, slums and shanties providing alternative affordable places of abode for the large class of urban dwellers and immigrants, see Table 1 and Figures 1 and 2 below:



	Benin City	Enugu	Ibadan	Ilorin	Iwo	Kaduna	Lagos	Oshogbo	Sokoto	Warri
% with pipeborne water	24.3	50.6	44.3	42.6	20.4	42.1	70.6	26.2	25.4	63.2
% with WC	5.2	29.6	25.6	31.2	8.0	16.2	41.6	15.8	15.2	12.3
% with electricity	63.4	93.1	57.2	65.6	26.2	66.2	96.2	68.5	52.3	90.2
% occuping oneroom	53.2	64.9	51.3	48.2	18.2	68.2	76.4	42.4	41.2	68.4

Fig. 1. Housing Conditions in Nigeria

Table1: Room occupancy ratio

Area	Occupancy Ratio
Victoria Island	1.6
Ikoyi	2
Obalende	8.7
Lagos Island	5.4
Ebute- Metta	7.4
Yaba	7.2
Ajegunle	5.8
Surulere	6
Ikeja	2.7
Mushin	8

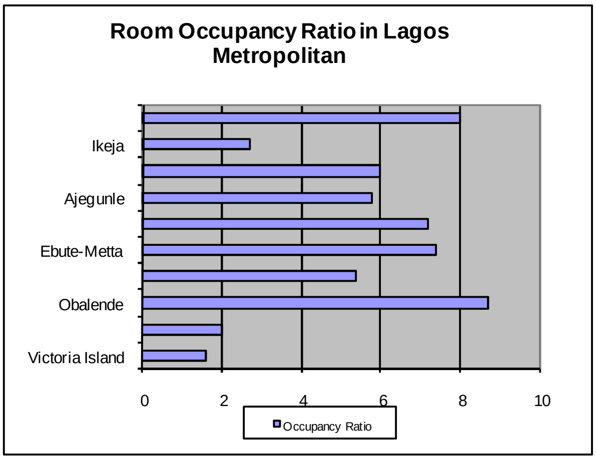


Fig. 2. Room occupancy Chart

Source: Table 1 and Figures1&2: Author 2007 adapted from Ezenagu, 2000 &Ajanlekoko, 2001 and modified by the author

However, the situation was able to point government attention to the growing housing problem and the mounting quantitative shortages. Added to this was a realization that housing problems could not be solved only by a generous infusion of money without an effective institutional framework and mechanism for delivery. Therefore, as a panacea to this problem, experts called for a reform of the policy and put housing requirement at about 8 million housing units between1991 to 2002. This orchestrated a second housing policy.

4.2 Second National Housing Policy

The second national housing policy was introduced in 1991. Since the advent of Nigeria as a modern state, this was the most detailed and most debated housing policy. The policy addressed many of the vexed problems of the housing sector that the former policy could not resolve. Amongst others, the policy addressed the problem of availability and accessibility of land, it discussed the problem of building materials such as sourcing, cost and availability. Furthermore, it dwelt extensively on the institutional apparatus and strategic modalities for policy implementation.

Indeed, it was this policy that closely mirrored the international opinion (UN, 1983) that governments should not engage in direct housing production but should, instead provide the enabling environment for the execution and actualization of policy objectives and directives. The policy is also noticeable for its decided focus, attention and sweeping reforms in the area of housing finance. This has been one of the critical areas to Nigerian housing sector. Accordingly, the policy rejuvenated the Federal Mortgage Bank of Nigeria (FMBN) into a wholesale bank and established the Primary Mortgage Institutions/Banks (PMIs) for the much needed but hitherto absent finance mortgage intermediation.

As a result of this reform, in the process of actualizing the housing finance sub-sector of the policy, many institutions were created, and consequently many more jobs opportunities as well. Furthermore, the prospect and possibility of using housing as a poverty alleviation strategy as observed by Agbola (2007) was unconsciously made manifest. However, despite the good intentions of the 1991 national housing policy as evident in its contents and by the various institutional apparatus established to actualize them, the experts (Onibokun, 1988

&1990 Agbola 1998, FGN 2001, FMH&UD 2004) have viewed the performance of the Nigerian housing sector as abjectly poor when measured by number of Nigerians who newly owned houses or who have access to decent accommodation. According to Agbola (1998) there is a widening and frightening gap between aspirations, expectations and the capacity of realization and a yawning chasm between the magnitude of demand and the capacity of supply. Onibokun(1990) and Agbola(1998) therefore suggested the need for greater participation of the profit-motivated private sector in order to ensure sustainable development of the Nigerian housing sector. For this reason and the evolving environment resulting from the new macroeconomic and political reforms compel a fundamental modification of the National Housing Policy for a more virile housing delivery system.

4.3 Third National Housing Policy

The 3rd National Housing Policy was evolved in year 2002 in response to the lapses of the 1991 housing policy. The main thrust of the policy is the use of the private sector as the fulcrum of the new policy and this represents a major shift in government view on how to promote mass housing for the citizens. The essential features of the new policy was aptly summarised by Mabogunje (2004):

"The main thrust of the new policy is to seek vigorously to make and increasing majority of Nigerians home-owners on the basis of mortgage finance. This policy entails involving a large number of private sector real estates developers and State Housing Corporations in the development of estates with houses for sale at affordable prices to low and middle income groups in the country; promoting the growth of small and medium-size industrial enterprises to provide local construction materials of all types to keep the cost of producing houses within reasonable limits: mobilizing primary mortgage institutions to assist any Nigerian desirous of purchasing a house on how to access mortgage finance, restructuring the Federal Mortgage Bank of Nigeria to be able to provide ample and abundant funds besides the National Housing Trust Fund to meet the secondary mortgage transactions for home ownership, reviewing and amending all legislations necessary- to facilitate the robust development of home-ownership in the country and setting up a Federal Ministry of Housing and Urban Development to regulate, promote, monitor and supervise all of these changes."

To ensure the success of 2002 National Housing Policy, legislative reform on land was proposed. This aimed at making land accessible to Nigerians and easing the whole land titling and registration process for quick transactions in mortgages. Furthermore, the foreclosure procedure was to be made easier and faster, devoid of incessant adjournment that stalls many mortgages foreclosures. This housing policy just like the 1991 NHP put the private sector developers as the fulcrum of housing delivery in Nigeria. In order to foster great participation of private sector in housing government facilitated the development of large number of private sector real estate developers and building materials manufacturers. Although, this was also included in the 1991 policy but it would seem that the nation and real estate sector of the economy was not mature enough to undertake such an assignment without governmental motivation.

The above led to the government formation of the Real Estate Development Association of Nigeria (REDAN) to champion the goal of private housing production on which the success of the policy critically depended. For the policy to also succeed there was need to address the problem of building materials, its sourcing, cost, availability and affordability. To this extent, the government again blazed the trail in the formation of the Building Materials Producer

Association of Nigeria (BUMPAN). The goal is to encourage the pooling together of resources by the building materials producers in order to gain the advantages of economies of scale, produce in large quantities to solve availability problem which consequently will reduce cost to solve affordability problem. With these structures in place, then the prospect of building more housing units at affordable costs may be achieved.

The other vital elements of the reform involves the proposal for the reform of legal, institutional, and regulatory provisions that currently inhibits mass housing delivery, housing market efficiency, finance, and private sector participation. This brought about a new Federal Ministry of Housing and Urban Development. The responsibility of this establishment is to regulate, promote, monitor, coordinate and supervise the private sector-led housing delivery.

On the financial sector, creation of financial mechanism and institutions that will make funds available to the private sector developers for mass housing production and ensure efficient functioning of mortgage system were put in place. These include laws for restructuring, strengthening and recapitalization of the vital institutions such as Federal Housing Authority (FHA), Federal Mortgage Bank of Nigeria (FMBN), Federal Mortgage Finance Limited (FMFL) and Urban Development Bank (UDB). In addition, the review of many laws particularly to make them more effective and enforceable, such as Mortgage Institution Act, National Housing Fund Act, Trustee Investment Acts, Insurance Trust Fund Act, and Land Use Act of 1978, particularly the foreclosure provision and access to land for estate development by developers were to be undertaken.

5. Effects of Housing Reforms on National Development

In assessing the 2002 NHP in relation to housing reforms, the researcher is aware that policies do take time to mature and various implementation strategies sometimes take longer time to take effect. However, tentative results of the reforms implementation efforts on the overall sustainable development of Nigeria are:-

1. The slow pace of legal reforms to give teeth to many of the major changes proposed in the 2002 Housing and Urban Development Policy is observed. Prominent among these are the proposed amendment of Land Use Act of 1978 to ease land titling process, make foreclose easier and faster and make land available for estate developers. Surprisingly, many of the laws are still lying in the National Assembly as Executive bills, after the end of the initiating government.

2. The area of infrastructural provision in the estates development is another issue that most desired. The provision of primary infrastructure is essentially the responsibility of the government federal, state and local, while secondary infrastructure should be provided by the estate developers. However, failure of governments to provide these primary infrastructural facilities has forced added burden on estates developers, with consequent limitation on the number of serviced building plots and high cost at which their housing units come to the market. This same reason account for the small number of housing units being delivered by the estates developers. The public sector must be alive to its responsibility of primary infrastructure provision, particularly if the anticipated volume of activities in the housing sector is to be realized. However, alternative strategy for the provision of such infrastructure open to governments, as practiced in other parts of the world, include public-private partnership and floatation of bonds as a means of public accessing capital market funds.

3. The stringent conditions for private sector developers to access the Estate Loan from National Housing Fund, the limited funds available and reliance on depository system of funds mobilization also post a serious challenge to the housing sector reforms. In addition, this problem is compounded by failure of some government agencies such as Nigerian National Petroleum Corporation (NNPC), the Nigerian Police, Central Bank of Nigeria (CBN) to contribute to the fund, which limits its financial base, and invariably the funds at its disposal.

4. Furthermore, despite the reforms, the financial depth of the Nigerian economy is still shallow and this has impacted not too favourably on the development of the mortgage market. The failures to develop secondary mortgage market and link mortgage and capital markets have limited the diversity and intensity of mortgage penetration among Nigerians. This has seriously hampered the sustainable development impact of housing sector reforms on the overall economy.

Despite of the 2002 NHP shortcoming, the reforms has been able to achieve the following:

1. Accelerated growth in the number and activities of the real estate and the increasing volume of their activities remain a ray of hope.

2. The efforts of the Federal Mortgage Bank of Nigeria, Nigerian Securities Exchange Commission (SEC) and Nigeria Stock Exchange (NSE) at developing the nation secondary mortgage market through the floating of Mortgage Bond are encouraging.

3. The enthusiasm with which the Nigerian industrialists and manufacturers of local building materials take the opportunities embedded in the reforms may be the needed signal in reassuring the high success possibility of the whole housing sector.

6. Conclusion

The gateway to realizing a given objective lies in the right attitude. The literature review shows there is a widening and frightening gap between aspirations, expectations and the capacity of realization and a yawning chasm between the magnitude of demand and the capacity of supply (Agbola 1998, 2000; Ajanlekoko 2001,FGN 2002, Ojerinola 2004) There is therefore a need for total commitment and discipline on the part of government and private developers in realising the objectives of NHP 2002 which is to ensure that all Nigerians own or have access to decent, safe and sanitary housing accommodation at affordable costs by 2000 AD. To achieve this aim following the review of literature, the following recommendations are deemed necessary. Firstly, the amendments to the Land Use Act 1978 should be ratified and approved as a matter of priority to make land available to estate developers. Furthermore, government could readily give land to those companies ready to provide housing for the low-income people. There is need also for clear policies on the roles of government and the private sector in the area of infrastructural provision regarding affordable housing scheme. Without government support and intervention in infrastructural development, the cost of housing units will continue to be high which would perpetually deny low-income earners from benefiting from housing scheme. Both the government and the developers need to be more involving in the provision of basic infrastructure as part of social responsibility to the citizenry. All Primary Mortgage Institutions need to be recapitalized to create as many mortgages as possible. It will also help the PMIs to prevent liquidity mismatch arising generally from using short term funds to finance long investment in housing. Interest rate on loans for providing and lending monies to low income housing could be 2 to 3 points lower as incentives. Lastly, organised public and private developers should be supported with seed fund to embark on estate development for sales to low–income earners who could access on loans/mortgage to purchase such housing units.

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Affordable Housing: A Strategic Analysis

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Abstract:
The scale of the Housing crises is massive worldwide. In Britain, Government projections show that between 2004 and 2026 the annual rate of household growth in England will be 223,000, up on previous estimates of 209,000. Last year around 160,000 homes were built, a 60,000 annual shortfall in the number of homes needed. In the USA, the Federal Government currently provides assistance to approximately 4.6 million households, but roughly 9.7 million low-income households receive no housing assistance. The situation is worst in the developing and poorest countries.

The aim of this research paper is to identify the reasons behind the ineffectiveness in the performance of housing industries and how it can be improved. The reasons are related to economical, political, social and environmental factors. It is also related to strategy/policy setting and important factors in construction. These reasons have forced people to live in slums under extreme conditions as an alternative solution to housing. The research methodology will consist of two parts; literature review and a selection of case studies from different housing industries. The literature review will shed light on important factors such as finance, land, labour, building materials, projects, centralised and decentralised planning, etc. which directly influences the performance of the housing industry. Literature will also investigate the performances of the housing industry in developing countries such as India, China, Brazil and South Africa. These developing countries have very high demand, limited resources and massive annual growth of populations. This process will unveil the facts on how these countries are coping with the current housing crises.

Finally, a thorough analysis based on a comparison between literature review and case studies will assist stating the findings and recommendations.

Keywords:
Affordable Housing, Strategy/Policy/ Resources Modelling and Important Factors in Construction.

1. Introduction

This research paper addresses affordable housing problems, which governments worldwide are struggling to cope with. In fact, Affordable Housing is one of the biggest challenges facing governments worldwide. It is one of the main issues politicians raise during their campaign to win elections. The poorest, developing and advanced countries such as South Africa, Malaysia, Indonesia, Britain, USA, Germany, etc. are suffering from housing crises. UN reports show that there are millions of homeless people worldwide; in Africa, Asia, South America, etc.

The scale of the Housing crises is massive worldwide. In Britain, Government projections show that between 2004 and 2026 the annual rate of household growth in England will be 223,000, up on previous estimates of 209,000. In 2007 around 160,000 homes were built, a 60,000 annual shortfall in the number of homes needed (UK Homes Crises, 2007). In the USA, the Federal Government currently provides assistance to approximately 4.6 million households, but roughly 9.7 million low-income households receive no housing assistance (Freeman L., 2002). The situation is worst in the developing and poorest countries namely Brazil, India, China and etc., (UN-Habitat 2003 and UN-IRIN 2008, China Gate 2006, BBC 2006).

The aim of this research paper is to discover the reasons behind the failure in the housing industry's performance and how it can be improved. The research methodology will consist of two parts. A literature review spotlights on important factors such as finance, land, labour, building materials, projects, centralised and decentralised planning, etc. which directly affects and influences the performance of a housing industry. Then, an examination will be carried out on the performance of housing industries in developing countries such as India, China, Brazil, and South Africa. These developing countries have very high demand, limited resources and massive annual growth of populations. This process will unveil the facts on how these countries are coping with the current housing crises. Finally, thorough analysis based on a comparison between the literature review and case studies will assist formulating the findings and recommendations.

2. Affordable Housing's Definition

There are several definitions of Affordable Housing; all of which seem similar and serve the same purpose in a different way. DCLG (2006) argues that Affordable Housing includes social rented and intermediate housing, provided to specified eligible households whose needs are not met by the market. Affordable housing should: meet the needs of eligible households including availability at a cost low enough for them to afford, determined with regard to local incomes and local house prices; and include provisions for:

(i) the home to be retained for future eligible households; *or*

(ii) if these restrictions are lifted, for any subsidy to be recycled for alternative affordable housing provision.

Moreover, WCEL (2008) state that Affordable housing is housing that is safe, appropriate and accessible and where rent or mortgage plus taxes are 30 percent or less of the household's gross annual income, where as Northampton City Council (2008) defines Affordable Housing that covers both low cost market and subsidised housing (irrespective of tenure, ownership – whether exclusive or shared – or financial). Thus, Affordable Houses are offered by a government, local government, or a governmental department for key workers such as nurses, teachers, council employees etc., who can not afford to buy or rent from the housing market depending on their monthly income. In many cases, government usually subsidise toward the construction cost in an attempt to bring down the building cost of these houses to make them affordable to buy and to meet the average income of key workers. In other cases, governments and local governments build their own houses to rent by low income people living in the borough. In this case these houses are called social houses or social estates.

The difference between affordable and social houses is that affordable houses are built and subsidised by governments and local government for key workers such as nurses, teachers, council workers and etc., TO BUY, where as social houses are built by governments and local governments for low income people living on welfare benefit such as unemployed, single parents, disabled, retired people and etc., TO RENT. In other words, Affordable Houses are houses built or subsidised by governments or local governments for key workers to buy and live in.

3. Affordable Housing as Global Phenomenon

Affordable Housing problems are increasing rapidly, and almost 32 per cent of the world's urban population, live in slums, the majority of them in the developing world (UN-Habitat 2003 and UN-IRIN 2008). Thus, in the developing world, poverty has forced people to live in poor condition in slums and shanty towns on fringes of cities. It is a great challenge to government worldwide. The following sections will highlight the scale of the problem, the reasons that forced people to live in slums and shanty towns and their living conditions.

3.1. The Scale of the Problem

Figures show that Britain needs to build 60% more houses a year for the next 14 years if the country is to avoid a housing crisis (The Guardian, 2008). Moreover, it appears that there is not a single country worldwide has escaped the housing crisis and the scale is massive and keeps growing every year (UN: Habitat, 2004).

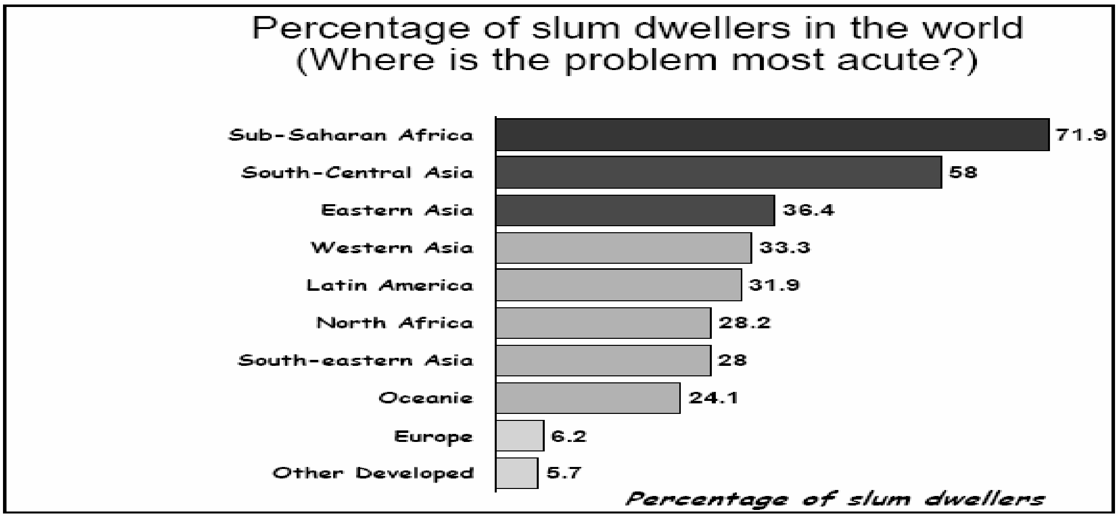

Fig. 1. the percentages of slums in regions Worldwide (UN-Habitat, 2005a).

According to Figure 1; it seems that the Housing crisis is concentrated in the poorest regions. This is because of the lack of resources, planning and finance. By the year 2030, an additional 3 billion people making up about 40 percent of the global population will need housing. Slums worldwide have been created as an alternative solution to the lack of affordable housing and ethnic segregation on the fringes of cities (UN-Habitat 2005a).

3.2. Slums as a Solution

It is important first to define slums and then discuss all aspect and reasons related to this global issue. It has been estimated that one third of the world's urban population today do not have access to adequate housing. (UN-Habitat 2003)

3.2.1. Slums' Definition

There are several definitions of slums. Slums are a street, alley, court, etc., situated in a crowded district of a town or city and inhabited by people of a low class or by the very poor; a number of these streets or courts forming a thickly populated neighbourhood or district where the houses and the conditions of life are of a squalid and wretched character (Oxford Dictionary). Slums are areas where the poorest are living in overcrowded areas on the outskirt of cities. Moreover, a slum is a contiguous settlement where the inhabitants are characterized as having inadequate housing and basic services. A slum is often not recognised and addressed by the public authorities as an integral part of the city (Turkstra and Raithelhuber, 2008). In other words, slums are featuring lack of public services such as health, education, fresh water, sewage, etc. In a recent report conducted by the UN-Habitat (2006) shows that slums issue is a significant challenge and serious and immediate action is needed to be taken, the number of slum dwellers worldwide is projected to rise over the next 30 years to about 2 billion.

3.2.2. Characteristics of Slums

According to UN-Habitat (2003), there are several characteristics which are associated with slums:

- Lack of basic services
- Substandard housing or illegal and inadequate building structures
- Overcrowding and high density
- Unhealthy living conditions and hazardous locations
- Insecure tenure; irregular or informal settlements
- Poverty and social exclusion
- Minimum settlement size

3.2.3. Reasons for the Current Crises

People worldwide are driven to live in urban slums settlements and continue to grow for a variety of reasons (Un-Habitat, 2003):

1. Economic,
2. Social,
3. Political and

4. Environmental.

The above reasons could be illustrated in the following:

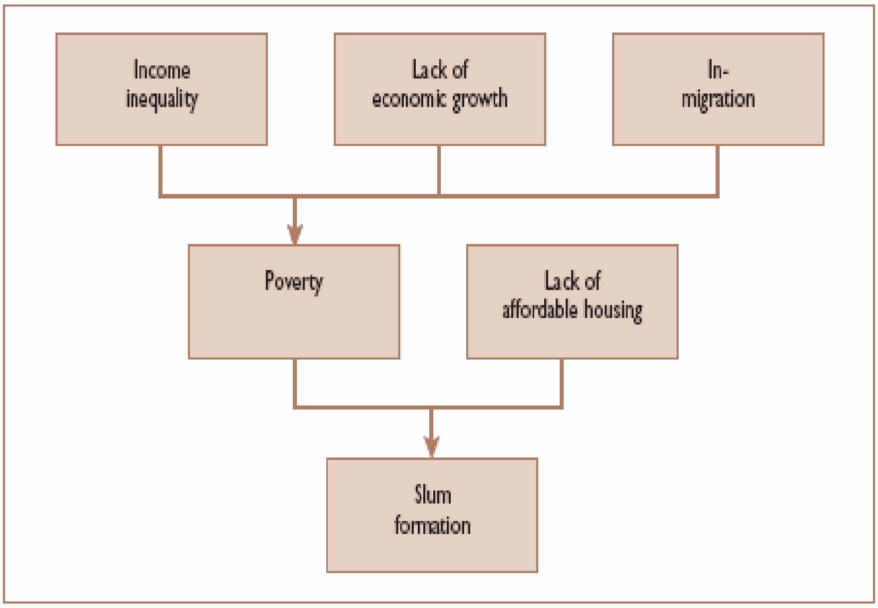

Fig. 1. Reasons for the creation of Slums (UN-Habitat, 2003)

4. Housing Strategies, Policies and Resources

In his statement, the previous UN Secretary General; Kofi Anan argued that slums represent the worst of urban poverty and inequality. Yet the world has the resources, know-how and power to reach the target established in the UN Millennium Project (2005a). More over the previous UN Secretary General added that for most things in life, however, knowledge is power, and where there is a lack of knowledge, there is often a fear of the unknown (UN-Habitat, 2003). Slums must be seen as the result of failure of housing policies, laws and delivery systems, as well as of national and urban policies (UN-Habitat, 2003). The following is an attempt to highlight the importance of strategy setting and its affect on housing.

4.1. Strategy and Strategy Map

Hendrickson *et al* (2003) argue that strategy is creating fit balance among a company's activities. The success of a strategy depends on doing many things well - not just a few - and integrating among them. If there is no fit balance among activities, there is no distinctive strategy and little sustainability. In other words, planning a strategy is the process of finding the best combination, among others, of factors, processes and activities that makes it more successful and serves it purposes.

Hendrickson *et al* (2003: 37) add that: in this view, successful firms must improve and align the many processes underway to their strategic vision. Strategic positioning in this fashion requires:

- Creating a unique and valuable position.

- Making trade-offs compared to competitors
- Creating a "fit" among a company's activities.

Thus, according to (Hendrickson *et al*, 2003) and (Kofi Anan Statement; UN-Habitat, 2003); strategy planning as based on finding the best combination between Resources, Power and Knowledge (the Know-How). Resources mean Human, Natural and Human-Made Resources (see section 4.3) including Finance, Land, Infrastructure (Labour, Building Materials, and Equipments), Power means Legislations and Regulations, and Knowledge means the Know-How. These factors could be illustrated in the following diagrams:

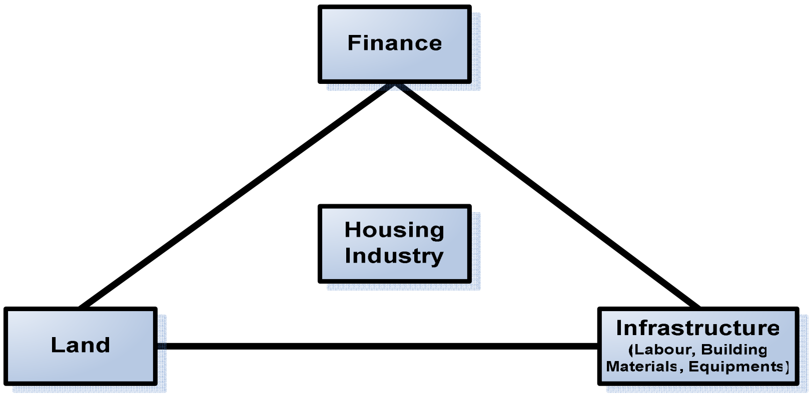

Fig. 3. Housing Industry Three Factors (UN-Habitat 2003)

The above diagram excludes Knowledge (THE KNOW-HOW), and could be re-illustrated in more comprehensive form as follows:

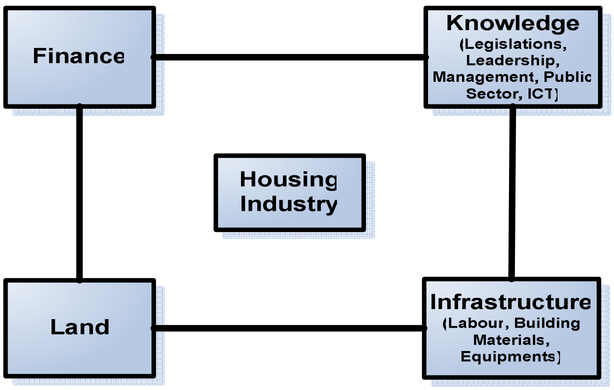

Fig. 4. Housing Industry Four Factors (UN-Habitat 2003)

Strategy Map

Scholars and researchers argue that there is a map explaining strategy stages or aspects. This concept is well explained by Robert *et al*, (2004) and refers to the strategy map is based on five principles: strategy balance contradictory forces; strategy is based on the differentiated customer value proposition; value is created through internal business processes; strategy consists of simultaneous, complementary themes, strategic alignment determines the value on intangible assets. In other words, a strategy is governed by five principles discussed in the above and explained in the following figure (Figure 5). It is important to mention that the above description of strategy is a corporate one (Micro-Level), however, it may be altered and adopted to an industry, ministry or country level (Macro-Level). The only difference would be the volume, capacity and significance of variables that the Macro-Level will deal with.

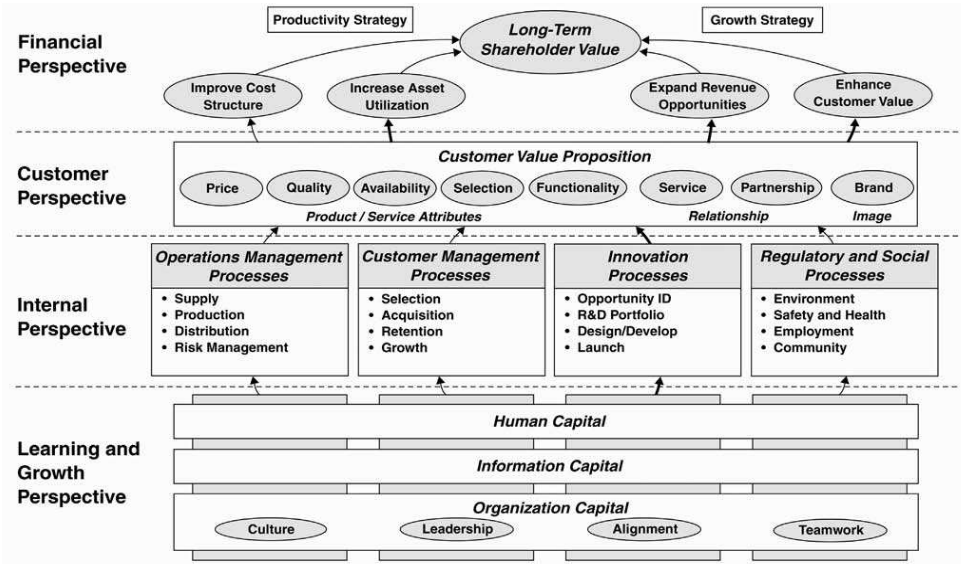

Fig. 5. Shows Strategy Map (Robert *et al*, 2004, p: 12)

Thus, there are four tangible principles and one non-tangible principle which are important to consider when setting up a strategy plan. The four tangible principles are strategy balance contradictory forces; strategy is based on the differentiated customer value proposition; value is created through internal business processes; strategy consists of simultaneous, complementary themes. These four tangible principles is countable such as Finance, Land, Infrastructure (Labour, Materials, Equipments), and Knowledge (the Know-How, Legislations, Leadership, Management, Public Sector, ICT). The non-tangible is strategic alignment determines the value on intangible assets. This principle concerns with uncountable factors such as organisational culture, employees behaviour and attitudes, organisational internal relations, and etc.

4.2. Policy

Policies are written statements of ideas, goals and plans of action, proposed or adopted by some agencies (Khalid H., 2008). Policy is considered a set of principles which guide a regular course of action and lists the following components (Menou, 1991):

- An image of the desired state of affairs, as a goal or set of goals, which are to be achieved or pursued;
- Specific means by which the realisation of the goals is to be brought about;

- The assessment of responsibilities for implementing the means;
- A set of rules or guidelines regulating the implementation of the means.

Thus, policy is a set of principles, parameters and decisions that guide implementing plans toward goals and targets. So, what is the difference between strategy and policy? According to the above discussion; a Strategy is a long term plan and it is the combinations of factors that make it unique and feasible, where as, policy is making decisions on how to implement and execute these plans. For example; setting plans to provide homes for homeless people in a country within the next twenty years is a strategy. However, making decisions on how to legislate, finance, land allocation, supply chains, partnership, contracts, the role of SMEs and etc. is policy. A good mix between strategy and policy may provide rapid, effective and sound solutions to solve housing problems.

4.3. Resources

There are concepts within the term resources. In the following; the concept of resources will be explained in order to establish the relations and importance among strategy, policy and resources. Resources could be defined as natural, human, and human made resources (Andersen, 2007):

1. Natural Resources
2. Human Resources
3. Human-Made Resources
   - Equipment, machinery, buildings etc.
   - Technology
   - Legal bodies and political, cultural and social institutions

4.4. Strategy, Policy and Resources Relations

In this section the discussion will focus on establishing the relations between strategy, policy and resources. Strategy can be best understood if it is viewed as an element of a troika that includes policy, strategy, and resources (the PSR Troika), (Warnock, 2000). The above described relations could be explained in the figure below:

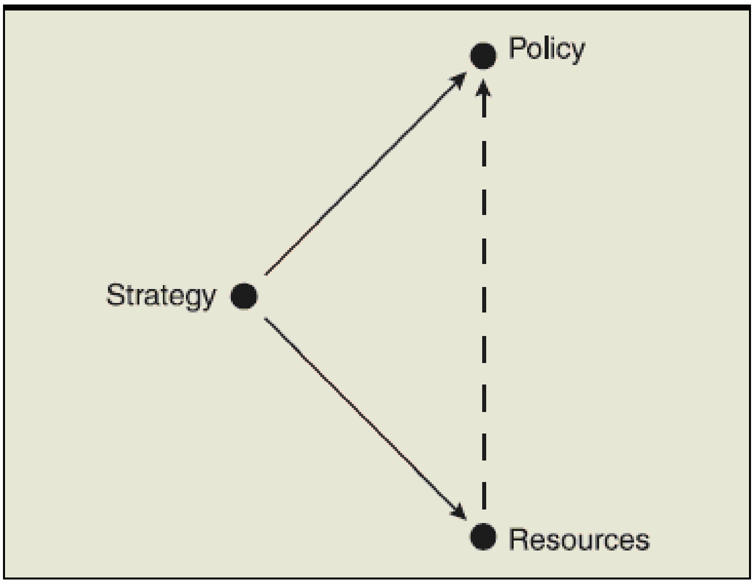

Fig. 6. Strategy, Policy and Resources Relations (Warnock, Purdue University Press, 2000)

It is clear that Strategy, Policy and Resources have significant relations. In fact, the three terms are inseparable. If one is mentioned then it would indicate to the others. According to Figure 6; it is safe to say that strategy is like an umbrella incubating both policy and resources. The execution of processes towards strategy's goals could not be set unless both resources and policy decisions are made. In other words, resources shape and determine the length of time of achieving a strategy's goals where as policy is setting legislations and making decisions on the best way of utilising resources toward achieving strategy's goals.

Policy defines a company's reason for existence and sets the parameters within which it intends to achieve its purpose. . . Strategy is a design or plan that defines how policy is to be achieved. . . Without resources, strategy can achieve nothing (Warnock, 2000).

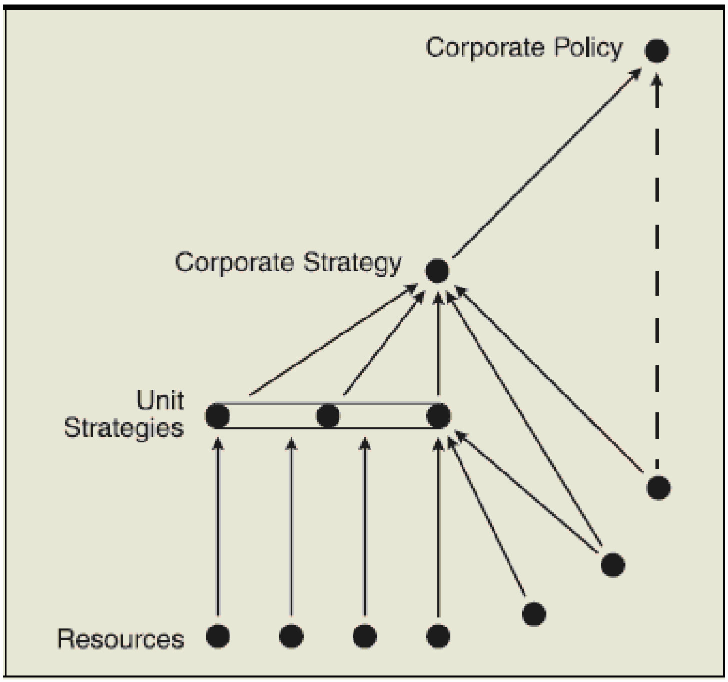

Fig. 7. Strategy, Policy and Resources Relations (Warnock, Purdue University Press, 2000)

According to Figure 7; it is crucial and decisive that one of the main characteristics for setting a successful and sound strategy is the availability and accuracy of all information on resources. This is a part of the data collection process which eventually make strategy goals more feasible and realistic. It is also important that data accuracy on resources will help in making correct decisions toward policy making in terms of implementing, evaluating, monitoring controlling, changing etc. In other words, the success of a strategy and policy depend on the accuracy of data and information collected on resources. Moreover, Warnock (2000) claims that there are three criteria that take precedence over simplicity in business decision-making: the solution must be implementable, it must not produce unacceptable adverse consequences, and it must allow for flexibility.

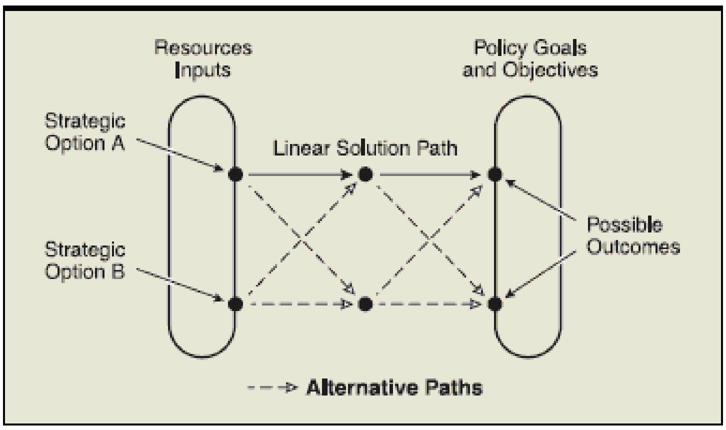

Fig. 8. Strategy, Policy and Resources Relations (Warnock, Purdue University Press, 2000)

Thus, according to Figure 8; in a strategy setting there should be some room to manoeuvre .i.e. a strategy should be flexible to change. In other words, when setting a strategy, there must be more than one option to follow to achieving the strategy's goals. If a path did not work as planned and anticipated, then there should be another path (plan B or even C) that might be more progressive to meet aims and targets. Because planning is based on estimations of resources, then it is impossible to reach the planned targets in one go and without any changes and alteration. Estimations also are made on similar previous planning processes and strategies. Therefore, strategies require setting multi option/path plan, have resilience and flexibility, and ready to accept any change at any stage during implementation. Figure 9; however, is a more detailed format and variables might be necessary to discuss at the Macro Level.

UN-Chronicle On-Line (2004) proposes and draws a slightly different picture but similar in principles. The model is called *a Model City Strategic Framework*. It could also be implemented at the Macro level as follows:

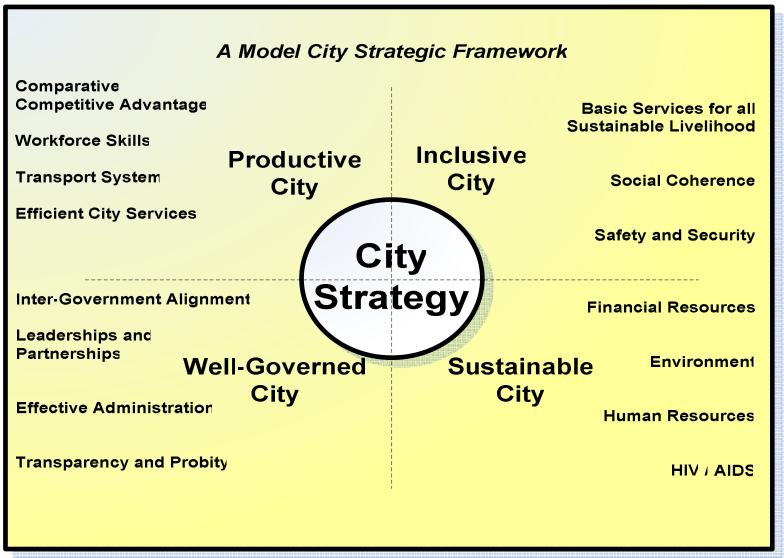

Fig. 9. Model City Strategic Framework (Talwar, UN-Chronicle On-Line, 2004)

5. Important Factors in Construction

In this section; the discussion will shed light on important factors which participate significantly in developing and improving the processes of a housing industry. These factors are such as centralised and decentralised planning, partnerships and SMEs, selection of construction method and offsite manufacturing, etc.

5.1. Centralised/Decentralised Planning

UN-Habitat (2006b), a report published on Iraqi Housing Industry; claims that one of the major reasons; among others that led to the current Iraqi housing crisis is that the Iraqi Ministry of Housing and Construction used a system of centralised housing planning, implementing and land distribution. The report (UN-Habitat, 2006b) continues to blame the centralised system by stating that this dysfunctional, centralized system of housing and land delivery has resulted in a number of unmet housing needs. Most countries worldwide: Asia, Africa, South America, etc. are suffering from centralised regimes and centralised planning, strategies and policies. In some countries, however, the shift in systems from centralised to decentralised systems have made a noticeable improvement in the performance of housing industries.

5.2. Partnership; SMEs in Construction

Small and Medium Enterprises (SMEs) make substantial contributions to national economies (Jutla *et al.*, 2002; Poon and Swatman, 1999) and are estimated to account for 80% of global economic growth (Jutla *et al.*, 2002). Thus, SMEs is the nerve of all economies and industries and as an indicator to a success or failure of performance.

Burke et al (2004) argue that the definition of strategy in SMEs is often perceived as person centred rather than process driven. The performance (in many cases the survival) of small firms can be synonymous with the success of the leadership style of the entrepreneur. Thus, SMEs strategies are usually set by a person who is most of the time the leader or the owner of the business. Strategy relations are explained in the figure below:

Fig. 10. Elements of strategy (Burke *et al*, 2004)

It is important to acknowledge the vital role of SMEs not only in construction but in all industries. There are factors that need to be addressed to revive the role of SMEs in construction (Burke *et al*, 2004):
1. Legislation and Regulation
2. Finance and Banking

3. Education and Training
4. Governmental advice, support, guidance
5. Standardisation
6. Collaboration and Integration

According to the above, there are some important factors that can be affective and influence the performance of SMEs and therefore the entire constructions industry. These factors are such as legislations and regulations, financial services and banking, training availability, governmental force task and control, quality management systems/bodies, and collaboration and cooperation among local, national and international SMEs.

5.3. Construction Method Selection

Egan Report (1998) emphasises that one of the solutions for the affordable housing crises is the selection of a construction method. Two alternative methods are as follows:

a. Traditional Method of Construction

BRE (June 2004) argues that clients prefer bricks and blocks because:

- They allow for greater tolerances
- Masonry constructed floors and walls go above and beyond building regulations in terms of thermal mass, durability, adaptability and inherent resistance to fire
- Materials are not affected by being exposed to the elements
- Currently on average up to 10 per cent cheaper the off-site

b. Offsite Manufacturing

Blismas N. *et al* (2006) state that there are several advantages can be obtained by using off-site manufacturing as follows:

1. Minimises on-site operations
2. Reduces congested work areas and multi-trade interfaces
3. Minimises on-site duration
4. Improved health & safety by reduction and better control of site activities
5. Produces high quality or very predictable quality finishes
6. Minimises number of site personnel
7. Benefits when only limited, or very expensive on-site labour
8. Enables existing business continuity
9. Can cope with restricted site storage area
10. Enables inspection and control off-site works
11. Provides certainty of project cost outcomes
12. Provides certainty of project completion date
13. Less environmental impact by reduction and better control of site activities

6. Case Study: Dharavi, India

This section discusses the relations between strategy and policy implementation and how they are carried out in slum areas to improve living conditions and to maximise their contribution to their local economy. The case study selected is the slums in Dharavi, Mumbai, India because it has the biggest population and its massive contribution to the Indian economy.

Dharavi has a population of up to a million (Perry A. 2006). The figures are rough because the area was officially an illegal settlement until 2004 and the authorities have yet to quantify it. The annual turnover of business in Dharavi is estimated to be more than $650m (£350m) a year. (Perry A. 2006).

The strategy was set by the Local Government of Maharashtra to redeveloping Dharavi. The macro-development plan has many amenities such as wider roads, electricity, ample water supply, playgrounds, schools, colleges, medical centres, socio-cultural centres etc. For proper implementation, Dharavi has been divided into 10 sectors and sectors will be developed by different developers. The total duration of this project is excepted to be of 5 to 7 years. Rehabilitation building will be of 7 storeys. (INRNews, 2008).

The policies were planned to meet the targets set by strategies. The Local Government first put in charge the Slum Rehabilitation Authority (SRA) to be responsible for setting policies and making and implementing all decisions. SRA was also responsible for (INRNews 2008):

1. Legislation and Regulations

   Obtaining legislation and regulations were necessary and required for legalising Dharavi's properties in 2004 and the redeveloping process. Moreover, SRA was responsible for verifying the occupier/owner of a property to be eligible for government assistant by accessing the national database system, contacting government departments and registering unregistered tenants. (INRNews 2008).

2. Development Procedure
   After considering the redevelopment plan, a detailed plane table survey has been carried out to know the ground realities. Also, consent of the slum dwellers to join this project is being obtained. After obtaining suggestions & objectives from the public for the revised development plan, the same is finalized by Govt. For each sector a detailed sectoral plan will be prepared by the selected developer in consultation with SRA. This will be placed before the public for suggestion/objectives and then finalized after due amendments. (INRNews 2008).

3. Appointment of the Developer
   Global tenders are invited from developers for this project. The developer are evaluated technically and financially by a Committee headed by the Chief Secretary of Government of Maharashtra. Each developer is required to explain his development strategy in his sector and obtain objectives & suggestions from the residents before starting the development process. (INRNews 2008).

4. Development of local Industrial units
   Taking into consideration the various industrial units in Dharavi, it is being proposed that, non-polluting industrial / businesses will be retained in Dharavi itself. All the established businesses and manufacturing units will be encouraged and will be provided with modern technical and economical strategies for sustainable development. (INRNews 2008).

Thus, the relations between strategy and policy are simple and clear; the strategy was the re-development of Dharavi by widening the roads, building schools and medical centres, provide fresh water, etc. over a period of 5-7 years. Policy implementation is carried out through appointments of governing body (SRA), and making decision on detailed plans, selecting developers, etc. In other words; a strategy is setting a macro-plan in accordance with all the resources available, whereas a policy is how to break down macro-plans into micro-plans and all decision making processes related to their implementations.

7. Conclusion

There are facts could be extracted from this research paper. These facts reflect the reasons that led to the current housing crises and forced people to resorting to slums and living on pavements worldwide. These reasons could be listed as follows:

1. Poverty
2. Lack of power: legislations and regulations
3. Non existence of governing and monitoring bodies (task force)
4. Lack of resources, information and data (financial, human, building materials, land) essential for planning strategies.
5. Lack of knowledge (The Know-How); leadership, management, public sector, ICT, and etc.
6. Centralised/Decentralised planning; direct intervention by central government which generates bureaucracy, inaccuracy, time consuming, etc.
7. Corruption and dictatorships
8. Absence of effective private sector and partnership; non existence of SMEs in supply chain systems.
9. Lack of education and training.
10. No involvement, or perhaps; absence of financial institutions; banks, financial bodies and governmental support.
11. Housing industries are totally depending on traditional method of construction.
12. Little use off-site manufacturing; which increases quality, and reduces time and cost (in long term).

Governments worldwide have accepted the existence of slums and shanty towns as a reality. They have decided to deal with the current situation in slums and shanty towns by improving the quality of life and legalising and awarding property titles for slums, providing public services and include slums in the strategies and development of cities because slums contribute massively to local economies by several hundred of millions of Dollars.

Affordable Housing desperately needs the participation of sufficient Partnerships and Private Sector (SMEs), wide use of Offsite Manufacturing and the exchange of Knowledge (The Know-How) to advance forward. Moreover, Egan Report (1998) put the emphases on developing relations among Partnerships, Private Sector, SMEs and Supply Chains and Off-site Manufacturing. For an industry to be successful and cope with massive demand; the industry must maintain a good balance between Governments Resources, Private Sector, SMEs, Off-site Manufacturing and Knowledge (The Know-How).

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Decalogue to Solve the Housing Problem in Libya

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Abstract:
Libya has suffered from a shortage of housing since the early 1980s. These shortages caused many negative effects in society, and became a chronic problem. To redress this situation, Libya has made a number of attempts to solve the problem of housing shortages, but the success rate was low.

A study was conducted to investigate the reasons which caused the shortage, in order to understand the reasons behind the failure of attempted solutions. This exploratory study reached a number of recommendations, which would contribute to solving the problem of the housing shortage in Libya.

Finally; this paper presents a number of recommendations that could bring a solution for shortages of housing in Libya.

Keywords:
Housing, shortages, policy, practice, Libya

1. Introduction

A housing problem is one of the most important problems of concern to all countries, including developed and developing countries. Even for some political parties, housing shortages occupy the top of their manifesto at elections times, as a good method to gain popular votes. It also takes the priority agenda of most governments, and Libya is no exception to these countries. After a big boom in the 1970s, in the whole Libyan economy, the housing crises appeared in the early 1980s. Libya attempted to overcome the housing shortage by relying on its own governmental efforts but success was not achieved. Through exhaustive study as a part of a PhD field study, entitled "How to attract foreign direct investment to invest in housing in Libya" there were a number of reasons identified that led to the housing shortage; also there were several causes that hindered attempts at solving this problem. This paper draws from chapters five and six in a PhD study mentioned earlier, and used multiple data sources, such as official documents, legislation survey and semi-structured interviews.

An exploratory methodology has been adopted in this study, due to the rarity of studies in this field in Libya. This paper is divided into two issues, the first issue deals with the housing shortage; causes of the housing shortage, attempts to solve the shortage problem and its failure, and suggestion for recommendations to overcome the housing shortage. The second issue deals with how to attract FDI to invest in housing in Libya. Multi sources of data are used, whereas, official documents such as legislations, governmental decrees, speeches of high level officers, the second kind of data is observations, as well as semi-structured interviews with various levels of officers. A triangulation analysis method has been used to analyse these various data at the same time to achieve the aim of this study. Through in depth investigation, the following issues have been clarified.

2. Reasons of the Shortage

Libya has faced many difficult circumstances since the 1980s that caused many economic and social problems. The housing crisis is one of the most important problems. There are a number of reasons behind this housing shortage, some of them are internal and others are external.

2.1. Internal Reasons:

An in-depth investigation has been conducted, it has been found that the internal cause's fall under a variety of headings: such as:

2.1.1. Overambitious targets have been adopted:

As a result of abundant oil revenues, Libya started to develop its economy rapidly. An enormous amount of money had been allocated for development plans; in particular, in the housing sector, but in some years the actual expenditure was significantly less than allocated amounts as a result of these overambitious targets bigger than Libyan ability. Libya generally failed to reach targets, for example, the shortfall was 17.1% in 1991 and 18% in 1994. This is illustrated in the report of the General People's Secretariat of Planning, Economic, and Commerce in 1997.

2.1.2. Administrative System Instability:

Libya had adopted a socialism regime since 1977, which resulted in a lot of changes in the Libyan government administration. Both the high level (decisions makers) and low level (decisions implementers) had been changed several times, often at the same time. Mergers of some of the General Peoples' Committees (Ministries) occurred at times, even their abolition at other times. This administrative instability has been considered as one of the most significant causes, which led to the decline in development levels in the Libyan economy (Al-Megharbi, 1993)

Generally, it can be said, that many of the changes in administrative organisations and the administrative instability were a real cause for unsuccessful development plans in whole sectors of the Libyan economy, including housing.

2.1.3. Population Increases:

As a result of the oil heyday which affected the whole Libyan economy, the Libyan population has seen high growth levels. It reached 4.3% in 1972 (Lahmeyer, 2003). Shamia and Kaebah (1996) mentioned the number of families rose from 387,043 families in 1973 to 727,523 families in 1995. In addition, 78% of interviewees affirmed that the increasing population was one of the reasons causing the housing shortage. However, numerous people postponed their marriage plans until acquiring a house, also leading to a further increase in housing demand.

2.1.4. Local Contractors' Experience Inadequacy:

Since the 1990s the Libyan policy in housing has been to encourage contracting with local contractors. In executing and sometimes investing in the Libyan housing sector, it became apparent that most of the local contractors suffered experience weaknesses in executing large scale housing projects. 68% of interviewees confirmed this as a problem supported by the General Board for Housing (2003). As a result of the deterioration of the contracting apparatus, and in spite of attempts to re-organise many times, it became even harder to satisfy the stringent demand in this sector. Absence of local qualified labour and skilled labour in the construction sector led to near total dependence on foreign companies and labour (General Council of Planning, 2002).

2.1.5. Establishment Legislation That Prevents Leasing:

The socialism regime has been adopted in Libya, and that led the government to establish laws rejecting ownership for leasing purposes. "The house is a basic need of both the individual and the family. Therefore, it should not be owned by others." (Al Qathafi, 1975:53). As a consequence legislation that prevents leasing has been established. One of most important laws is Act no: 4, 1978, which prevented leases. As a result, these laws prevented activities for profit and stopped rental housing and prevented the private sector building houses for lease purposes.

The General People's Committee for Planning, Economic, and Trade study (1997) pointed to a lack of private sector participation in the housing sector. Moreover, 88% of the interview sample confirms that the legislation that prevented leasing was an important reason for the housing shortage

2.1.6. Decrease in Financial Resources:

One of the methods which policy-makers in Libya believed would solve the housing problem was dependent on individual savings from the people to implement the personal capabilities policy, 51% of the total Libyan workforce are government employees as cited in the Porter report (2006), while Dr. Ghanem the Secretary of the General People's Committee (SGPC) (Prime Minister), (2004) illustrates in his speech that the percentage of government employees is more than 70% of the formal workforce. 400,000 of 800,000 government employees are in public education. Whereas, 8% - 10% is considered as an acceptable percentage of the workforce employed in the public sector - as confirmed in the Porter Report. However, the majority of public employees' monthly incomes are low, where 95.7% of them earn less than 500 LD, and 85% less than 300 LD per month (General Board of Information, 2002:51). 500 LD is equivalent to £200 (XE Trade Currency, January 2008). These low levels of income are insufficient for even essential goods. When matched by equally poor income levels in the private sector, there is little left for saving and investment.

The next form of financing was by loans and mortgages from commercial banks to put into effect lending as an implication of the government personal capabilities policy. But it suffered procedural complications (Porter Report, 2006, ranked Libya 98th out of 100 countries that has difficulties in banking procedures) and restrictive laws, hence it became inefficient.

The Governor of the Central Bank of Libya' in a letter dated 30.11.1994 to the Secretary of the General People's Committee requested an extension to the period for 60,000 units from three years to five years due to financial difficulties. This letter is evidence of the lack of financial resources in the housing sector. Furthermore, 58% of the interviewees said Government financial difficulties were one of the causes of the shortages in the housing sector.

2.1.7. Vacillating Public Targets:

The crucial feature at the beginning of the period 1970 - 1995 was the government's total service provision to all people. These services included housing. Therefore, huge amounts of the development budget had been allocated to the housing sector. As a result of economic and political events in the first half of the 1980s this led to a severe decrease in devoted amounts for the housing sector, which consequently resulted in changing targets and priorities.

The Evaluation of Housing Policies in the Jamahiriya study by the General People's Committee for Planning, Economic, and Trade (1997), advocated stopping development plans for housing from 1985, and then allocating finance annually to complete previous targets. In addition, 57% of the sample interviewees said the vacillation of targets in the different periods caused the neglect of housing as a priority.

2.1.8 Lack of Adequacy in Urban Planning:

A study on housing policies prepared by the General Council for Planning Act No: (23) for 2002, identified the cause of the housing shortage as the lack of contemporary urban planning. The current plans ended in 2000 (General Council for Planning, 2002), yet, the efforts to prepare new urban plans still suffer from a lot of complications. Hence, land prices have increased rapidly and sharply. Furthermore, 78% of the interviewees affirmed (and in particular 100% of Managers of Urban Planning in the Shabiat) that a lack of urban plans has contributed significantly to the shortage problem in housing.

2.1.9. Changes in the Residential Behaviour of the Population:

In the period before oil was discovered at the end of the 1950s, most Libyans dwelt in troglodyte dwellings, cottages or tents. In the period 1960 - 1970 mass migration to the cities occurred with people looking for better jobs due to the oil boom. This period was characterised by the appearance of inhabitant gatherings in shanty towns on the cities outskirts. Most dwellings were typically occupied by two or more families as cited by the census of 1964. Most families resided in rented dwellings.

However, since 1970, housing behaviour for inhabitants has changed. Families stopped sharing houses as a result of the initial housing sector boom. Libyans were also affected by new cultures and trends, and as a result of this, consumption behaviour was affected. Housing expectations had been permanently changed; this led inexorably to the increase in demand on housing. This increase through time brought about a shortage in housing which was not accompanied by a sufficient increase in supply.

2.2. External Reasons:

These reasons could be divided into: economic sanction effects; foreign companies boycott; and decrease in oil revenues.

2.2.1. Economic Sanction Effects:

Libya has faced sanctions because of political issues; the USA hurried to impose sanctions on Libya in 1982, and continues; these sanctions put Libya in severe circumstances, and this led to economic shrinkage in all economic sectors and a development recession. This harmful economic situation affected the housing sector, similar to the rest of economy. 76% of interviewees saw the sanctions as having a crucial effect on the housing sector and it was one of reasons cited for shortages in housing in both direct and indirect ways.

2.2.2. Foreign Companies Boycott:

Many foreign companies boycotted Libya, in obedience to the UN decision No: 748 for 1992 and decision No: 883 for 1993 which put Libya under sanctions. The departure of these companies led to stops and delays in many projects in which the housing sector has been affected. A lack of hard currency and payment delays also led to the withdrawal of many other multinational companies; as a result completion dates were delayed extensively (Benkrima, 2001; El-hasia, 2005). For instance, according to the decision of the Secretary of General People's Committee of Housing and Utilities No: 191 for 2000, seventeen companies withdrew from housing projects by mutual agreement, most of them Turkish companies (General Board for Housing, 2003: 43-46).

2.2.3. Decrease in Oil Revenues:

The decrease of oil revenues started appearing after the USA administration imposed sanctions on Libya in 1982, where US companies stopped dealing with the Libyan oil sector in particular. As an effect of this, the cost of production in the oil sector had increased and net oil revenues declined (Alavi, 2003). Moreover, the UN decisions in the early 1990s made the situation worse; additionally oil price fluctuations (mostly decreases) participated in creating instability in the economy and made the establishment of development plans more difficult. Based upon the disturbances that dominated the oil sector, this was transmitted to all economic sectors including the housing sector.

3. State Initiatives to Cover the Shortage in Housing:

It can be said that the governments' role in the housing sector in Libya, continued playing a significant role as a bailsman, from the beginning of the study period in 1970 until 1995 despite the bottlenecks in 1980s. In this period the government built houses and allocated them to people. The government assumed total control of the planning process and the provision of land for construction. However, it cannot continue to play the same role because of its limited financial resources and increased workloads.

70% of the interviewees identified that the government had played a significant role in solving the housing shortage problem, while 30% of interviewees regarded the results of government intervention as not solving the problem. Furthermore, the Central Bank of

Libya clarified in its Economic bulletin (2004, first quarter: 24) that the housing loans increased gradually in the period 1990 – 2000, whereas housing loans from the Saving and Real Estate Investment Bank increased from 26.4 million L.D, to 37.7 million L.D, in 2000, and then increased rapidly from 75.5 million L.D in 2001 to 511.6 million L.D in 2003. But the maximum amount of individual loans was not enough for total construction cost. The maximum loan amount was 15,000 L.D, while the actual cost for a typical house was more than 40,000 L.D. The General People's Committee decisions No 393 in 1999 and No 30 in 2000 increased the maximum personal loan to 30,000 LD, but this is still insufficient.

In addition, the government intended to establish 60,000 housing unit projects in a three year plan 1996 – 1998. This period was then extended to five years 1996 – 2000. (The General Housing Board Report (2002)). 63% of interviewees pointed to the project as evidence of government activity.

Nevertheless, this project has been faltering, only 2840 units had been completed by 2004. This report identified financial difficulties were one of the crucial reasons.

Furthermore, new legislation and decisions have been established to encourage local companies to participate, and have made procedures easier for new companies. 46 local public companies and contribution companies have been assigned the task to implement the project of 60,000 housing units. (General Housing Board Report, 2002). Due to the low efficiency of these companies and their lack of experience there was a minimal level of implementation.

4. The Reasons That Hindered Solving the Housing Problem:

The most important reasons behind the failure of housing shortage programmes are:

4.1. Legislatory Reasons:

Through a comprehensive survey of Libyan laws, concerning the housing sector, one can notice that Libya adopted socialism as an eco-political regime and started establishing a number of laws that prevented private sector activities. Law No (4) 1987, was one of the effective legislations, which prevented ownership of more than one house for the family. This law still applied, until law No (11) 1992 was established to give the right for some categories of people to own more than one house. Moreover, it gave some institutions and companies' the right to build houses for rent as investment projects. In addition, there was a lack of conveyancing law applicable to society developments in ownership and lease issues. Moreover, there was an absence of laws that guaranteed banks security on their loans by legal distraining.

The several tenors of these laws were to prevent the private sector from contributing to solve the problem of housing shortages. New legislation established later, gave the right to own dwellings for leasing, such as law No (11) 1992, law No (14) 1995, and law No (21) 1998, which now encourage the private sector to construct dwellings for sale and lease.

4.2. Administrative Reasons:

The absence of efficient administration led to a waste of time and resources without achieving targets. The following points could be the most important in this regard:

Through a survey of the General People's Congress, it was evident that the administration instability was one of the failure reasons. 63% of the interviewees’ answers confirm that the administration problems led to unsuccessful solutions. The rapid changing of the responsible officers led to ignorance of the previous procedures, and the starting of new ones. Therefore, lots of money and time were wasted. Moreover, 52% of respondents think that choosing responsible officers in the councils directly by elections were not efficient. The short period in office was another reason. Furthermore, 83% of the sample affirmed the absence of action to respond to a problem at the beginning and failure to analyse it systematically. This led the problem to grow to a crisis level.

4.3. Political Reasons:

The socialist regime that was adopted in Libya as a political system led to a decline in the private sector and reduced individual initiatives and personal aspirations. Consequently, the changing administrative system in the governmental institutions as a result of political decisions caused confusion in decision implementation. 78% of interviewees confirmed this. 66% of them saw the political decision to repudiate financial obligations had affected the dedicated amounts for development plans. 59% of interviewees responded that a delay to solve the external political problems that Libya was implicated in, led to further housing difficulties.

4.4. Economic Reasons:

Economic reasons occupied the first rank in the authorities' failed attempts to solve the shortage in housing; these reasons could be formulated as follows:

More than 87% of interviewees confirmed that, the dependence on unqualified local efforts to solve the housing problem was the crucial reason for failure. The authorities gave great opportunities to local companies to implement 60,000 units, unfortunately, these local companies abused this chance to benefit from differences in the exchange market, where variations between the official market price, and the black market price was large. In addition, 72% of interviewees stated that one of the significant reasons was financial policies that depended on personal savings. This was implemented without knowing the publics ability to offer sufficient financial resources for individual housing projects.

A weakness of efficiency of commercial banks was an important reason in the failure of the solutions. This was confirmed by 72% of the interviewees. This weakness led to an inability to manage instalments. The total of missing instalments reached 428.6 million LD in the period 1971 - 2001. That led to a decrease in the lending ability. Moreover, 61% of interviewees indicated that the absence of studies in advance for the cost of house construction led to wrong estimates for inappropriate loan amounts. The loan amount (15,000 LD) was less than half the typical building cost of a house. 57% of interviewees also reported that the urban planning departments lag in the implementation of new plans for new projects was one of the reasons for failure. This insufficiency led to a mushrooming of housing units, randomly located to areas which lacked the infrastructure and healthy conditions for effective community development.

5. Decalogue to Solve the Housing Problem

To reform the housing sector and solve the housing shortage in Libya, through field study from interviewees’ answers, studies, official reports, and legislation related to housing in Libya, recommendations have been deduced as follows:

1. Legislation should be reformed to be suitable to allow the private sector to contribute to solve the housing shortage. Establishing new laws to encourage people and organisations to build houses for leasing, and give them facilities such as tax-free status for investors in the housing sector. Making banking procedures easier through banking system reform also helps to solve the housing shortage.

2. The field study confirms that the urban plans have been stopped for more than two decades, and this lead to increased land prices due to scarcity of suitable land for building. This rarity of land makes total construction costs high. Therefore, Libyan authorities should improve urban planning departments and provide crowded cities with land at appropriate prices. New plans for urban development must consider the current needs for land to solve the shortage of housing and preparation of land for future demands.

3. Financing was a crucial issue in this research. When the government was faced with financing problems to solve the housing shortage, it prevented the private sector to contribute, and the inefficiency of state banks made the problem worse. So Libyan authorities should promote new resources to finance the housing sector, enact encouragement legislation and offer an appropriate investment environment to attract local and foreign investors to finance housing projects.

4. The Government should be playing its role to protect low-income families, and build housing units for these people. The Government can seek to achieve social targets which the private sector does not care about.

5. Overestimating the local capacity of public and private organisations in the implementation of housing projects must be avoided. Especially since Libyan authorities relied on local companies that suffered from a lack of experience and finance sources, and this was one of the reasons causing the housing shortage. Thus the Libyan authorities should seek assistance from people who have more experience and capability to finance huge projects.

6. The Government is recommended to establish specialised organisations concerned to research and study housing issues, and benefit from academic staff and specialists input to investigate housing matters. These organisations could foresee future strangulations and find solutions.

7. Non-over-reliance on local building materials is recommended, and importing sufficient materials to alleviate shortages and hence to eliminate the black market, and the provision of these materials at reasonable prices.

8. The Libyan Government should benefit from other societies knowledge and experiences in construction to reduce building costs and introduce affordable houses.

9. Commercial banks should be given more freedom to grant loans and create private housing finance projects in partnership with investors.

10. Administrative stability remains one of the crucial reasons that affect the whole Libyan economy, and housing is not exempt. Therefore, administrative stability

should be provided to solve most economic problems and the housing shortage being one of them.

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Defining a Facilities Management Research Agenda in a Developing Country Context at an Urban Scale

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Abstract:
This paper provides the contextual background for the consideration of an appropriate facilities management research agenda in a developing country context at an urban scale. To this end the paper provides an overview of the context within which local government operates in South Africa. The correlation between the private sector and the public sector in terms of the principles and practices of facilities management is shown. In specifically defining the agenda the paper is exploratory in nature and concludes that the application of facilities management practices and principles at a local government level is not only appropriate but essential in assisting the capacity of local government to deliver on its constitutional objectives.

Keywords:
Facilities management, local government, South Africa

1. Introduction

The purpose of this paper is to define an agenda for facilities management at the local government level and, more specifically, in developing countries. In achieving this objective an overview of the context within which local government operates in South Africa is provided. Following this the paper relates this local context to the principles and practices of facilities management at the urban scale and in so doing lays the foundation for the definition of facilities management in a developing country context.

2. The South African Local Government Context

South African cities still reflect the legacy of the *apartheid* government policies, which were grounded in inequality and racism. This resulted in cities being characterised by spatial separation of residential areas according to population group defined by race; urban sprawl; a lack of services, and the concentration of the poor on the urban edge (Robinson, 2008). The current urban environment is undergoing rapid growth and change, whilst government is struggling to address the social imbalances of the past. Parnell (2004) states that the political transition in 1994 paved the way for a commitment to a developmental state that would reduce inequality and poverty. More than 13 years after South Africa's first democratic elections, housing, infrastructure development and service delivery remain some of biggest challenges facing the South African government. With the aim of fulfilling the constitutional rights of all South Africans, South African legislation has been evolving over the last 13 years to provide greater accountability for the use of public resources, and there are growing demands for improved efficiency and value for money. Local government has a critical role to play in rebuilding local communities and environments, as the basis for a democratic, integrated, prosperous and truly non-racial society (DPLG, 1998).

In examining the South African context, the starting point must be with The Constitution of South Africa which sets out the framework for local government. More specifically, in Section 152 (page 44), The Constitution states that the '*objects of local government*' are:

(a) to provide democratic and accountable government for local communities;
(b) to ensure the provision of services to communities in a sustainable manner;
(c) to promote social and economic development;
(d) to promote a safe and healthy environment; and
(e) to encourage the involvement of communities and community organisations in the matters of local government (RSA, 1996:44).

Section 153 (page 44) of The Constitution further states that in terms of '*developmental duties*', a municipality must:

(a) structure and manage its administration, and budgeting and planning processes to give priority to the basic needs of the community, and to promote the social and economic development of the community; and
(b) participate in national and provincial development programmes.

2.1. The Constitutional Implications for Local Government

Cameron (2001) argues that this new national framework embodied in The Constitution has had a profound effect on local government. Cameron (2001; 1995) further argues that these clauses indicate a fundamental shift away from a system of provincial control of local government which has characterised South Africa's intergovernmental system since 1910. The key aspect of these developmental duties outlined in Section 153 of The Constitution that must be noted is the specific requirement that the municipality must *structure*, *manage*, *budget* and *plan* in such a way so as to promote social and economic development of the community. A traditional definition of 'community' is adopted for this paper that encompasses all individuals, groups and businesses that reside and work within a spatially bounded locality i.e. the municipality (Delanty, 2003). This mandate requires the municipality to restructure itself in such a way so as to be in a position to fulfill its obligations. Hence, shortly after the enactment of The Constitution in 1996, two White Papers were gazetted that entrench the constitutional vision for local government. These were the White Paper on Local Government (DPLG, 1998) and the Batho Pele - 'People First' White Paper on Transforming Public Service Delivery (DPSA, 1997).

Within the framework of The Constitution, the White Paper on Local Government (DPLG, 1998) establishes the basis for a new developmental local government system, which is committed to working with citizens, groups and communities to create sustainable human settlements which provide for a decent quality of life and meet the social, economic and material needs of communities in a holistic way. This White Paper requires local government to focus on, *inter alia*, the promotion of local economic development and community empowerment.

The purpose of the Batho Pele White Paper is to provide a policy framework and a practical implementation strategy for the transformation of public service delivery to all areas of the public sector including local government. It aims to change the value system through the development of a ‘belief set’ of ‘we belong, we care, we serve’ (DPSA, 1997).

A number of additional pieces of legislation followed The Constitution, namely: The Local Government: Municipal Structures Act No.117 of 1998, The Local Government: Municipal Systems Act No.32 of 2000, The Local Government: Municipal Finance Management Act No.56 of 2003, The White Paper on the Management of Provincial Property in 2004 and the Government Immovable Asset Management Act No.19 of 2007. At the heart of the legislation lies the need for local government to fulfill it constitutional mandate. As a result the legislation aims to provide core principles, mechanisms and processes to facilitate the need for local government to move towards the social and economic upliftment of local communities.

In light of the slew of legislation it is interesting to note that Cameron (2001) argues for the importance to evaluate the implementation of the new local government system. It is further argued by Cameron (2001) that one of the characteristics of many developing countries is the gap between the constitutional and legislative requirements of local government and the reality of the local government’s ability to deliver on these requirements. This argument is supported by Parnell (2004) who argues that there is a need to first focus on the incomplete transformation or restructuring of local government to ensure that municipalities are able to reach their social, environmental and economic obligations.

2.2. Correlating the Private Sector ‘bottom line’ and the ‘duty’ of Local Government

Pieterse et al. (2008) argue that post the 2000 local government elections, the ‘*objects*’ and ‘*duty*’ of local government, as it is set out in The Constitution (RSA, 1996:44), remained entrenched despite evidence that many municipalities were not able to function in any way that resembled the legislation. Furthermore, Pieterse et al. (2008) argue that the problem is one of institutional capacity failure. This apparent inability of local government to link its business processes and the management of its resources with the need to deliver on its core objectives is no different to that of a private sector company. Gordon (1993) argues that, within the context of local governments, the primary focus is not the ‘bottom line’ and their motives are not profit based. Furthermore, that emphasis is placed on the provision of services to the public with finite resources. In developing this analogy further, for the private company a core objective may be return on investment or share value whereas for the local government in the South African context it is, *inter alia*, ‘to promote the social and economic development of the community’ (RSA, 1996). Clearly, the local government objectives are set, the outcome/output of its performance is measurable, but this performance is dependant on the quality of facilities, utilities and infrastructure within their jurisdiction. Nutt and McLennan (2000), in a discussion of the ‘four trails to the future’, highlight an interesting aspect of the physical resource trail that points to the role that facilities and infrastructure can play in the provision of a sustainable and supportive environment for business and social organisations. At the urban scale any changes to the provision of facilities and infrastructure would be of the type that the local authority would deal with e.g. power supply, water supply, road infrastructure etc. If one returns to The Constitutional duty of local government, this analogy is even clearer. To reiterate, The Constitution states that local government must *structure*, *manage*, *budget* and *plan* in such a way so as to achieve its objectives. This ‘duty’ is in fact no different to that of any company aiming to achieve a defined return.

2.3. *Correlating the Private sector and the Public Sector in terms of the Principles and Practices of Facilities Management*

Following this argument, the next question is what management principles are at the disposal of local government to assist it to strategically align itself to be able to deliver on its core objectives? While business management principles are available, the facilities management context better reflects the problem outlined here and facilities management principles are clearly applicable. Traditionally the theory and practice of facilities management has focused on the strategic alignment of the organisation and its output via the provision of facilities and utilities (McGregor & Then, 1999; Nutt & McLennan, 2000; Alexander, 2003; Barrett & Baldry, 2003; Atkin & Brooks, 2005). In terms of theory and practice of facilities management being applied at the local government level this focus is entirely relevant. The 'strategic alignment' of local government and its required output is clearly documented in The Constitution and other relevant legislation in South Africa. At an operational level the local government is entirely responsible for the 'provision of utilities' i.e., water supply, sanitation, electricity, road infrastructure and other related services. It is at the strategic level that one would expect to find local government utilising facilities management practices and principles in an attempt to leverage local economic development and social upliftment.

Grimshaw (2004:29) in seeking to show the relationship between facilities management and critical theory concludes that in the context of the workplace, facilities management *"can be an active agent of change that integrates its technical, economic and social skills to promote social change for the benefit of all. It can contribute to the onwards development of social policy in one of its important and problematic arenas".* This conclusion is especially valid when viewed at the urban scale and in terms of the application of facilities management at the local government level. Clark and Rees (2000) review the findings from research into growth and effectiveness of facilities management in the health-care sector and local government public sectors in the United Kingdom and conclude that facilities management warrants a 'high status' in the strategic composition of local government authorities. Roberts (2004) calls for public service organisations (read 'local government') to reinvest in community facilities and systems at the urban scale. Alexander and Brown (2006) define the concept of community-based facilities management and call for the development of a socially inclusive approach to facilities management. Moreover, Alexander and Brown (2006) call for a new alignment between facilities management and the management of public infrastructure. Brackertz and Kenley (2000, 2002a, 2002b, 2002c) and Brackertz (2006) in an investigation of local government authorities in Melbourne, Australia, argue that local government authorities have difficulty in managing their property and facilities strategically. They further argue that the problem is exacerbated by the 'dichotomous structure' inherent in local government authority management.

Since the knowledge base of the application of facilities management within local government does exist, it must be assumed that the failure to deliver on the part of the local government is hypothetically as a result of organizational structure, and consequent problems with delivery and implementation.

3. Defining a Facilities Management Research Agenda

The foregoing argument has established that facilities management principles, at both the operational and the strategic level, can be applied at the urban scale. The next question is how do these principles translate into a facilities management agenda for local government?

The outputs that are required of local government are numerous as defined in The Constitution. In terms of part (a) of Section 153 local government is to 'give priority to the basic needs of the community, and to promote the social and economic development of the community'. Each of these outputs will be addressed individually below.

Firstly, the output of giving priority to the basic needs of the community can be seen in ensuring the provision of basic services to all. Hence, in terms of operational facilities management this would entail the 'provision of utilities' i.e., water supply, sanitation, electricity, road infrastructure and other related services.

Secondly, in the promoting the social development of the community the facilities management agenda is more complex. In order to define an appropriate facilities management agenda, an understanding of what is meant by 'social development' is required. The term "sustainable social development" may be viewed as the long-term transformation and continuous improvement of livelihoods of people in a given social context (Maaga, 2001). van Wyk (2001) argues that sustainable social development is concerned with the improvement of the living conditions of poor people in a sustainable manner. In this context van Wyk (2001) describes sustainable social development in terms of the local government facilitating the empowerment of communities to address their basic needs in a sustainable manner. Furthermore, that the role of local government is in promotion of cost-effective social development projects in order to uplift the poor in their society. At an operational level the definition of the facilities management agenda in terms of sustainable social development would clearly entail the adequate provision and maintenance of water supply, energy supply and basic infrastructure. At a strategic level, the facilities management agenda gains resonance in the emerging literature on 'community-based facilities management'. Alexander and Brown (2006: 264) define community-based facilities management as *"the processes by which all the stakeholders in a community work together, to plan, deliver and maintain an enabling environment, within which the local economy can prosper, quality services can be delivered and natural resources protected, in order that citizens can enjoy a quality of life"*. Furthermore, Alexander and Brown (2006) argue that the implications for facilities management entail a reorientation from the organization, workplace, business service and advocacy of the user to the community, neighbourhood, community resources and the advocacy of the citizens in that community.

Lastly, in defining an agenda around the promotion of local economic development, it is clear that in terms of the private sector there is a facilities management agenda that is set around the business objectives of 'getting the product to the customer'. The resources needed in order to achieve these objectives would, in essence be a good supply of essential services that keep the built facility functioning i.e., access to financial services, goods, telecommunications, energy, water and skilled workers. The facilities management literature abounds with knowledge on how best to structure, manage, budget and plan in order to achieve the strategic objectives of the company. At the level of the local government the agenda is most likely to be found in the identification of ways in which local government can impact on local economic development. At an operational level this would involve the adequate provision and maintenance of water supply, energy supply, transport infrastructure, trading places, residential places and security to the urban area. At the strategic level it would entail the relaxation of municipal by-laws. For example, this may encompass the relaxation of zoning by-laws in previously disadvantaged areas to allow residents to engage in retail trade from their home. It may also include the reservation of local government work, waiver of onerous contractual conditions etc for SMME's (Small, Medium and Micro- Enterprises).

4. Conclusions

In light of the contextual environment to be found in South Africa, it is proposed that the application of facilities management practices and principles at a local government level is not only appropriate but essential in assisting the capacity of local government to deliver on its constitutional mandate. In addition, this paper is positioned as a stimulus to the debate surrounding the definition of an agenda for facilities management at the local government level and, more specifically, in developing countries.

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Evaluating Real Properties by Historical Prices

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Abstract:
At the present time, property market value is most frequently assessed using the performance and the comparison method of evaluation. This paper informs the specialized public about an innovative method that assesses property market value using index maps of the properties` historical market prices. This method may be used for evaluation of properties for which a market price assessment has been elaborated in the past and/or the proprietary rights of which have been transferred.

Keywords:
Evaluation of properties, property market value, statistics.

1. The historical market value method

In the recent years, the Czech property market has gone through a significant development. More frequently than ever properties are becoming a subject of business activities, are used as a mortgage, are used in the realization of investment projects, etc. Thus, in case of a great many properties, a set of documents has been built up that maps their life cycle. It includes for example design documentation, building and legal documentation, insurance contracts, contracts of lease and also purchase agreements, market value assessments, expert statements, etc.

An assessor assembles all available information on the evaluated property and the respective locality prior to the market value assessment process. In case a market value assessment was elaborated in the past and/or there is an older purchase agreement concerning the evaluated property, the assessor gets important information on the historical market value of the evaluated property. However, the current evaluation methods do not enable an appropriate use of such information. Nevertheless, the historical market value gives the assessor objective information on the property value at a particular date in the past. Provided we are aware of the extent of the historical and current market price alteration concerning a given category of properties with a given location, we can derive its current market value using this historical property market value. The property market value is then calculated through the following formula

$$P_a = P_h * I_c * I_b * I_d \tag{1}$$

Where:

P_a … Current market value of the property.

P_h … Historical property market value found out in the property evaluation documentation (an older market evaluation of the property, an older purchase agreement, etc.).

I_c … Index of change in property market value of the particular property category and location in the time interval delimited by the date of the historical market value assessment and the date of the property evaluation.

I_b … Index of property physical appreciation. Used in the case of property renovation, reconstruction, annex or penthouse construction in the time period delimited by the date of the historical market value assessment and the date of the property evaluation ($I_b \geq 1$).

I_d … Index of property depreciation in the time period delimited by the date of the historical market value assessment and the date of the property evaluation ($I_d \leq 1$).

The index of property physical appreciation I_b is set by means of an authorized valuation. The index value depends on the range of the executed construction work. Provided that in the determined time interval the evaluated property renovation, reconstruction, annex or penthouse construction was not executed, the index value is set to 1.

With regard to a short time interval the *Index of property depreciation* I_d is calculated by means of a linear method using the following formula

$$I_d = 1 - \frac{n}{12 * L} \qquad (2)$$

Where

n … Number of months between the date of the historical market value assessment and the date of the property evaluation.

L … Expected total life of the evaluated property (in years).

The key variable of the historical market value method is represented by the *Index of change in property market value* I_c. For determination of its value EVAL software has been developed that calculates individual monthly indices of change in property market value according to the given category and location. The *Index of change in property market value* I_c is then calculated using the following formula

$$I_c = \prod_{i=M+1}^{n-1} I_{kl}^{i} * I_{kl}^{T} \qquad (3)$$

Where

I^{i}_{kl}… Monthly Index of change in property market value for the *ith* examined month, the *kth* category of property and the *lth* property location.

I^{T}_{kl} … Monthly Index of change in property market value in the month of evaluation. The index value is calculated by EVAL software using the trend in property market value development for a given category and location.

M … Month for which the information on the evaluated historical property market value was assessed. (e.g. Provided an older purchase agreement was concluded on September 15, 2007 then M = September 2007, M+1 = October 2007.)

n … Number of months between the date of the historical market value assessment and the date of the property evaluation.

EVAL software is used to calculate the monthly indices of change in property market value. It systematically assembles, analyzes and assesses the advertised property price quotations. To date, the software has assembled over 530,000 price quotations concerning sale or rental of apartments, family houses and plots of land. All offers are continuously stored in a database and are the subject of a thorough analysis of the data´s credibility. Thus every price quotation is assessed in light of the objectivity and accuracy of presented information and it is compared with older quotations. Moreover, repeatedly advertised properties are searched for, the integrity of presented information is assessed, etc. Thus approximately 250 possible errors, purposely misrepresented information and manipulation malpractices are verified concerning each quotation. In case of the slightest discrepancy (for example designed manipulation of information on the part of the real estate agent, purposely incomplete information on the presented property, duplicity, etc.) the given assessed quotation is discarded from the database. The monthly indices of change in property market value are thus calculated in EVAL software using the afore-mentioned database of pre-assessed credible price quotations.

2. Using the historical market value method for evaluation of lands

Determination of land prices results from existence many different parameters. These parameters are possible easily identify. Factors, which take affect, can be classified to a few main groups. These groups are divided by parameters characteristic. People give priority to the best locality, environment and property area. Somewhere it grew locations, in which there are small building areas with the same small houses. In these locations are missing civic amenities. These problems exist on satellites of the town.

The first group is covering parameters, which have very closely connection with land. This group involves:

1. Area.
2. Form of land.
3. Drop.
4. Cardinal points orientation.
5. Residence.

In the second group are factors, which they are relating to living in this are, where land are placed. Chosen factors, which they can be implicit to this group, are sought after. There it could be include factors:

1. Locality.
2. Environment.
3. Availability mass transportation.
4. Distance to mass transport.
5. Exist of civic amenities.

In next group the third one there are factors, which they pose availability of transportation and supply of services in location for building. In this group is chosen parameters:

1. Exist of waste water drainage, storm water sewer, water supply and others.
2. Density transport infrastructure.
3. Availability for building.
4. Services.
5. Industry.

It can be find out from some data of land registry, landscape planning.

1. Price map.
2. Kind of land in land registry.
3. Exist building, brownfield and the others.

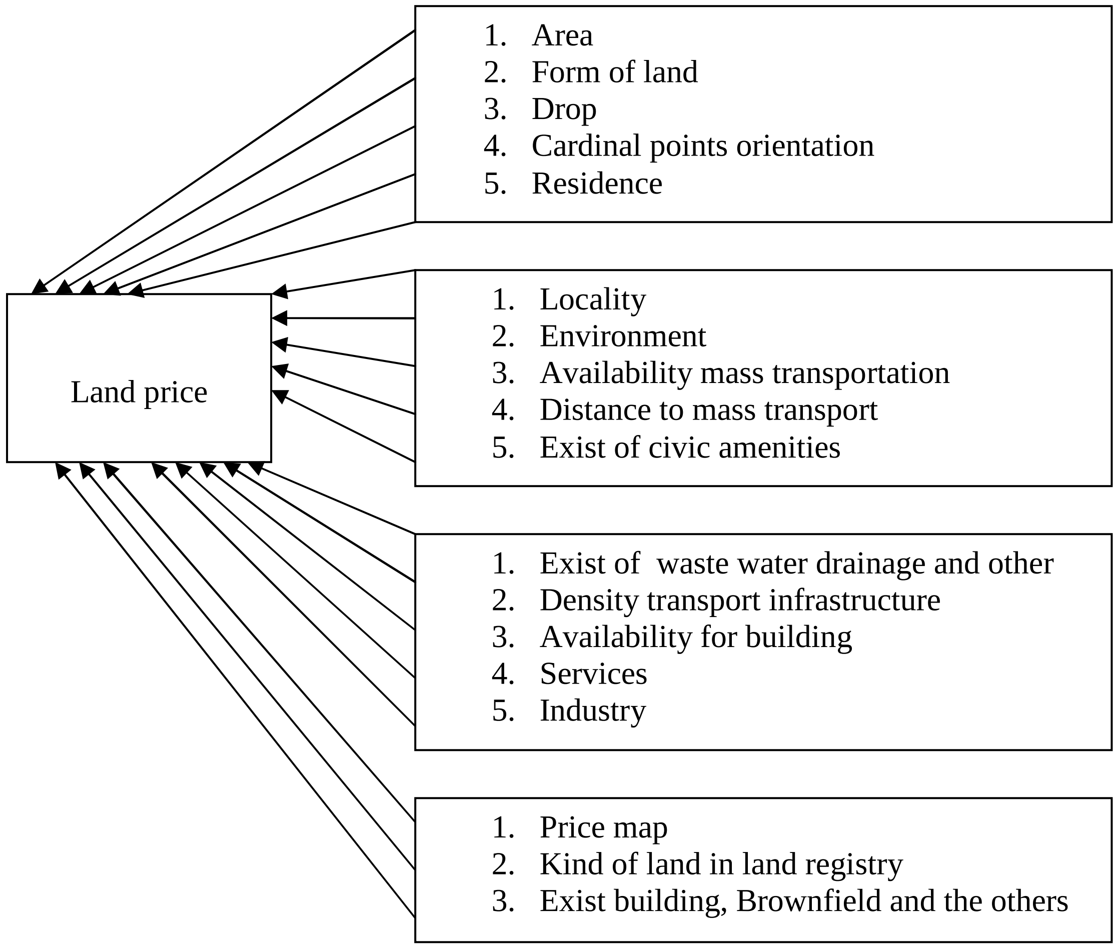

Fig. 1. The factors used for evaluation of lands.

Parameters mentioned above have the most influence in land price. These parameters are interacting together. One positive aspect of factor activate positive or negative aspects another factors. It's very important to include the most number of factors. After that land price should be the most predicative. Generally the most influential parameters are location, form of lands, area, drop and cardinal points orientation.

3. Conclusion

The historical market value method represents an innovative way of property market evaluation. It stems from the principles of the comparison evaluation method. It is usable for determining the market value of apartments, family houses and plots of land. It may also be used for the determination of the usual rate of the apartment or family house rent and for the determination of a property market value at an older date of evaluation.

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Factors that Affecting the Establishment of Accreditation to Industrial Laboratories in Libya

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Abstract:
Laboratories accreditation has been a subject of considerable interest to many groups, because product quality guarantee has become one of the prime factors to be considered in the present time of highly competitive industrial activity. The reliability of the test results, as well as the technical competence of laboratories gives its accreditation, according to international quality standard, such as ISO 17025 a necessity of major importance. Accreditation is still a new issue for the laboratories in Libya, a developing country these laboratories need to establish a new strategy towards accreditation focuses on the difficulties and barriers to implementation. This work paper presents the outcome of a questionnaire survey to investigate factors of laboratories accreditation that are very essential for successful implementation in Libyan laboratories. A total of 400 questionnaires were sent to a variety of industries which included food preservatives industries, industrial research centres, and petrochemical industries and so on. 350 usable questionnaires out of 400 returned, thus giving a response rate of 87.5%. The response rate was satisfactory, as Saunders et al. (1997) have recommended that a suitable response rate should be between 30 and 50 percent. The analysis lead to development of a criticality laboratories accreditation factor structure, comprising 19 factors arranged in descending order of criticality through three layers.

Keywords:
ISO/IEC17025, Laboratory Accreditation, Quality Assurance, Libya, Customer satisfaction

1. Introduction

Product quality is rapidly becoming the most major factor in consumer choice. This is correct whether the purchaser is a person or a big company. Therefore, quality guarantee has become one of the prime factors to be considered in the present time of highly competitive industrial activity. In late 1999, the international organization of standardization (ISO) and the International Electro technical Commission (IEC) issued the ISO/IEC 17025 International Quality Standard, which incorporates all of the necessary requirements for testing and calibration laboratories to prove their technical competence and validity of the data and results they produce ISO/IEC 17025. The reliability of the test results, as well as the technical competence of laboratories gives its accreditation, according to international quality standard, such as ISO 17025 is very importance. In Libya (a rather small country), testing laboratory needs to develop a quality assurance system, according to these international standards, in order to prove their technical reliability and competence. Accreditation is still a new issue for the laboratories in Libya, a developing country these laboratories need to establish a new strategy towards accreditation focuses on the difficulties and barriers to implementation. Among them are a variety of industries which included food preservatives industries, industrial research centres, and petrochemical industries and so on. Although there has been a substantial interest in the improvement of business management; quality management has been significantly less predominant in Libya.

Kekale and Kekale (1996) mention wherever basic approaches to quality management are adopted, an organization needs to develop a suitable implementation approach, which is culturally feasible. Also according to Kochan (1993) the safe way to develop an efficient quality assurance program is to consider the differences in culture, language or organization should be taken under serious consideration, when implementing the quality standard. The application of such a quality assurance system requires a great deal in human resources, top management commitment, organizational effort, expertise and expenses. The purpose of this paper is to identify and investigate the factors that effect the establishment of accreditation of industries sector laboratories in Libya. Due to the need for the implementation of an accreditation, this will enable the industries sector laboratories to comply with international standard called ISO/IEC 17025. Also this paper presents the outcome of a questionnaire survey to investigate factors of laboratories accreditation that are very essential for successful implementation in Libyan laboratories.

2. Literature review

Before engaging in a description of the benefits derived from accreditation and to discuss accreditation issues, it is an appropriate to start with the definition of laboratory accreditation. Ellie, (1990) defines accreditation is a system of impartial out side peer review for determining compliance with a set of standards.

Factors to be taken into consideration in establishing laboratory's accreditation

According to Anschutz (1995) Zamany et, al (2002), the business organization in the Western has developed due to quality issues in the planning process of that organization. In other hand quality issues within Middle Eastern Countries is lower than in Western economies due to a number of reasons such as many organizations in the Middle East have not operated as commercial companies due to different forms of government intervention and the companies have been protected from international competition by government imposed tariffs and trade barriers. Also the absence of competition and the ready market for their products resulted in a poor competitive environment which led to lack of innovation and improvement activities in these organizations This policy of protectionism led to bad effect such as lack of competitive pressure on the national industries, led to neglect of customers as individuals and to a focus on mass production. Sayeh (2005) mention if quality program is to succeed in Libyan Organization there are many factors for the desired culture should be taken in consideration such as building team work, opportunities for growth and development and decentralized decisions, also point out the implementation of quality program in Libya Organizations includes many issues or factors that need to be understood and implemented with careful planning and not merely linked to cultural issues .Al- khalifa and Aspinwall (2000) point out in order to move forward in terms of quality practices is to create a driving force, which is usually associated with pressure from customers or initiative from the owner or the managing director. Wong (1998) point out lack of a real understanding of the principles of quality program due to lack of training and education to develop a quality mindset with in the work force and specially with in the leadership led to fail many of the quality program's implemented in developing countries. Muna, (1980); Suleiman, (1984) found the contextual factors such as politics and culture played a role in Arab management organization .Al-zamany et al (2002) identified three main categories of difficulties of implementing quality management in the Arab countries .Factors related to government issues such as lack of governmental support program's to the quality issues, selection and assessment of managers in public organizations. Also many studies in developing countries such as (Malaysia:Hamzah and Ho,1994;India:Sterman et al., 1997;China:Chen,1997; Thailand: Krasachol et al.,1998; Singapore:Lee,2000) found the lack of governmental support program's to the quality activities is considered one of the most factor's to implement quality management program. Also they found lack of information such as lack of statistical data, effective information and liaising program between the organizations and their ministries to facilitate improvement activities. The second categories of difficulties of implementing quality programs are related to the lack of technical knowledge, short of skilled personnel to implement these activities. The third category of difficulties to implement quality program is related to the current organizational practices which are related to the culture such as people's attitudes or inappropriate managerial traditions. .Baidoum (2003) cite (Ramirez and Loney,1993; Zairi and Youssef,1995; Ali,1997;Ahire et al.,1996,D AYTON,2001;Saraph et al.,1989; Flyn et al.,1994;Thiagarajan,1996;Rao et al;1999;Pun,2001;Sureshchandar et al, 2001; Lau and Idris,2001;Li et al.,2001) found by several empirical studies that Commitment of top management is a critical factor to implement any quality program. Several studies such as (Lorente et al.,1998; Li et al.,2001;Claver et al.,2001; Zhang et al.,2000;Rao et al.,1999;WestlundandLothgren,2001) .Also (Bowden,2000, Wuagneux,2002;Kanji(1998) identified employee empowerment, people management including team work, consideration of culture, employee motivation and people make quality is one of the principles of quality management. Buch and Rivers (2002) mention employee involvement and commitment to the goals of quality management process is successful factors to successful implementation of quality program. Thiagarajan and Zairi (1997) consider the act of maximizing employee involvement in the quality process requires with in the organization to make major adjustments. Also (Oakland, 2000) mention middle management must go on to explain important of quality to the employee for whom they are responsible. According to Baidoum (2003), Thiagarajan and Zairi,1998; Quazi and padibjo,1998; Rao et al.,1999; Zhang et al.,2000; Yosef and Aspinwall,2000; Black and Porter,1996; Tamimi,1998;Pun,2001;Calisir et al.,2001; Dayton,2001) found by recent empirical studies that training and education are critical factor to successful quality program implementation. Zhang et al (2000) consider investment in education and training is important for quality success. Many researcher such as Oakland 2000; Easton, 1998, Haksever, 1996; Dayton, 2001; Everett, 2002, highlight the importance of rewards and recognition in the quality process. Team work is considered as a critical success factors to the success of quality program implementation by Crosby,1989; Kanji and Asher, 1993;Cebeci and Beskese,2002; Mehra et al 1998 Mc Adam and Kelly,2002;Everett,2002.Kanji and Asher (1993) consider communication is part of the cement that holds together the bricks of the quality process. Also Sureshchandeir et al., (2001) and Lorente et al., (1998) mentions communication is important for the success of any quality initiative and it is critical from the beginning of a change effort. Zhang et al (2000) point out materials and purchased parts are the most sources of quality problems so supplier quality management is an important aspect of quality management. Oakland (2000) mention self-assessment highlights strengths and improvement opportunities and drives continuous improvement.

3. Methodology

Based on the literature review of the major quality and laboratory accreditation factors and ISO 17025 requirement, 19 factors were derived to construct the questionnaire of this study. The questionnaire survey targeting the variety of industries sectors laboratory in Libya, which included food preservatives industries, industrial research centres, and petrochemical industries and so on, aims to identifying the awareness of these laboratory's of each of the 19 factors as to its level of criticality in order to establish a new strategy towards laboratory accreditation This study seeks to collect date about laboratory's employee's attitudes towards laboratory quality and accreditation through a structured survey. A questionnaire was developed based on literature review in the area of quality and laboratory's accreditation. The basic design of the questionnaire relied on closed questions and a three-point scale. The level of measurement used in the survey questionnaire is a three-point ordinal scale with critical, important, and minor importance. A total of 400 questionnaires were sent to industrial laboratories throughout Libya, randomly chosen from those listed in the Libyan, telecommunications directory. A covering letter accompanied the questionnaire, which explained the nature of the study, asked the participants to fill in and return the questionnaire in the self-addressed enveloped provided. 350 questionnaires were returned for analysis (a response rate of 87.5 per cent), the response rate was satisfactory, and as Saunders et al. (1997) have recommended that a suitable response rate should be between 30 and 50 percent. Following the data collection stage, the responses were coded to enable them to be computer processed. The researcher used the software package referred to as Statistical package for the Social Sciences (SPSS). Frequency distribution is most appropriate for the data organization as it allows the responses distribution for a variable to be summarized by computing the typical value (point of central tendency).

4. Analysis of responses

Table (1) shows the responses distribution for accreditation factors according to their important.

Factor	C.F	I.F	M.I	Factor	C.F	I.F	M.I
Training	286	28	31	Government support	161	102	87
Management commitment	227	89	34	Effective information	201	97	52
Rapid communication	188	114	48	Bad peoples attitude	112	145	93
Technical expertise	210	87	53	Technical experience	200	92	58
Time and resources	185	111	54	Resistance to new responsibilities	141	122	85
Documentation process	185	105	60	Managers as motivators	175	102	73
Cooperation	201	97	52	Financial capacity	182	94	74
International competition	186	101	63	Appropriate technical	190	98	62
Pressure from customers	97	117	140	Awareness of accreditation	151	122	73
Ready market	99	151	100				

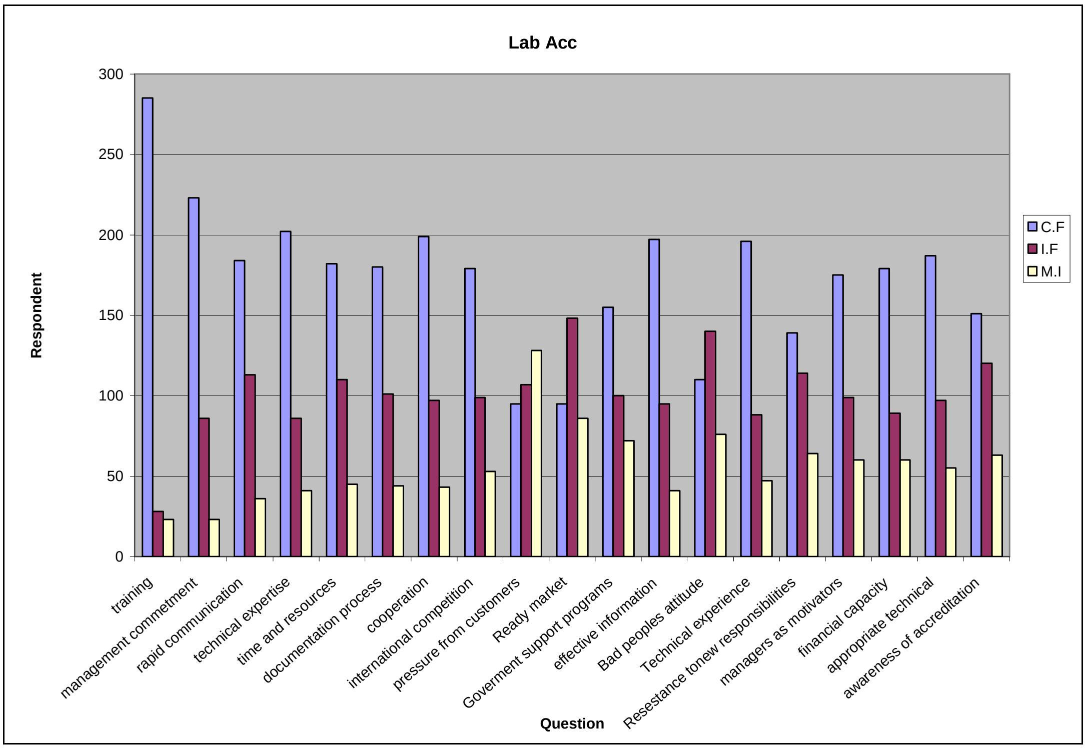

Fig. 1. Frequency distribution of responses

The use of mode as the measure of central tendency for this level of investigation is proved appropriate. A total of 16 laboratories accreditation factors were stacked on critical categories, 2 laboratories accreditation factors were stacked on important categories, while one factor was returned as of minor importance. This factor is related to pressure from customers (see Figure 1). Thus, the three types of modal categories are identified, that is, critical, important and of minor importance. These modal categories are presented in Table (2).

Table 2: Accreditation and quality factors ‘modal category

Accreditation factor
Modal category- Critical
1- Lack of training of employee and education
2- Lack of top management commitment and involvement
3- Lack of rapid and effective communication
4- Lack of technical expertise on ISO 17025 implementation
5- Lack of time and resources
6- Lack of documentation process
7- Lack of cooperation and commitment of work force
8- Lack of international competition
9- Lack of governmental support programs to accreditation
10- Lack of effective information
11- Lack of experience amongst managers
12- Resistance to new responsibilities
13- Lack the role of middle managers as motivators and transmissions
14- Lack of financial capacity to meet the accreditation implementation cost and maintenance costs
15- Lack of appropriate technical knowledge amongst workers
16- Lack of awareness of accreditation at the management level
Modal category –important
17- Ready market and poor competitive environment
18- Bad peoples attitudes towards accreditation
Modal category- minor important
19- Lack of any pressure from customers

4.1. Variation ratio and Stratification of the identified critical quality factors

Using the variation ratio will help to separate the accreditation factors with majority consensus from other accreditation factors with no majority consensus as perceived by some respondents as of no consequence to the success or failure of the implementation process of laboratories accreditation. Table (3) shows the computed variation ratio for the 14 accreditation factors returned by respondents as critical. The variation ratio values, however, identified 14 accreditation factor to have majority consensus (those with variation ratio values greater than (0.5). The findings, therefore, represent the fundamentals to build the stratified structure of the critical accreditation factors.

Using the range and the variation ratio provide an opportunity for objective judgment in the process of ordering and stratifying the critical accreditation factors, exactly as the mode did in the identification of these accreditation factors. Sorting and ordering these accreditation factors according to the level of consensus is measured by the variation ratio, which shows how descriptive the mode is of the responses. Having identified the critical accreditation factors using the modal category, and developed the hierarchical structure using the variation ratio, the stratification of these critical accreditation factors becomes essential. Stratification of the accreditation factors, therefore, describes the identified accreditation factors with regard to their degree of impact in the successful implementation of Laboratories accreditation applying prioritisation process of these accreditation factors according to their perceived criticality. Table (3) presents the accreditation factors ranked in a descending order of their frequency distribution of the mode and the range of these factors.

Table 3: Accreditation factors clusters

Ques.	Accreditation Factor	Variation Ratio	Frequency distribution of the mode.	Stratification into tier
Q-1	1- Lack of training of employee and education	0.186	0.817	1
Q-2	2- Lack of top management commitment and involvement	0.363	0.637	1
Q-4	3- Lack of technical expertise on ISO 17025 implementation	0.423	0.577	2
Q-7	4- Lack of cooperation and commitment of work force	0.431	0.569	2
Q-12	5- Lack of effective information	0.437	0.563	2
Q-14	6- Lack of experience amongst managers	0.440	0.560	2
Q-3	7- Lack of rapid and effective communication	0.474	0.526	3
Q-5	8- Lack of time and resources	0.480	0.520	3
Q-6	9- Lack of documentation process	0.486	0.514	3
Q-8	10- Lack of international competition	0.489	0.511	3
Q-17	11-Lack of financial capacity to meet the accreditation implementation cost and maintenance costs	0.489	0.511	3
Q-16	12- Lack the role of middle managers as motivators and transmissions	0.500	0.500	3
Q-11	13- Lack of governmental support programs to accreditation.	0.557	0.443	4
Q-15	14- Resistance to new responsibilities	0.603	0.397	4

The criteria to be used in the stratification process are as follows:

Critical Accreditation factors stratified in tier 1 are those that are have Frequency distribution of the mode more than 60%, and these factors are Q1, 2.

Critical Accreditation factors stratified in tier 2 are those that are have Frequency distribution of the mode more than 55-60% and these factors are Q4, 7, 12, 14.

Critical Accreditation factors stratified in tier 3 are those that are have Frequency distribution of the mode more than 50-55% and these factors are Q 3, 5,6,8,17,12.

Critical Accreditation factors stratified in tier 4 are those that are have Frequency distribution of the mode less than 50% and these factors are Q 11, 15.

Critical accreditation factors stratified in tier 1 and 2 are those factors that are essential to successful Laboratories Accreditation implementation as perceived by the vast majority respondents to impact on the success of laboratories accreditation implementation. This tier includes six laboratories accreditation factors as shown on table3.The tier3 Laboratories accreditation factors are absolutely essential as perceived by the majority of the laboratories while some laboratories perceive them to be of no consequence with regard to the success of Laboratories Accreditation Implementation. Tier 4 includes two laboratories accreditation factors, which are arranged in order of their majority consensus level as shown on the table (3) as perceived by the respondent.

5. Discussion

All factors are shown to be important with different degree of importance. However as the finding shows on table 3 that the level of importance varies from one set of criteria to another, Most of the critical accreditation factors stratified in tier 1 is known in the literature as fundamental components to be emphasized in the early stages of the implementation process. Particularly:

5.1. Training and education

Adequate employees' training such as short courses and seminars is vital especially in Libya. ISO 17025 requirement and several recent studies revealed that training and education are critical to successful any quality program implementation such as laboratory's accreditation .Zhang et al. (2000) consider investment in education and training vitally important for quality issues success. 82% of the respondent which represent the overwhelming majority of the respondents identified training factor as the most important factor to implement accreditation, and this agree with literature.

5.2. Top management commitment and involvement

It is very importance to the success of the whole laboratory's accreditation project is getting true commitment provided by management due to the management supply the laboratories by necessary resources such as money, training and time as well as any type of support. Gillespie (1998), mention absence of management commitment is the main reason for the failure of a quality program. This occurs especially when top management fails to understand the magnitude of the effort required. 64% of the respondent identified management commitment and involvement is very important to implement accreditation

5.3. Lack of technical expertise on ISO 17025 implementation

58%. identified lack of expertise on ISO/IEC 17025 is important factor to implement laboratory accreditation, this is agree with literature review according to Vlachos and Michail (2002) results about implementing and maintaining quality assurance program such as laboratory's accreditation, it took a time consuming and difficult preparation to implement ISO/IEC 17025, considering the laboratory's lack of previous experience.

5.4. Lack of cooperation and commitment of work force

57% of the respondent identified lack of cooperation of work force is important to implement laboratory accreditation, this is agree with many previous research such as Crosby, 1989; Kanji and Asher, 1993; Cebeci and Beskese, 2002; Mehra et al 1998 Mc Adam and Kelly, 2002; Everett, 2002 all of them were considered team work is a critical success factors to the success of quality program such accreditation implementation

5.5. Lack of effective information

56% of the respondent identified lack of effective information is important to implement laboratory accreditation, this also agree with many previous studies such as (Malaysia:Hamzah and Ho,1994;India:Sterman et al., 1997;China:Chen,1997; Thailand: Krasachol et al.,1998; Singapore:Lee,2000) they found lack of information such as lack of statistical data, effective information and liasing program between the organizations and their ministries to facilitate improvement activities

5.6. Lack of experience amongst managers

56% of the respondent identified lack of experience amongst managers is important to implement laboratory accreditation this agree with literature many researcher mention the difficulties of implementing quality programs are related to the lack of technical knowledge, short of skilled personnel to implement these activities.

5.7. Lack of rapid and effective communication

53% of the respondent identified lack of rapid and effective communication is important to implement laboratory accreditation this agree with literature that Kanji and Asher(1993) mention effective communication is part of the cement that holds together the bricks of the total quality process.

5.8. Lack of time and resources

52% of the respondent identified lack of time and resources is important to implement laboratory accreditation this is have the same opinion with literature review according to Vlachos and Michail (2002) time and resources should be provided to various departments in order to completely assimilate the accreditation requirements.

5.9. Lack of documentation process

51% of the respondent identified lack of documentation process is important to implement laboratory accreditation this agree with literature that quality manual and all quality system documents such as ISO/IES 17025 for laboratory accreditation and any other document related to quality improvement or any piece of information should be issued ,distributed and kept safely.

5.10. Lack of international competition

51% identified lack of international competition is important to implement accreditation. According to Anschutz (1995) Zamany et, al (2002), organization in Arabic countries have not operated as commercial companies due to different forms of government intervention such as lack of international competition.

5.11. Lack of financial capacity to meet the accreditation implementation cost

51% of the respondent identified lack of financial is important, but it is not as the other factors due to good Libyan economic situation, this be against to literature might due to the contextual environmental factors which are related to the politics and culture factors such as people's attitudes or inappropriate managerial traditions which played a role in Libyan management organization.

5.12. Lack the role of middle managers as motivators and transmissions

50% of the respondent identified lack of middle managers as motivators is important to implement accreditation this agree with the literature. Thiagarajan and Zaire (1997) considered the act of maximizing employee involvement in any quality requires middle managers to make major adjustments. The middle management has a particular role to play, they must go on to explain them to the people for whom they are responsible.

5.13. Lack of governmental support programs to accreditation

44% identified lack of governmental support programs is important to implement accreditation, this is agree with literature Al-zamany et al (2002) identified factors related to government issues such as lack of governmental support program's to the quality issues, selection and assessment of managers in public organizations are the main difficulties factors to implement quality management in the Arab countries.

5.14. Resistance to new responsibilities

40% identified Resistance to new responsibilities is important to implement accreditation, this oppose to literature might due to the contextual environmental factors which are related to the politics and culture issues such as people's attitudes or inappropriate managerial traditions which played a role in Libyan management organization.

6. Conclusion

The implementation of laboratories accreditation requires a great deal in management and technical issues such as human resources, top management commitment, organizational effort, expertise and expenses. The discussion of the findings reveals that 14 out of19 critical factors identified in this investigation share most of the values covered by the ISO 17025 requirement and several recent studies as mentioned in literature. The results of this investigation suggest that need to be addressed and dealt with the Libyan context the 19 critical laboratories' accreditation and quality factors.

The findings of the survey questionnaire returned that all 19 factors are of critical importance except one factor (Lack of pressure from customers). This might be due to the contextual environmental factors which are related to the politics and culture issues such as many laboratories in Libya have not operated as commercial laboratories due to different forms of government intervention and the laboratories have been protected from international competition by government imposed tariffs and trade barriers. Also the absence of competition and the ready market for their products resulted in a poor competitive environment; therefore, the stratified critical factors can be used to construct a framework for laboratory's accreditation implementation in Libya. Such a framework is based on the implementation of the 19 critical factors ordered according to their importance. Finally the implementation of laboratories accreditation in Libya will require considerable work to set priorities for implementation. More work is needed to provide better understanding of the difficulties of implementation those factors and to establish laboratories accreditation.

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Forgotten Dimensions of Low Cost Housing Crisis in Zimbabwe

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Abstract:
The provision of housing, particularly for low income persons, is seriously inadequate in most developing countries and the main reasons for this imbalance of shelter delivery are in most cases beyond the control of the individuals affected. The housing crisis in Zimbabwe is no exception, where the people on the bottom of the income scale are faced with escalating troubles as a result of wrong housing strategies and policies. All policies, strategies and efforts aimed to alleviate the housing crisis in Zimbabwe are based on the number of house units to be built for equal number of home seekers. But this approach of demand and supply of housing units in the aim of solving low cost housing crisis in Zimbabwe has failed. Misconception of meaning and understanding of 'Housing' and 'House', misconception and government policy of squatter settlement, inappropriate contextual factors, choice of inappropriate building materials and construction techniques, user participation, obsolescence and overcrowding, and inappropriate Building Standard and By Laws are some of the forgotten dimensions of low cost housing in Zimbabwe. This paper identifies these forgotten dimensions of the housing crisis and analyses the solution addressing these issues.

Key words:
Dimension of housing crisis, house, squatter, appropriate technology, building standard

1. Introduction

Hundreds of millions of people in the world today live in poor housing under adverse climatic conditions that stress their undernourished bodies toward the limits of human endurance and occasionally beyond (Shearer, 1986). According to Kamete (2006), the housing crisis is often sold and pushed onto the agenda in pre-dominantly quantitative terms and the mismatch between supply and demand is perhaps the scariest indicator used by proponents of increased housing delivery. Kamete (2006) also quoted that, it is hardly an exaggeration to conclude that housing policies and strategies are assessed by the number of housing units they produce and by their contribution to the reduction or elimination of housing deficits (Mayo et al., 1986), especially in the lower echelons of the urban income pyramid (Burgess, 1978, 1982). This is true not only in academic and professional circles (Buckley and Mayo, 1989), but also on the institutional policy and decision-making arena (Shildo, 1990), both at the local scene (NHTF, 1999), and on the international stage (World Bank, 1993).

This paper aims to identify and examine the forgotten dimensions of Zimbabwe's urban low cost housing crisis. It analyses the solutions of the forgotten dimensions of low cost housing problem and brings out how the forgotten dimensions of the low cost housing crisis influenced the overall housing situation in Zimbabwe. It also assesses how the current perception of dimensions of low cost housing crisis and policy framework, thought inadequately and how these thoughts obscures the total solution of housing problems. The critical analysis of this paper concludes by highlighting the importance of addressing wider dimensions of low cost housing crisis in Zimbabwe. Below is the list of overall dimensions of housing crisis in Zimbabwe which the author strongly recognised to be addressed in order to achieve a sustainable low cost housing solution: -

1. Misconception of meaning and understanding of Housing and House amongst the Professionals, Politicians, Government decision makers, Stakeholders, and House owners.
2. Misconception of Squatter settlement and government policy towards squatter settlement.
3. Inappropriate Contextual Factors: - Design of the house units and layout design is done without the consideration of Vernacular Forms, cultures, values, climate, and materials.
4. Finance
5. Choice of Inappropriate building materials and construction Techniques.
6. Poor land delivery system.
7. User Participation: - Isolation of user groups from design and construction process.
8. Obsolescence and Overcrowding (Kamete, 2006)
9. Inappropriate Building Standard and By Laws: - Town Planning, Infrastructure, and Building Standards.
10. Shortage of skilled manpower
11. Unstable political situation and hyperinflation of the country

Finance, available land for the low cost housing, shortage of skilled manpower, unstable political situation and hyperinflation are more or less being discussed amongst the relevant government ministries and public Medias in Zimbabwe. The forgotten dimensions of housing crisis which are discussed and analysed in this paper are as follows: -

1. Misconception of meaning and understanding of Housing and House amongst the Professionals, Politicians, Government decision makers, Stakeholders, and House owners.
2. Misconception of Squatter settlement and government policy towards squatter settlement.
3. Inappropriate Contextual Factors: - Design of the house units and layout design is done without the consideration of Vernacular Forms, cultures, values, climate, and materials.
4. Choice of Inappropriate building materials and construction Techniques.
5. User Participation: - Isolation of user groups from design and construction process.
6. Obsolescence and Overcrowding (Kamete, 2006)
7. Inappropriate Building Standard and By Laws: - Town Planning, Infrastructure, and Building Standards.

2. Misconception of meaning and understanding of Housing and House

The house, more than sheltering us from rain, sun, dust, and other elemental afflictions, shelters us from the world. A house is not a machine for living in; it is a private world, dependable, unchanging, a constant kindly refuge in the cultural avalanche that we are pleased to call civilization (Fathy, 1960). According to Rapoport (1969, 46), the house is an institution, not just a structure, created for a complete set of purposes. Because building a house is a cultural phenomenon, its form and organisation are greatly influenced by the cultural milieu to which it belongs. If the family is the fundamental social group- the interpreter and buffer between the individual and society – then the house has an analogous function as between the individual and the world of things. It is the objective and tangible projection of the family, and the most important thing in a family's or an individual's life

(Fathy, 1960). A house is not only a physical space in which people live, but also a space where social interactions and rituals take place (Ozaki *et al*, 2002).

Houses express culture, whether through purposeful design or everyday use. House forms, their internal layouts, and the layout of dwellings in a neighbourhood can be disruptive or supportive of the culture of their occupants (Rapoport, 1969; Bochner, 1975; Ozaki, 2002). A house is laid out according to how it is to be used and various sociological and historical studies of housing have thus claimed that the layout of a house expresses underlying cultural values and norms, which limit the possible choices for use of space (Clark, 1973; Jordanova, 1989; Mumford, 1970; Rapoport, 1969). House forms are reflections of socio-cultural factors in England and Japan and it has been found that, intervening factors make the causal relationship between cultural values and housing form a complex one, as a variety of cultural factors affect housing forms. For example, women's status has had an impact on the spatial arrangement of the kitchen and the living area in both in England and Japan (Ozaki, 2002).

On 19 May 2005, the Government of Zimbabwe embarked on an operation to "clean-up" its cities and it was a "crash" operation known as "Operation Murambatsvina", referred to "Operation Restore Order" (Herald, 2005). It is estimated that some 700,000 people in cities across the country have lost their homes, their source of livelihood or both and indirectly, a further 2.4 million people have been affected in varying degrees (Tibaijuka, 2005). Tibaijuka further highlighted that education for thousands of school age children has been disrupted and the vast majority of those directly and indirectly affected are the poor and disadvantaged segments of the population. They are, today, deeper in poverty, deprivation and destitution, and have been rendered more vulnerable. Operation Restore Order took place at a time of persistent budget deficits, triple-digit inflation, critical food and fuel shortages and chronic shortages of foreign currency and was implemented under lack of dialogue between Government and local authorities, and between the former and civil society (Tibaijuka, 2005, p7). As a solution to the housing crisis because of Operation Restore Order, the Government of Zimbabwe embarked on low cost housing projects like Operation Garikai and Hlalanikuhle, in which the main objective is to construct cells of structure for the homeless poor people. From the above concepts of house defined and explained by different authors earlier in this paper, it can be summarised that house is not only a cell or structure to live in but a complete institution, created for cultural phenomenon (values, norms, etc.), social interaction, rituals, economic and psychological factors. Considering house as an institution as explained; current low cost housing projects in Zimbabwe merely contain the above characteristics.

3. Misconception and government policy of squatter settlement

Srinavas (1996) defines squatter settlement as a residential area in an urban locality inhabited by the very poor who have no access to tenured land of their own and hence "squat" on vacant land either private or public. In squatter settlements, the illegal occupation of land and illegal development usually does not conform to town planning standards. So, theoretically it can not be considered as housing. According to Turner (1976), this is a misunderstanding of housing. What is important about housing, he notes, is "not what it is…. But, what it does". The observation is particularly relevant in the cities of the third world where resources (especially finance) are very limited and the persons involved are in dire poverty. However it is important to note that the definition varies from country to country. Therefore, squatter can be described as a residential area, which is developed without legal permission from the city authorities to build, hence their infrastructure and services are usually inadequate. Common confusion exists between squatter settlements and slums. A slum is a residential area that is physically and socially deteriorated. This includes bad housing with inadequate lighting, lack of privacy and subject to fire hazards. These however can be been legally settled and might be properly planned in terms of settlement patterns. On the other hand squatter settlements refer to the condition and legal status of the settlement. Various names are used to describe them, such as: - Informal settlements, Low-income settlements, Semi-permanent settlements, Shantytowns, Unauthorized settlements, Unplanned settlements.

Squatter settlements in some countries trace their existence to three main factors; high rate of population growth due to rural-urban migration leading to low-incomes and unemployment, financial constraints that prevent the government from building conventional houses to meet the demand (Chilowa, 1996). In most developing countries squatter settlements have their emergence dating back from the colonial era where the urban space was exclusively for the whites and the locals were allowed in for the services they could offer and were housed in certain localities with no free means of acquiring land. With independence, the flow of locals to the cities was and has been too large for services planned for a small number of people (Jere, 1984). Besides the above, rural poverty and opportunity differences have contributed to mass movements from rural to urban areas. There are other factors like influx of refugees common in Africa and some Asian countries, natural calamities associated mainly with weather and economies that do not seem to improve (Hall and Pfeiffer, 2000).

According to Baum in Checkoway (1986, 25) planning was institutionalised in local government with the promise of offering a technical, value-free source of assistance for public decision making (Boyer 1983; Brownell 1980; Scott 1969). Nevertheless, planning has always been a political activity in the sense that recommendations affect private interests and interested actors have sought to influence decisions. According to Chipungu (2005, 20) the conflict between professionalism and politics have far reaching negative implications than one would expect on the mere surface. Most third world countries seem to be advancing politics at the expense of economic growth. It is now a common phenomenon that politicians try to use their powers even in areas where professional advice is required and essential. But then the point is how much more damage can be allowed before professionals interfere? Recently the so called clean up campaign (Murambatsvina) carried out by the Ministry of Local Government and the City of Harare is one of those political decisions made by the politicians in Zimbabwe. Developing Operation Garikayi/ Hlalanikuhle (meaning, ‘be at peace’) low cost housing is also a kind of solution to low income housing problem which was taken by the Ministry of Local Government and National Housing.

As mentioned above, Zimbabwe government policies towards squatter settlement up to date is either eviction and destroys the settlements. Eviction however, has not succeeded as squatter settlements have continued to increase in number and size from country to country. Some governments started housing programs to replace the earlier programs of clearance. Mass housing on the other hand requires resources in terms of funds and skills. This is in short supply in developing countries and most of them are said not to have had housing policies, which contain clear and effective measures to deal with major housing constraints (Payne, 1984). It is also noted that most governments cannot afford to house large number of the urban poor. Present level of public investment in housing is inadequate in relation to demand and private housing agencies are building very slowly (Asiama & Acquaye, 1986). With self-help groups and Non Governmental Organizations (NGOs) some have acquired a level of improvement leading to recognition by the government officials. It is in recognition of these efforts to house one-self that the governments and World Bank came up with the sites and services schemes. According to Hall and Pfeifer (2000), the poor have built their own city, without any reference whatsoever to the whole bureaucratic apparatus of planning and control in the formal city next door, and they are rightly proud of what they have achieved.

According to the Cities Alliance (2002), upgrading consists of physical, social economic, organizational and environmental improvements undertaken cooperatively and locally among citizens, community groups, and local authorities to ensure improvements in quality of life for individuals. It is the improvement of the settlements ensuring minimal relocation of the residents (Abbott, 2000). What is emphasized through these definitions is the on site improvement by provision of basic services and through the participation of the residents. There are those services, however, that individuals cannot afford to do on their own outside the formal government set up (Payne and Davidson, 1983). These include expensive undertakings like building roads, schools, legal tenure and planning.

4. Inappropriate Contextual Factors

Cities and larger urban areas have distinctly different cultural tradition from the rural areas and this has contributed to the housing problem (Quazi, 1987). In the built environment, cultural and religious influence is evident in our attitudes, the preferences we have towards various aspects of a building and in the way we use buildings. According to Rapoport (1982), culture may be more important than climate, technology, materials, and even economics in influencing the built form. Cultural factors are often responsible for what are sometimes seen as 'irrational' architectural solutions. Solutions influenced by factors such as the need for privacy or religious beliefs, for ceremonial purposes, or even for status and prestige, factors that are usually not trans-cultural. Culture defined as: "... the integrated patterns of human knowledge, beliefs and behaviours. It refers to the art, music, styles, tastes, festivals, rituals, ceremonies, customs, codes, taboos, tools, techniques and institutions like marriage in a given community. ..., culture is the sum total of what binds individuals as a group with roots or into a community in which they think and will together" (Olweny, 1994, p12). So, housing is affected by the cultural and religious idiosyncrasies of a particular population. In defending cultural authenticity, one of the well known Egyptian Architect-Planner Hassan Fathy emphasized that, there is an essential non-interchangeability of cultures. By that he meant that basic cultural elements developed in response to indigenous needs, environmental and psychological, and that alien elements cannot be implanted or transplanted from other cultures or other environments if they are culturally inappropriate. Culturally inappropriate elements that are so inserted into the fabric of the harmonious built environment will undoubtedly generate contradictions, and will, with time, corrode and degrade the traditional culture (Serageldin, 1985, p 17).

The above analysis of culture and its relation to housing clearly shows that, planning and designing of any housing needs a detailed analysis of the particular culture the housing is designed for. The indigenous context (culture, climate, landscape, building material, etc.) must be respected and incorporated into the planning and design of the housing. The question can be asked here, whether the low cost housing designs is implemented considering local context of Zimbabwe? Design of low cost house units and housing layouts are done without the consideration of local culture, vernacular form and climate in Zimbabwe.

According to Ahmed *et al.* (2002) Planners seem inexplicably wedded to the rectilinear gridiron pattern in dealing with low-cost housing and the drawbacks of this approach, when the designs are regularly repeated without much revision and the executed projects never brought to completion, have become all too obvious after four decades of practice. Hassan Fathy stood against the bureaucratic approach to mass housing, the repetition of prototypes in ever-shifting combinations. He advocated individualized attention to each building (housing unit). He admonished architects never to take commissions of more than 15 to 20 house units at a time, to deal with users as individual clients and persons and not as "prototypes" or "generic average families" (Serageldin, 1985, p 18). A research carried out by a group of postgraduate students on low cost housing project layout patterns in Sudan summarises and tested the following hypothesises (Ahmed *et al.* 2002): -

- The physical patterns adopted in these projects were invariably gridiron of simple shapes with no real evolution over more than four decades and minimum benefit from feedback;
- Planners do not take the design of low-cost housing as seriously as they do First- and Second-class housing, where more attention has been devoted;
- Public participation has been overlooked at all stages of planning and implementation;
- Whatever experimentations or innovations were introduced have not been followed up or developed to satisfaction;
- Political expediency has sometimes forced planners hastily to turn up designs or mechanically repeat old ones without much effort in working them to maturity;
- The single-storey developments have contributed to the horizontal expansion and low densities prevalent in the city.

In the case of low cost housing in Sudan, Ahmed *et al.* (2002) stated, "In virtually all the projects the rectilinear gridiron has been adopted as the housing pattern. Planner after planner for almost half a century has apparently seen no reason to change and only a few, fairly superficial variations on the theme have been attempted". Despite the availability of a variety of planning patterns, the simple gridiron was the one invariably adopted for low-income groups; this has enhanced the cheerless profile of the extensions of the city. In the case of Zimbabwe, the scenarios and situations are the same as above Sudanese case studies of low cost housing.

The field of vernacular architecture offers an abundance of concepts that can be of use today in solving the critical housing situation now facing millions in the Third World (Shearer, 1986). The solutions that were found relied on energy from the sun and wind and the innovative, architectural structures and forms that were developed to make use of this natural energy. The vernacular architecture of the Arab World and neighbouring regions not only solved the climatic problems but did so with a combination of beauty and physical and social functionality (Shearer, 1986). A lot of lesson can be learnt and implemented in Zimbabwe low cost housing planning & design if the vernacular architecture is well analysed. Mafico (1991, p43) analysed the problems of community participation, privacy, home ownership and building material are dealt in Zimbabwe vernacular architecture and prescribed the solutions in the low cost housing.

Appropriate housing is housing suited to the needs of the occupants, and takes into account social, economic, cultural and environmental constraints and housing should be viewed not only as a physical product, but as an activity, an activity in which the users' economic, social, cultural and psychological needs are considered (Olweny, 1996). Such an approach will go a long way towards improving the appropriateness of public housing, and ultimately, user satisfaction with housing. According to Turner (1972) the acceptance or otherwise of a need is the most important product of any human activity. Thus, whether or not a house is appropriate, is contingent upon the needs being fulfilled by the housing supplied (Turner, 1972; Sharifa, 1994). So, appropriate low cost housing is only achievable if all appropriate contextual factors are considered in the planning and design stages of low cost housing in Zimbabwe.

5. Choice of Inappropriate building materials and construction Techniques

The Ministry of Public Construction and National Housing (MPCNH) has the responsibility of building and maintaining all government buildings including provision of decent and affordable houses to people of Zimbabwe. The unprecedented boom in the construction industry since independence resulted in the high demand of building materials that superseded the production capacity of the manufacturing sector. In the period between 1989 to 1992, the estimated demand for bricks was 1250million yet only 1002 million were produced. In the same period, cement production levels have only been able to satisfy 84% of the demand most of which was taken by commercial and industrial sectors (MPCNH, 1993). The high demand in basic building materials caused the prices of these materials go up. For instance the cost of constructing a $50m^2$ four roomed house in urban areas rose from ZW $3800 in 1983 to about ZW $22000 in 1990 and more than doubled to be pegged at ZW $50000in 1993 (MIPTP, 1993). According to MIPTP (1993), only 23% of the urban population could afford to buy a house that cost ZW $50000 in Zimbabwe. Chakwizira & Kuchena (2004) highlighted that, the government of Zimbabwe in 1996 had an aim to build houses for all by the year 2000 which unfortunately never achieved and by 2004 approximately 50% of the population in Zimbabwe resided in urban areas. Inflation in August was at 200%, in September 2003, at 400% and by 2004 it was 600%. Up to date the official inflation has reached to 8000% in Zimbabwe (SW Radio Africa, 2007). According to the MPCNH (2000), cement was priced at ZW $15 (1991); ZW $450 (2002); ZW $9000 (June 2003); ZW $30 000 (December 2003) and ZW $40 000 (May 2004) per bag.

According to Zami & Lee (2007), a house is composed of several materials such as brick, cement, timber, window frames and panels, door frames and leafs and several other building materials which contribute to the finished product and the use of bricks as a standard building material began in the early 1900s in Zimbabwe. This was because materials in use then were neither thermally friendly nor sound proof nor above all non fire resistant. However, high density housing in Zimbabwe allows the use of 115 mm brick walls to be used as load bearing walls (Model Building by Laws, 1977). So brick, cement, sand and timber are the major construction materials in Zimbabwe up to date which is unaffordable nowadays and an appropriate building material & construction technique needs to devise to solve the low cost housing crisis. For example, ‘earth’ can be used as an appropriate construction material in Zimbabwe

Zimbabwe did not recognize the use of earth for construction of ‘descent’ shelter for the urban environment (Zami & Lee, 2007). The Zimbabwe Standard Code of Practice for Rammed Earth Structures was started shortly after publishing the Code of Practice in 1996. The In-situ Rammed earth Company led by Mr. Rowland Keable, initiated the request to the Standards Association of Zimbabwe [SAZ] and was seconded by the then newly formed Scientific and Industrial Research and Development Council [SIRDC]. The In Situ Rammed Earth Company promoted the use of rammed earth as a green, sustainable material for the future. He pioneered many rammed earth projects in Zimbabwe among them is DfID School block at the Scientific and Industrial Research and Development Centre (SIRDC), Hatcliffe, Harare, Zimbabwe. This project was mainly constructed to demonstrate that rammed earth could successfully support a roof span of 8m whilst at the same time being a test bed for the publication of RE Structures: A Code of Practice. The building also incorporates boron treated timber roof, which was designed by the Timber Research and Development

Association TRADA. The building was inexpensive, and showed that wide span roofs are possible with the technology, important for classrooms and clinics. The creation of this was a milestone in illustrating how RE can be used to lower construction costs. This building technology was 60% cheaper than concrete blocks and could provide double the number of built units for the many African school building programs, as well as clinics & houses. The In Situ RE Company also carried out a number of rammed earth projects in the Zimbabwe, among some of them were a classroom block in Bonda, Manicaland commissioned by pioneering architect Mick Pearce in 1997, Office and housing in Chimanda on the North East border with Mozambique.

Earth is affordable and available and would be appropriate in the case of low cost house construction in Zimbabwe. It is possible to use un-stabilised raw earth as rammed earth or compressed earth blocks; but the stabilised form is more suitable for the Zimbabwean situation in terms of by-laws and housing standards. The only challenge that prevents earth becoming the preferred choice of building material amongst the general population is the acceptability of this material by that same population. An awareness and understanding by people to environmental issues such as air pollution, deforestation, land degradation and energy conservation would help them change their attitudes and views towards earth building. The flexibility and simplicity in technology incorporated in earth building affords adaptability and easy transfer of knowledge between different stakeholders in the building industry. Individuals and community as a whole can easily participate in building their own homes in affordable ways.

6. User Participation in low cost housing projects

Citizens must participate in the design of buildings, thereby leading to a triangular relationship between the citizen, the architect, and the builder. This means that the task of the architect is not to express his own ideas in the building but those of the locale, the people, and the culture (Shearer, 1986). Far from being viewed as partners, beneficiaries were given no active role to play in shaping their habitats (apart from filing complaints); planning proceeded totally inside government departments and the accusations often repeated that planners were insulated and beneficiaries isolated are by no means unfounded (Ahmed *et al*, 2002). Hassan Fathy also encouraged self-help and promoted user participation in design. He allowed the peasants to express their wishes for the lay-outs of their homes, in other instances he left the peasants use a courtyard for a number of days and then established the lay-out of the courtyard on the basis of their use, defining the pathways where the earth had been beaten by their steps. All these efforts are examples of Fathy's persistent attempts to introduce further individualization in the design process (Serageldin, 1985, p 18).

The self-building process has been described as belonging to vernacular architecture or what is termed new traditional environments, but this new tradition must be qualified (Rapoport, 1988; Kellett & Napier 1994). Studies have shown that vernacular architecture in many places is based on profound elements which embody environmental quality. The self-building process in Brazil, however, has specific characteristics and problems. Mainly due to low-quality design solutions, self-built houses present on the whole a low environmental comfort standard (Labaki & Kowaltowski, 1998). The local new vernacular thus lacks some of the positive elements of many traditional buildings, especially praised for their intelligent solutions to climatic problems (Kowaltowski *et al*, 2005). In Brazil, 30 times more homes are being built in the informal as against the formal ways of construction (Augusto & Bastos, 1997). Due to specific local economic and social structures, as well as urban growth patterns, self-built houses, houses built by owner families, make up a substantial percentage of

Brazilian housing production (Nolasco, 1995; Kowaltowski, Pina, & Ruschel, 1995a, Ornstein, Romero, & Cruz, 1995; Werna, 1996). Self-built houses are the predominant mode of urban habitation production of a low-income population in other Latin American countries as well (Turner, 1976; Kellett & Napier, 1994). According to Brazilian data around 60% of the local housing production is self-built (Schulz, 1996). As in many developing countries, spontaneous housing, without tenure, is synonymous of extreme conditions of poor-quality housing and has a negative impact on the urban environment (Pettang & Tatietse, 1998). So, a distinction must be made between self-building activities on land without tenure such as invasions and slums or the so-called favelas, and those on lots acquired by families in private subdivisions or through government distribution programs (Kowaltowski *et al*, 2005).

According to Kowaltowski *et al* (2005), Self-builders need access to information, in various forms, from simple technical manuals or booklets distributed in construction material shops, to on-site assistance on choices of materials and building techniques. Technical reasons behind design features can be made clear, gaining importance and thus avoiding changes that may diminish comfort aspects. Information shown on drawings is of prime importance. Care must be taken in relation to furniture arrangements, shown on floor plans. Perception of room sizes are based on furniture layouts and self-builders tend to interpret empty space on drawings as opportunities for design modifications. In Zimbabwe so far there are no self building projects. But it is a high time now to think along the line of Brazilian self building projects to solve housing crisis in Zimbabwe.

7. Obsolescence & Overcrowding

According to Kamete (2006), though harder to define, overcrowding is evident in all urban high density areas and the situation is a post-independence phenomenon, which dramatically manifested itself after the colonial restrictions on rural-to-urban migration and occupancy were relaxed. The notorious Mbare flats, which were originally intended to house unmarried workingmen, now house more than one family complete with children and other kith and kin, some of them adults (Chombo, 2000). Chief among the forgotten aspects of the urban housing crisis in Zimbabwe are obsolescence and overcrowding (Clauson-Kaas et al., 1996), both of which have a strong bearing on health, convenience and safety (cf. Cotton & Franceys, 1991; Hardoy & Satterthwaite, 1989).

Besides, the obsolescence and crowding situation in Sakubva in Mutare, Rimuka in Kadoma, Makokoba in Bulawayo, St Mary’s in Chitungwiza, is nowadays in an alarming situation. According to City of Gweru (1998), Mutapa Township in Gweru was established before independence to cater for 4500 single men but After independence, families moved in and the township now houses some 15,000 people who share one block of old toilets. All the townships discussed above are among the oldest in the country. Overcrowding has now taken even greater proportions not only in older areas but even in comparatively newly developed areas such as Epworth, Budiriro, Dzivaresekwa, Kuwadzana & Glen View in Harare, Zengeza in Chitungwiza, Mkoba in Gweru, Cowdary Park in Bulawayo. Overcrowding in these areas said to create problems on services especially sewerage reticulation which frequently breaks down and blocks, electricity which becomes overloaded, and roads become congested. Obsolescence and overcrowding have repercussions that are now becoming evident not only in the centres mentioned above, but also throughout urban Zimbabwe and the most obvious and easily recognisable is the overloading of facilities (Kamete, 2006, p989). So, it is crucial and must to increase the capacity of the infrastructural facilities to serve the increased population of these housing discussed above ensuring sustainable solution to housing crisis in Zimbabwe.

8. Inappropriate Building Standard and By Laws

According to Mafico (1991, p107), housing standards can be defined as, “relative measures of suitability, acceptability and liveability for a given socio-cultural, economic and cultural settings”. In the same text, the UN defines standards as, “measures of the acceptability of housing at a given time and place in a cultural, technological and economic setting.” Mafico also (1991, p108) states that, housing standards were first introduced in the western world during the 19th century to protect the weaker members of society against overcrowding and ill health. The main thrust of these standards was to acquire minimum standards of hygiene, safety and privacy in the housing units, which were provided to the working class. In developing countries, and Zimbabwe in particular, housing standards were said to have instituted by the colonial government to protect the European settlers and officials, the standards usually led to the replication of the type of dwelling enjoyed in the home country. It is within this background the central components of the conventional low cost housing paradigm were developed and housing has been perceived as structures built within the guidelines of Town Planning, Infrasructure and Building standards and housing is an end state of construction activities (Zami & Lee, 2007).

Infrastructure standards are applied on the services that enable the efficient and hygienic use of any building. These inevitably affect the quality of the low cost structures. The width of the access roads of old low income suburbs in Zimbabwe are 10 meters. Older (before independence in Zimbabwe) high density suburbs had narrower roads because; residents of these suburbs were not expected to own vehicles. Roads of these old high density suburbs were tarred, and are still tarred but full of potholes which is very inconvenient to motorists. On the other hand, newer (after independence) high density suburbs in Zimbabwe are blessed by wider (15 meters) access roads because of the revised infrastructure standards but surfaced with only gravel. Introduction of gravel road leaves the new high density suburbs looking like a growth point whereas these suburbs are located in the country’s largest cities. Mafico (1991) states that, “this has reduced costs of providing services (which it has), it has on the contrary, actually lowered the minimum quality requirements of newly established suburbs.” Reticulation Standards ensures supply of water to dwellings for keeping the home environment safe and hygienic for the user. They also guarantee the disposal of all waste be removed from the home environment. Older high density suburbs used to have communal water taps and toilets, which resulted in poor maintenance of hygiene conditions around these facilities. Theses standards have been upgraded and the provision of communal water taps and toilets have been abolished. The individual houses now have their own taps and toilet facilities. But unfortunately, some of these households can’t afford sinks, W.C or shower fittings.

Town Planning Standards cover a wide range of standards in the building industry. For example: - subdivision, height restriction, land use, zoning etc. Subdivision Standards govern minimum dimensions of plot which is suitable for construction, future expansion, and gardening and or recreation. Plots in older high density suburbs measuring 25 X 15 meters, were reduced to 25 X 12 meters, and further reduced to 25 X 10 meters. Further reductions in plot sizes resulted in these plots measuring 25 X 8 meters. These dimensions are the ones currently in use in newer suburbs such as Cowdary Park, Pumula South and Operation Garikayi/ Hlalanikuhle housing areas. All the above mentioned problems are due to the revision of subdivision standard/ plot sizes. The arguments in favour of the reduction of plot size are the “reduction of costs.” The reduction of costs should not stand as a justification for compromising privacy and the economic condition should not be used as a barometer in determining revision or evolution of standards.

According to Building Standards, high density housing in Zimbabwe allows the use of 115 mm brick walls used as load bearing walls which is a cost cutting measure. It almost reduces the cost of housing by more than a quarter of its total anticipated costs. These walls do not however have good sound and thermal properties due to the inadequate thickness. It is important to note that, the local authorities in Zimbabwe do not allow such 115 mm brick wall even for garage construction in low density suburbs. The minimum room size by the legislation is 7 sq. meters with the shortest side measuring 2.1 meters. According to architectural standards, a habitable room should comfortably accommodate the occupants, furniture and circulation space. Most of the bedroom and kitchen in high density suburbs cannot accommodate minimum furniture with any circulation space. Natural ventilation and lighting are big problems in these high density suburbs. Fig 1 shows a typical layout of plot subdivision plan with house units on it in Cowdary Park Housing and natural airflow pattern. It is very difficult for natural air to circulate around the house units because of poor composition of the house units. Fig 2 shows a typical section through two adjacent house units and boundary wall in between of Hlalanikuhle Housing and how sunlight is obstructed by the boundary wall and roof structure.

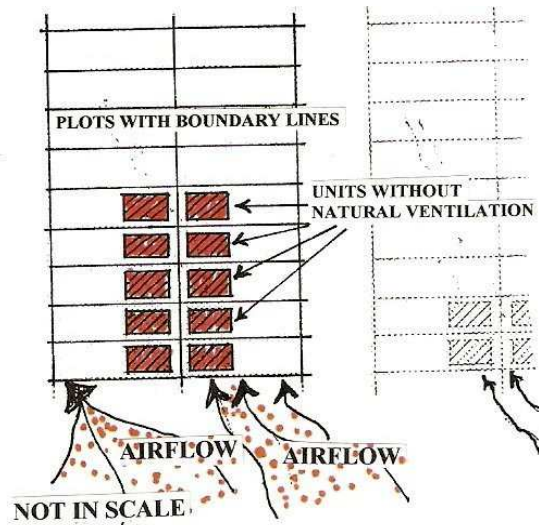

Fig. 1
Layout of plot subdivision plan of Cowdary Park Housing. Source: Zami & Lee, 2006.

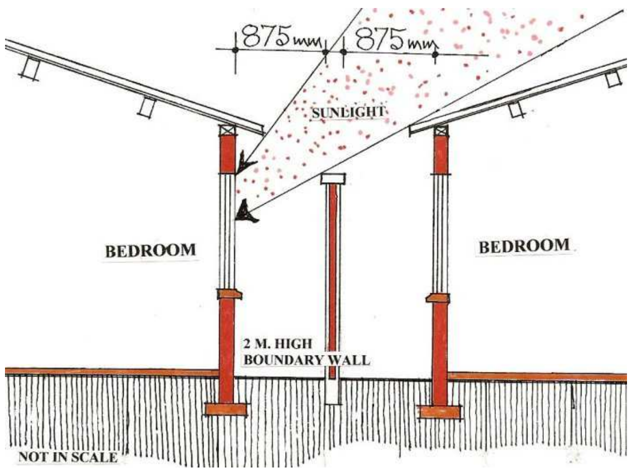

Fig. 2
Section through two adjacent house units in Hlalanikuhle Housing, Zimbabwe. Source: Zami & Lee, 2006.

The definitions of housing standards as mentioned earlier also do not go along with the discussed housing standards. Besides, housing standards currently practiced in Zimbabwe were adopted in 1977 and for the past 30 years there have been a lot of economic, technological and cultural changes. There is an immediate need for the Government of Zimbabwe to review the Regional, Town and Country Planning Act and other relevant Acts to align the substance and the procedures of these Acts with the social, economic and cultural realities facing the majority of the population, namely the poor (Tibaijuka, 2005).

9. Conclusions

Problem of low cost housing crisis in Zimbabwe is not just going to be solved by constructing a huge number of similar designed cells or structure by the government based of housing waiting list and it will not be fair to expect that people are going to live in those cells. Low cost housing problem needs to redefined and refocused. The refocused definition should encompass all the above discussed forgotten dimensions of low cost housing crisis in Zimbabwe. To fully understand and solve the problem of low cost housing crisis in

Zimbabwe it very important to understand the definition and what does house and housing ideally means. The ideal meaning of housing consists of quantitative and quantitative requirements that ensure the sustainability and success of the housing. Quantitative dimensions of housing crisis are always being taken by the government of Zimbabwe to solve the housing crisis and the qualitative dimensions are always being avoided. But to solve the problem housing crisis it is a must to readdress and change the problem of misconception of squatter settlement and government policy towards squatter settlement, inappropriate contextual factors, choice of inappropriate building materials and construction techniques, user participation (not to isolation of user groups from design and construction process), obsolescence & overcrowding, and inappropriate building standard and by laws.

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Grounded Theory for Beginners and its Potential use in Healthcare Infrastructures

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Abstract:
Research methodologies are used in all contexts of research and are fundamental to the study and exploration of any topic. They allow concepts to be examined and investigated, hypothesis to be formed, proved or disproved. This paper provides a glossary of terms, an explanation for research terminology that exists and an overview of the theory and process of Grounded Theory. The paper will then move on to discuss the potential use of Grounded theory in healthcare infrastructures.

The glossary section of the paper will be developed through a literature review of key texts within research practices. A literature search will also be undertaken on the theory and process of Grounded Theory, with focus moving to its potential use within healthcare infrastructures. The anticipated outcome of this paper will be guidance for those new to research and for those undertaking Grounded Theory especially within the realm of healthcare infrastructures.

Keywords:
Research terminology, Grounded Theory, Healthcare infrastructures

1. Introduction

Research methodologies are used in all contexts of research and are fundamental to the study and exploration of any topic. They allow concepts to be examined and investigated, hypothesis to be formed, proved or disproved. The paper is aimed at a new researcher who is thinking of undertaking research using grounded theory and in particular using it for a study into healthcare infrastructures. The aim of this paper is to:

1. Provide an overview of the terminology that is used within research
2. Provide an overview of Grounded Theory
3. Discuss the potential use of Grounded Theory into research of healthcare infrastructures.

To develop the research terminology section of this paper a review of key texts within research practices was undertaken. The exploration and discuss around grounded theory and its process was achieved through a review of literature on the subject since its development in 1967. The paper concludes with a discussion about the potential use of grounded theory within healthcare infrastructures. The next section will provide the starting point for a researcher a glossary of research terms frequently used within research.

2. Research Terminology

There are a number of models and diagrams used by authors to describe the relationship between the different choices to be made within research, such as Ticehurst and Veal's (2000) Approaches and methodologies, Kolb's (1984) Experiential Learning Cycle and Karl Knox's (2004) Hierarchy of Research Needs. It is however the research 'onion' (fig 1.) developed by Saunders et al. (2007) that fully illustrates the relationship and the differences between the terms philosophies, choices, strategies, approaches, time horizons and techniques and procedures. The onion also illustrates the different layers that need to be addressed before data collection can take place. Without a clear understanding of what the research aims to do it is impossible to know which method of research is the most appropriate.

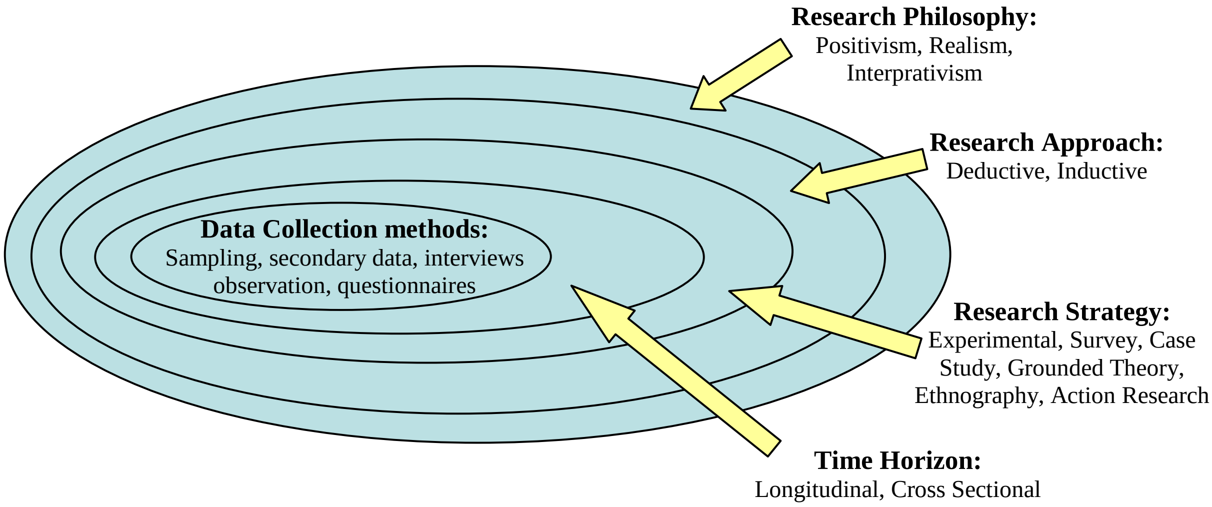

Fig. 1. Research Onion Saunders et al 2007

As described by Gerring (2007) before discussing research there is a need to develop a shared understanding of the key definitions that are clear and coherent with all those within the study. Through using the onion and other frequently used terms the following will provide a brief description of these different terms.

- ***Research Philosophy:*** The research philosophy chosen by the researcher will contain assumptions about the way the researcher views the world and the context of their history in the society they are part of (Saunders et al, 2007, Gibbons and Sanderson, 2002). This relates to the development of knowledge and will be used to underpin all other decisions made during the research. Guba and Licoln (1994) describe philosophy, as a paradigm of 'basic belief system/world view'.
- ***Research Approach:*** Deductive and inductive are two approaches for undertaking research. Deductive is to undertake a study in an area in which a lot of past research and therefore material already exists. It is upon this existing material the researcher develops a hypothesis and theoretical framework (Saunders et al, 2007). Contrastingly inductive is used when researching a new area, which has not been explored and has little or no literature/data existing. It is from the primary and practical research that the theoretical framework is developed (Saunders et al, 2007). These differences do not mean research has to be one or the other, it is possible for both approaches to be used within the same research project.
- ***Research Strategy:*** The research strategy is the way in which a person decides to undertake the research. It is the plan the person has for gathering the data required to either test out or generate a hypothesis. Yin's work demonstrates that it is important when

making decisions about the strategy one is going to use within a study that it is linked to the research question, the below adapted table illustrates this (Yin, 2003).

Table 2: Which strategy to answer which questions (adapted from Yin, 2003)

Strategy	Form of Research Question
Experiment	How, why?
Survey	Who, what, where, how many, how much?
Archival Analysis	Who, what, where, how many, how much?
History	How, why?
Case Study	How, why?

- ***Time Horizons:*** This refers to the time span of the research taking place, whether it is a longitudinal study or a cross sectional. A longitudinal study is repeated at different times with the same group/groups following exactly the same procedure at all times, so that comparisons can be made over time (Gerring, 2007, Robson, 2002). Whilst the cross sectional study occurs at the same time but across different sample groups (Easterby Smith et al, 2002).
- ***Data Collection Methods:*** This can be broken into two: the techniques and method. A research method is the way in which evidence and data is collected (Galliers, 1992 and Weick, 1984). These methods indicate the techniques of data collection that are being used such as a quantitative method will mean a technique such as a questionnaire will be used. Robson (2002) makes it clear that the choice of methods is dependant on the information that the researcher wants to gain, the circumstances and who the information is being obtained from. Robson (2002) suggests that the following are simple rules of thumb for selecting methods and techniques:
    - To find out what people do in public use *direct observation.*
    - To find out what they do in private, use *interviews* or *questionnaires.*
    - To find out what they think, feel and/or believe, use *interviews, questionnaires* or *attitude scales.*
    - To determine their abilities, or measure their intelligence or personality, use *standardised tests.*
- ***Population:*** The term population within research refers to the whole of a particular group being studied (Robson, 2002). If one was to be undertaking research on the performance of girls in UK public school between the age of 14 and 15, the population would refer to all those that fell under that category.
- ***Sample*****:** A sample is chosen from the population, and must be representative of it. Sampling also refers to variables that are not people related such as time and place. Samples can help make research more manageable maintaining validity and reliability (Robson, 2002).
- ***Representativeness:*** This relates to the group/sample that is being studied and whether they can be said to be characteristic of the larger group (Gerring, 2007 and Stake 2005). Generalizations from the sample group can be made and assumed upon the larger population (Stake, 2005).
- ***Falsifiability****:* Hypothesis are tested many times in an attempt that on one of these times the hypothesis is proven wrong, the more times something is proven correct the more reliable. Karl Popper (1963) argued that every genuine test of a theory is an attempt to falsify it or refute it, fig 2. illustrates this:

1. Problem: refutation of existing theory A.

2. Proposed solution: from the development of a new theory B which is as yet unfalsified

3. Deduction of testable predictions aimed at the falsification of new theory B

4 Empirical testing aimed at the falsification of new theory B

5. Preference established between theories A and B – ‘survival of the fittest’ theory

Fig. 2. Popper’s epistemological Darwism – explaining falsification (adapted from Johnson and Duberley, 2006)

- ***Reliability:*** The reliability of a method is the ability to reproduce the same results using the same method at any time, the ability for a different person to replicate (Schwandt, 1997). This can often be hard in social situations as one cannot ensure the variables will remain the same at different times.
- ***Validity:*** The term validity refers to how representative the results are of what is being studied, whether they present a true picture of the world (Robson, 2002). It is the testing of the new research findings against what is already known (Stake, 2006).
- ***Generalisability:*** This is the extent to which the results of a study can be applied outside of the situation they occurred (Robson, 2002). The more they are applicable in other situations the greater the generalisabilty of the study. This relates to Little et al (2002) and Nonaka, Toyama and Komo’s (2000) belief that knowledge is contextual. That even when knowledge is documented and made explicit whether it is understood fully or used appropriately is dependent on the community, circumstance, context, time and space.

These definitions are general and it should be remembered as with many research terms the interpretations of these are different between different philosophical standings. These differences are outlined in the below table by Easterby-Smith et al (2002).

Table 2: Which strategy to answer which questions (adapted from Yin, 2003)

	Viewpoint		
	Positivist	**Relativist**	**Constructionist**
Validity	Do the measures correspond closely to reality?	Have a sufficient number of perspectives been included?	Does the study clearly gain access to the experiences of those in the research setting
Reliability	Will the measures yield the same results on other occasions	Will similar observations be reached by other observers	Is there transparency in how sense was made from the raw data?
Generalisability	To what extent does the study confirm or contradict existing findings in the same field?	What is the probability that patterns observed in the sample will be repeated in the general population?	Do the concepts and constructs derived from this study have any relevance to other settings?

The terminology that lies within research has been clarified and the importance of each is justified. The paper will now go on to discuss in depth Grounded Theory, where the terms that have been described in this section will be used.

3. Grounded Theory (1967): An Overview

Grounded theory perspective, was in 1994 the most popular used qualitative approach in the social sciences according to Denzin and Lincoln (1994). It was developed in 1967 by Barney Glaser and Anselm Strauss, both sociologists but with different backgrounds in research methods (Jeon, 2004). Glaser of Columbia University had a background in quantitative techniques, whilst Strauss of Chicago University was primarily linked to qualitative methods (Glaser and Strauss, 1967). The theory was developed whilst the two researchers attempted to bridge the gap between different research theories using logical deductive reasoning (Jeon, 2004).

The name grounded comes from the aim of the new theory to be fully grounded in the research findings without any influence from the researcher's beliefs or ideas or any other theories that exist on the same matter (Loosemore, 1999). Grounded theory is an approach for producing theory that explains social phenomenon that is grounded in findings that have been the result of continual, simultaneous and synchronised collection of data and the analysis of it (Glaser and Strauss 1967).

Grounded theory aims to 'elicit fresh understandings about patterned relationships between social actors and how these relationships and interactions actively construct reality' (Glaser and Strauss, 1967; Suddaby, 2006). It builds up a new theory from data collection with an understanding that it is not to be influenced by those that already exist on the same subject area. Grounded formal theories are described by Glaser and Strauss (1967) in Sonali and Corley (2006) as something that has arisen from a conceptual area of sociological inquiry e.g. behaviourism, socialisation. Glaser and Strauss (1967) believed that to get to this grounded formal theory it was preferable to link substantive theory as this provided a focus as well as early direction in the research.

The method lies within the interpretivist philosophy and aims to produce qualitative data to develop theories that provide an understanding of the experiences of people from that particular person's perspective, social actions and processes (Schwandt, (1997) and Robercht, 1995). Interprativism is a social science which unlike positivism and functionalism does not focus on the generation of hypothesis but instead on observation and description of actions (Silverman, 1998). It does this through an understanding and commitment to research that focuses on the meanings and concepts produced by social actors in real settings and the rejection of rejection of a priori theorizing (Gephar, 2004: 457 in Suddaby, 2006, Locke 2001). As the name suggests Interpretive research uses the interpretations of social actors of certain phenomenon to understand that phenomenon more clearly (Sonali and Corley, 2006). Interpretivists are fully aware that interpretations of a particular phenomenon can differ greatly between social actors, and therefore ensure that information is collected from as many different social actors as possible in a thorough and accurate way (Denzin and Lincoln, 1994, Robson, 2004). From the different interpretations gathered the researcher will then make sure they have a clear understanding of each and from this acquire an understanding and interpretation of the phenomenon of their own. The researcher will ensure that the interpretation they give for the phenomenon can be related to current theory, and is not only understood by all those who gave their own interpretations but also by those who are unaware of the phenomenon and have no background knowledge (Sonali and Corley, 2006). Interpretive data analysis should provide the researcher with rational and credible understanding of a phenomenon.

It is important when undertaking grounded theory research to observes rather than tests an existing hypothesis. Suddaby (2005) identifies a number of ways that can help a researcher to avoid this:

- Research should focus on more than one key area that is present in everyday life;
- The researcher should always be conscious to the fact that they and their research could be affected by their views and beliefs of the subject they are looking at; and
- Remembering that this research is about new theories not elaboration of existing ones.

The background of grounded theory gives an understanding of where and how the theory was derived; for a full understanding the practicality of the theory must also be described, the next section will go into this in detail.

3.1. Grounded Theory: The Process

Grounded theory is a process that involves a number of key features that occur simultaneously throughout a study. However there are many different variations of the process and the steps that should be undertaken. Therefore when undertaking grounded theory the researcher must decide upon the route that is going to be taken and stick to this to ensure the research is grounded (Hunter et al 2005). For the purposes of this paper and from a literature review of the different processes the steps as identified by Jeon 2004 from Glaser and Straus 1967 will be used. It was felt that these six steps encompassed the process developed by other authors, and each step could be referenced by Glaser and Straus which is important as they developed the theory. The six steps are (Glaser, and Straus, 1967, Jeon 2004):

1. The question
2. Theoretical sampling,
3. The constant comparative method,
4. Coding and categorising,
5. Memo writing
6. Theory generation

Although it is important for all of the above 6 features to be worked through for effective grounded theory research, the research must be flexible to changes that may occur in terms of resources and time. Due to the possibility of changes it is important that a log is kept throughout the study detailing any decisions or changes that are made (Jeon, 2004). These features will now be further explored:

1) The Question

As previously discussed grounded theory aims to create new formal theory from an Interpretivist approach. Therefore it is a theory best suited to answer some questions rather than others. The questions it is most suited to are ones of an exploratory nature (Glaser and Strauss, 1967; Yin, 2003, Suddaby, 2006).

2) Theoretical Sampling

Sampling is a very important part of any research method due to the influence it has on the validity and reliability it has on research. Theoretical sampling within grounded theory is data gathering that aids the development of a theory (Jeon, 2004). After the data is gathered it is analysed and it is from here that the researcher can then target where to undertake data collection next in order to support and developing theory (Glaser and Straus, 1967 and Locke 2001). Therefore theoretical sampling is not static, it is used and flexible throughout the study, building from one data collection exercise to another. Here the constant comparative method can be used to develop the theory through the data that is collected from one sample to the other (Jeon, 2004). To help establish the limits of the theory and to ensure it is applicable to different contexts the researcher may chose to test the theory is different contexts, with different samples (Sonali and Corley, 2006).

3) Constant comparisons.

Constant Comparison is the constant comparison between information gathered in four simultaneous stages, they are (Sonali and Corley, 2006, pp. 8):

a. Comparing incidents applicable to each category (categories will be later defined),
b. Integrating categories and their properties,
c. Focusing the theory and,
d. Writing the theory

Glaser and Strauss (1967) argue that it is important to use the constant comparative method throughout grounded theory research as it allows the researcher to understand what is being observed whilst identifying causal relationships (Locke, 2001). Glaser and Strauss (1967) and Jeon (2004) point out that this method can also help to make research researcher more rigorous, enabling the researcher throughout the study to compare and question findings helping their understanding of the study area. The method at times will take the research in a different direction or will provide evidence that another area related to the phenomenon needs to be looked into at greater detail (Jeon, 2004). Due to these reasons it can be said that comparative analysis within grounded theory provides a fuller, clearer and more precise understanding of a phenomenon and hence a theory of much strength and validity, grounded within rigorous data collection and analysis.

4) Coding and categorising

This phase can be seen as data analysis of the raw data. It takes place throughout Grounded Theory and is especially important during comparative analysis. It is during this stage that the quality of the theory being developed is verified and established through data analysis (Strauss and Corbin, 1998; and Strauss and Glaser, 1967). The raw data from the study is coded. There are different coding processes that take place they are described below (Hunter et al. 2005).

- *Open coding*: Initial categories of information are developed through the data gathering.
- *Axial coding*: The data gathered is coded and a coding paradigm is developed. This paradigm identifies the central phenomenon to be explored whilst exploring causal conditions and identifying the strategies for the research with an understanding of the context it is in.
- *Selective coding*: Catergories identified are integrated into the axial coding model. It is here that the ‘core catergory’ from where the other catergories are built upon is identified.

This coding occurs simultaneously with Theoretical coding which identifies the links between the codes and the developing theory (Glaser, 1978). The groups that are identified are not necessarily the same concepts but they may instead represent activities directed toward a similar process (Pandit, 1996). Through the process of coding the data collected can be used to support the developing theory. The whole process according to Glaser (1978) is vital to developing a theory that can be used to make sense of a phenomenon, as it is through this core category that the developing theory and other ideas evolve (Jeon, 2004).

5) Memo writing.

Memo writing or a log is a vital part of grounded theory and is a way of keeping track of the research being undertaken, in particular any changes that occur and the effect that these changes have on the study. Glaser (1978, pp.83) states that ‘memos are the theorizing write-up of ideas about codes and their relationships as they strike the analyst while coding'. It acts as the link between the different parts of the grounded theory process.

6) *Theory Generation*
Throughout the process, through all five previous steps theory is being generated.

The six steps of grounded theory have been explained as has the reason for them, adding validity and rigorousness to the research; however grounded theory is not without its criticisms. Below are just some of these (Pandit, 1996, Allan 2003, Hunter et al 2005)

- It is extremely time-consuming.
- Long periods of uncertainty.
- Management of the coding and catergorising process
- Software does not always code the data fully
- Collecting data from on-line databases is expensive.
- Coding is complicated
- A grounded theorist must be rigorous in interviewing and analyzing or the theory will be greatly flawed

A large criticism that has come through the literature is the ambiguity of the process. As previously stated there is not one clear process and even the originators of the process Glaser and Straus are not in agreement of some of the processes within the theory (Allen, 2003). The 'Glaserian' approach to the theory is that it should begin without any presumptions of the area allowing the ideas to emerge through the findings (Easterby-Smith et al, 2006, Glaser, 1992). Whilst the 'Straussian' approach is that that even though Grounded Theory focuses on the development of new material it is still important when that one is fully aware of all the material that exists on the issue being addressed (Sonali and Corley, 2006; Suddaby, 2006). This ambiguity creates confusion from the outset, consequently research can become inconsistent and careless.

With the background, process and critique of grounded theory given the paper will conclude with discussion on the potential use of Grounded Theory within healthcare infrastructure and the scope for future work and papers.

4. Conclusion: The Potential of Using Grounded Theory in Healthcare Infrastructures

The healthcare system is turbulent, complex and adaptive with multiple complex systems nested within it (Sweeney & Griffiths, 2002). In particular the study of healthcare infrastructures provides an experimental terrain that can hardly compare with any other sector. Increased investment in healthcare infrastructure and the use of financial and procurement have increased the complexity of an already negotiation-based system. The number of stakeholders has also increased without significant clarity existing on their roles and responsibilities. This coupled with a policy of a patient-led NHS and commissioning the NHS, has meant that new real-world situations have emerged that are still in a state of flux with limited empirical data. It can be argued that traditional approaches to sensing and solving problems and issues within this environment are not wholly adequate. It can also be argued that Saunder's research 'onion' has its limitations in such an environment where the iterative cycles between developing and implementing research strategies and data collection happen much more frequently and at a faster pace. It is because of this that it would seem that grounded theory would be most suitable for the study of healthcare, and in particular healthcare infrastructures when real world phenomena need to be addressed. Grounded theory would potentially be able to deal with the nature of healthcare infrastructure through being modifiable (Wuest, 2000). Also its ability to discover new areas, go into great depth within these areas, obtain information from many stakeholders and produce an unbiased picture of the real world makes its potential for healthcare infrastructure research great. It is already used by a number of researchers in the study of different areas within healthcare, it Sharrock and Happell (2007) study into the experience of mental health nurses, Wuests 2000 study into helping systems within healthcare and Keady and Williams continued research into Alzheimer's; and was originally developed by Glaser and Strauss (1965) when investigating dying patient. The next stage of this study is to discuss and go into greater detail about the use of Grounded Theory in the different areas within healthcare such as management, organizational, knowledge transfer etc.

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Infrastructure Asset Management: The Valuation of Complex Objects

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Abstract:
For two years now, Rijkswaterstaat, an agency of the Dutch Ministry of Transport, Public Works and Water Management, is required to have a financial administration, which is based on accrual accounting principles. This involves the use of a balance sheet and the equivalent of a profit and loss statement. These documents will the basis for planning and controlling of public spending. The question to be answered is: Will it be possible to calculate a 'generally accepted' value for infrastructure over its useful life by using sound accounting principles? The research is based on economic and accounting theory as applied internationally. Preliminary results indicate, that existing accounting principles are suitable for use in infrastructure management, enabling better control of public spending on infrastructure. Interviews with infrastructure providers in the Netherlands show that the transition towards an accrual-based administration will take more time than planned. Further test cases will be used for verification.

Keywords:
Accountancy, asset management, infrastructure, life cycle costing, valuation.

1. Introduction

Infrastructure networks, such as for land based transport systems on land, represent vast investments, made over many generations by both public and private sector organisations. Rijkswaterstaat, the Government agency responsible for road infrastructure in the Netherlands (infrastructure provider), has a programme of activities to keep road infrastructure in optimal condition pertaining to maintenance, repair, renovation and new construction. As an agency Rijkswaterstaat is subject to special rules to increase accountability (Hoek 2005). The Supreme Audit Institution stated that the introduction of a financial system based on accrual accounting (Algemene Rekenkamer, 2000: 13) is expected to lead to:

1. Improve the effectiveness of allocated budgets by:
   a) Providing insight in the life cycle costs of policy decisions.
   b) Allowing a more efficient making process for investments.
2. Improve the budget allocation process.

In line with these expectations, the Government emphasises the need to employ the best management skills, processes and practises available, in order to ensure that infrastructure related services are delivered economically and timely. Part of this recommendation is an exploration of the application of asset management methods and techniques in the Dutch situation. Valuation of assets at market value is one aspect of asset management being explored by this research paper.

Will it be possible to calculate a 'generally accepted' value for infrastructure over its useful life by using sound accounting principles?

The research is aimed at the following:

a) To highlight the relevance of road asset valuation with respect to the needs of users and providers, like Rijkswaterstaat;
b) To identify benefits of valuation as an asset management tool;
c) To make suggestions for valuation techniques for road infrastructure.

The research is based on literature research. Verification of the results are based on interviews with key personnel at infrastructure providers and government agencies. In this paper, concepts like asset management, valuation and depreciation will be highlighted.

2. Asset management and valuation

2.1. Asset management – scope and definition

In Australia and New Zealand public sector reform in the area of financial accounting resulted in requirements for enhanced financial reporting. This led to new rules for valuation and depreciation of assets. These initiatives led to widespread interest in asset management and planning and can be an example for agencies in the Netherlands, although the situation in the Netherlands is quite different from Anglo-Saxon context (Ingenium / NAMS Group, 2006).

In the USA the Federal Highway Administration (FHWA) has established an Asset Management Office. In Australia and New Zealand forces are combined produce guidance for professionals in the NZ National Asset Management Steering Group (NAMS) and the Institute of Public Works Engineering Australia (IPWEA).

The World Road Association (PIARC) has adopted an OECD definition of asset management, which in turn was derived from a FHWA definition, viz:

"A systematic process of effectively maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing the tools to facilitate a more organised and flexible approach to making decisions necessary to achieve the public's expectations."

These broad definition boils down to the following: road asset management means managing a road network (roads, bridges, traffic facilities, etc) to satisfy the requirements of business and private road users, at the lowest possible cost over a long period of time.

The main phases in asset management are:

- Identification of need for the asset, in the light of community requirements;
- Provision of the asset, including its ongoing maintenance to suit continuing needs;
- Operation of the asset;
- Disposal of the asset when the need no longer exists or it is no longer appropriate for the asset to be retained.

Asset management includes elements focused on facilitating the delivery of community benefits such as accessibility, mobility, economic development and social justice.
Rijkswaterstaat has started the PIM project (Partner Programme Infrastructure Management) in cooperation with the UK Highways Agency and the Flemish Infrastructure Agency to look for best practices and to implement these (PIM - Partnerprogramma Infrastructuur Management, 2006).

Infrastructure providers in the Netherlands are implementing new administrative systems to improve their transparency and accountability. Valuation of the assets under their jurisdiction is one of the requirements. Asset valuation is a key element of asset management. Carrying out asset valuation requires the following (Falls en Haas, 2000):

a) A management framework;
b) Adoption of an accounting basis and methodology for actually valuing assets;
c) Performance indicators and depreciation functions or performance models for calculating future asset values;
d) Information systems for reporting network condition and asset value.

Rijkswaterstaat is aiming for better asset management, in which systematic maintenance and valuation plays an important role to provide appropriate management information in order to optimise total life cycle costs of the Dutch road network.

2.2. Valuation

Austroads, the association of Australian and New Zealand road transport and traffic authorities produced a great number of documents to facilitate the development and provision of Australasian transport. Research has shown that valuation plays an important role in enabling reporting of the physical condition of the road network in monetary terms. In addition, valuations help asset managers to inform owners about the effects of current levels of financing and management strategies.

Part of the framework for asset management is shown in figure 1. The asset management process relates information about road use, investments, standards and physical treatments, to public's expectations (needs). In the end, the assets are a means to deliver value to the community, and especially to road users.

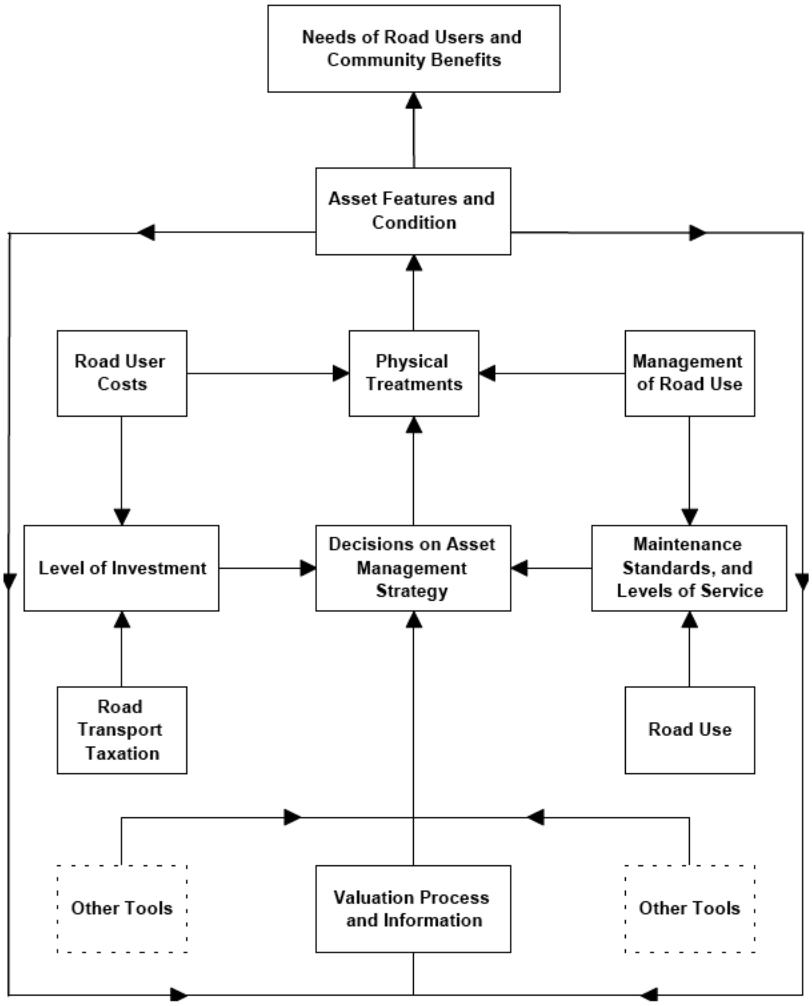

Fig. 1 The role of valuation in asset management
(Austroads, 2000: 2)

The valuation process is shown and identified as an asset management tool. The maintenance strategy and budget options can vary from eliminating all performance defects to doing nothing at all. Based on asset condition and asset inventory, valuation can take place by using 'costs to restore' or 'current replacement costs', as is indicated by international standards, laws and agreements (Austroads, 2000: 8). Most organizations use standards, which find their basis in the International Financial Reporting Standards. The IASB
(International Accounting Standards Board) - based in London – is committed to develop global accounting standards that provide transparent and comparable information in general purpose financial statements (IASB,2003:1). The Governmental Accounting Standards Board (GASB) is currently the source of generally accepted accounting principles (GAAP) used by State and Local governments in the United States of America.

2.3. Several approaches to valuation

Local legislative requirements (laws, acts) determine the valuation and depreciation of public entities. E.g. in New Zealand, the Local Government Act 2002 (NAMS Group, 2006:2.2) states:

“A local authority must manage its revenues, expenses, assets, liabilities, investments and general financial dealings prudently and in a manner that promotes the current and future interests of the community”

Valuation and depreciation of assets must be undertaken in accordance with the relevant financial reporting standards, primarily the International Accounting Standard 16 – Property, Plant and Equipment (IASB, 2003). The objective of IAS 16 is to prescribe accounting treatment for property, plant and equipment so that users of financial statements can discern investment information. The principal issues are the recognition of assets, determination of their carrying amounts, deterioration charges and impairment losses to be recognised.

Valuations of any type require the valuator to apply one or more valuation approaches (NAMS Group, 2006: 2.3). The valuation approaches for determining a market value (the estimated amount for which a property should change hands) include:

a) Sales Comparison Approach;
This approach considers the sales of similar or substitute properties and related data, and establishes a value estimate by the process of comparison.
b) Income Approach;
This approach considers income and expense data relating to the property being valued and estimates value through the process of capitalisation or discounting of cash flow.
c) Cost Approach;
This comparative approach considers the possibility that, as a substitute for the purchase of a given property, one could construct another property that is either a replica of the original or one that could provide equal utility.

It is noted that the cost approach to valuation is typically appropriate for infrastructure assets. The cost approach is based on the cost of reproducing the asset as an estimate of its fair value. The rationale for this is that if the asset:

- can be reproduced;
- provides the utility or service expected of it;
- is in its highest and best use.

Then, potential buyers will pay a cost-related price, which is equivalent to the cost of reproducing the asset themselves.

2.4. Depreciation methods

In practice, the cost approach to valuation also involves an estimate of depreciation. Depreciated replacement cost is an application of the cost approach used in assessing the value of specialised assets for financial reporting purposes, where direct market evidence is limited or unavailable. Infrastructure is classified as a non-current tangible asset, because infrastructure will be used during more than one period (e.g. one year). The majority of infrastructure assets covered by the guidelines (IAS 16) will be of a specialised nature and will therefore be valued using a depreciated replacement cost approach. Infrastructure consists of several components with different service lives. These components are crucial to the accounting for and the depreciation of the asset and its valuation. Expert judgement will be required to decide how different components of complex items of infrastructure are accounted for.

In accounting terms, depreciation is the proportion of an asset consumed during an accounting period (e.g. one year). Infrastructure is seen as a non-current asset, which has a useful life extending more than one accounting period. Accumulated depreciation is the part of the original cost of a non-current asset, which has been treated as an expense in successive profit and loss accounts. Accumulated depreciation, therefore, is a measure of the loss of service potential of an asset since the asset was acquired or constructed.

The purpose of depreciation is to know the net cost of a fixed asset over time. The basis for depreciation differs from place to place. Even within one country, like Australia, there are differences. Some objects are depreciated on condition and some will use the age of the construction (the service life). The depreciation curve is in some cases (traffic signals) a straight line or parabolic (bridges) over the economic life of the construction as can be seen in Table 1.

Table 1: Depreciation methods in use (selection)
(Austroads, 2000: 18)

Roads	Bridges	Traffic signals	Street lighting
Condition based, using 4 categories of roads. Pavement management System is used to calculate accumulated depreciation as the estimate of cost of restoring pavement to "near new" condition in one year.	Parabolic (age squared). Steel, concrete 70 years Timber bridge 25 years T-Beam 50 years Historic 250 years Major 100 years	Straight line, different lives are assigned to different components from 11 to 40 years	Straight line. 50 years

Australian Accounting Standard AAS 4 (AASB 1021) 'Depreciation' specifies that entities:

- Should depreciate assets on a systematic basis over their useful life;
- Apply a depreciation method which reflects the pattern of the asset's future economic benefits;
- Estimate the useful life of a depreciable asset by assessing physical wear and tear, obsolescence, and legal or other limits for the asset's use;
- Review depreciation rates and methods at least annually.

Until recently, infrastructure objects were not depreciated in the Netherlands. The maintenance strategy was solely based on inspections. It can be argued that a properly maintained road has a virtually unlimited life. In the United States, financial reporting guidelines issued by the Governmental Accounting Standards Board (GASB) recognise that some infrastructure assets, such as roads, have a very long live expectancy (as the Via Appia in Italy shows). Asset depreciation should be applied only to those parts of the infrastructure, which are subject to wear.

Accumulated depreciation in the context of an asset such as a road network is an indicator of the future cost of restoring the network from its present condition to an as-new condition. In order for accumulated depreciation to be a reliable management tool, a robust depreciation model is essential. Some assets (road pavements) can be restored to an as-new condition through physical treatments. But restoration is not economical for all assets. For instance, pavement generally exhibits a non-linear deterioration pattern, due to traffic loading, pavement age, and variations in quality of construction components. Engineering information will be necessary to determine the deterioration pattern.

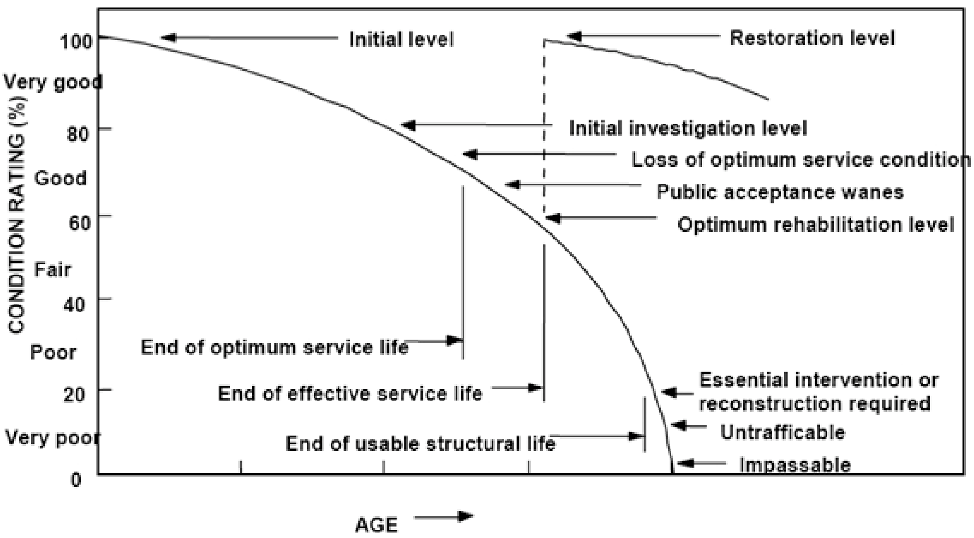

Fig. 2 Pavement deterioration curve
Source: (Austroads, 2006)

Some assets lose service potential through technical obsolescence, rather than through a deteriorating condition. Especially electronic control equipment is subject to losing service potential through technical obsolescence. In those cases condition based depreciation is not appropriate. Instead age based depreciation could give the solution, as can be seen in Table 1.

3. Possibilities of valuation in the Netherlands

The impressive international literature on infrastructure accounting topics indicates that the accounting standards will be applicable in the Netherlands. IAS 16 is available for financial reporting of accounting infrastructure. The valuation of infrastructure assets can be based on the calculation of DRC – Depreciated Replacement Cost, while depreciation calculations can be based on several methods as long as they meet international standards. In the Netherlands, pilots in the PIM project will indicate what is suitable for Dutch circumstances.

Research has been carried out through interviews of key personnel of infrastructure organisations, such as traffic managers, financial staff members and strategic officers of the Ministry of Ministry of Transport, Public Works and Water Management. The Tasmanian

Audit Office reports that a significant range of practices and policies being applied to the financial reporting of road assets (Jeff Roorda and Associates, 1998). Indications are that the same goes for the Netherlands, obviating the need for standards.

In the Netherlands there is no general agreement for assigning lifespan to infrastructure in valuation matters. International literature indicates that a ‘standard’ economic life for each category is not recommended since economic life for each road is the product of past and future maintenance, strategy, climate and topography, construction standards and traffic. The recommended strategy is that infra providers analyse the economic lives of their assets and corresponding depreciation charges and be able to explain differences and changes over time and show how their economic life is derived. The variation in economic life should continue to be reviewed because road assets are a major financial responsibility for infra providers like Rijkswaterstaat.

The Netherlands has a road asset base, which reflects the large building programme of the past decades. In comprise many sophisticated installations like traffic information systems and tunnel installations. Future funding requirements for retention of these assets might increase markedly in the next ten years. Regions where a large proportion of road networks approaches the end of their useful lives should use a valuation and depreciation methodology that estimates the remaining life of the asset, taking into account local variations such as climate, traffic, condition and maintenance levels.

Some complicating factors should taken care of by the infra provider.
Such as:

1. The capitalisation and financial reporting of infrastructure assets is a new concept. Concerning an administration based on accrual accounting, RWS is still in a transition phase;
2. Rijkswaterstaat does not have the resources and expertise yet to carry out asset management activities, necessary to provide accurate asset inventories and valuations. Asset information is therefore either minimal or fragmented and still difficult to access;
3. Asset management and public reporting of consumption of the service potential of an asset often have a low priority. The only information available is that which is perceived to be necessary for minimum statutory compliance.

4. Discussion and conclusions

The question to be answered is: Will it be possible to calculate a ‘generally accepted’ value for infrastructure over its useful life by using sound accounting principles?

As a result of researching literature and interviewing experts the following conclusions may be drawn about applying asset management, including valuation, in the Netherlands:

- There is substantial experience with asset management and valuation in some countries, especially Australia and New Zealand that can be used as reference for the Dutch situation;
- An administration which is based on the principles of full accrual accounting, is a requirement for successful implementation of asset management in the infrastructure

business;

- The International Financial Reporting Standards offer sufficient opportunities for implementation of standards for valuation and depreciation of infrastructure in order to realise effective financial statements;
- In the Netherlands, several pilot projects are investigating the implementation of infrastructure management, but none of them have realised full accrual accounting;
- Experts state that Dutch agencies are still in transition to make use of valuation techniques on a regular basis;
- International expertise can be useful for applying valuation techniques for Dutch road infrastructure.

The projects in the Netherlands indicate that the transition of cash based administration towards an accrual accounting based administration will take more time than planned. It would be worthwhile for infrastructure providers to increase their expertise in the field of accounting standards and business administration.

AMI – Asset Management Initiative – is a programme in which the following parties participate: the Delft University of Technology, the Erasmus University, infra providers (Rijkswaterstaat, ProRail) and 25 contractors. Participation of these organisations in the AMI-programme will be of utmost importance for implementing methods and techniques, strategies en reporting standards in government agencies.

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The Buildings Appraisal with Respect to the External Benefits – the Way to the Sustainability Development

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Abstract:
Traditional building's appraisal, which considers only economic returns, does not adequately and readily consider environmental effects, social, and environmental issues. This approach is shown to be no longer feasible. Buildings have a long life, so any improvement in their appraisal techniques can reduce their future environmental impacts and can satisfy the requirement of sustainable development. The sustainability indicator includes financial return, energy consumption as well as social and environmental issues in decision-making framework.

Keywords:
Appraisal, decision-making, sustainability

1. Sustainability in Building

The interpretation of sustainability in building has gone change over the years. At the beginning, the accent was on how to deal with limited resources and on how to reduce the impacts on the environment. Later, the accent was on technical issues – energy related design (passive houses, low energy houses), construction technologies, buildings components, materials. Presently, the accent on soft issues of sustainability is growing. There are the economic, social, cultural issues, and cultural heritage, that gain ground.

According to CIB, outside and inside factors affect the use of sustainability concept in building and construction, there are:

- quality and property value,
- meeting user needs, flexibility, adaptability,
- prolonged service life,
- use of local resources,
- building process,
- efficient land use,
- water saving,
- use of by-products,

- distribution of information relevant to decision making,
- immaterial services,
- urban development and mobility,
- human resources,
- local economy.

Three pillar of sustainability characterize the sustainability development and, in the strict sense of the conception, the sustainability building and construction according to the new approach in a global context, there are:

- quality of environment (internal and external),
- economic effectiveness and economic constraints,
- social equity and cultural issues.

The Figure 1 illustrates the process of traditional engineering concept. Traditional building process focuses on cost, time, and quality. In the new concept, the impacts on environment - limited resources, emissions quantity and type, biodiversity are considered. In the global context, the economic, social, and cultural issues are counted together with the environmental issues.

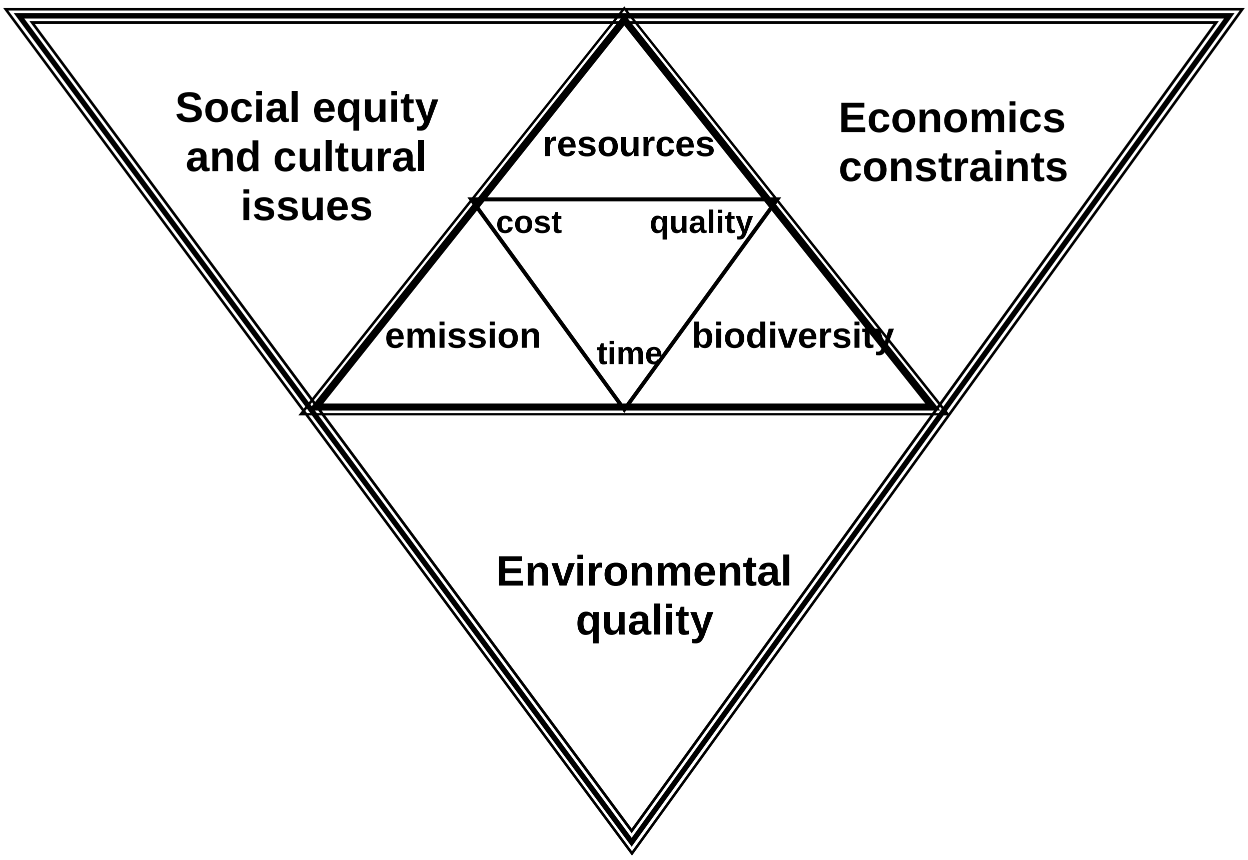

Fig. 1. The New Concept of Building Process in Global Context

Sustainable construction is considered as a way for the construction industry to contribute to the larger effort of achieving sustainable development.

2. The Buildings Appraisal

2.1. Traditional approach to buildings appraisal

Traditional approach to buildings appraisal is based only on financial return. Net present value, recovery of investment, internal rate of return are calculated and represent only economic point of view on building or project. Traditional project appraisal does not adequately and readily consider environmental effect and therefore does not satisfy the requirement of sustainable development.

This traditional approach to building appraisal can be modified with life cycle cost calculation. The life cycle costs are the cost of a building over its entire life. Life cycle costing (LCC) is a method for analyzing the total cost of the acquisition, operation, maintenance and support of a building throughout its useful life, and including the cost of disposal. This LCC analysis can provide important inputs for the decision making process. Classification of life cycle costs can be:

- investment, maintenance, repairing, reconstruction, modernization, disposal – the costs associated with technical parameters of building,
- energy, cleaning – operational costs
- realty tax, insurance, property management – administrative costs.

It is evident, from this classification, that the approach to building appraisal using the life cycle calculation considers energy consumption. The social and cultural issues are not considered.

2.2. Sustainability approach to building appraisal

Sustainability approach to building appraisal has to consider quality of environment, economics constraints, social equity and cultural issues. Proposed building appraisal using sustainability index includes the following four criteria:

- financial return,
- energy consumption,
- external benefits,
- environmental impact.

The four criteria and their sub criteria are measured by different methodologies and in different units. Transformation into a common dimension or common dimensionless unit using standardization procedure is necessary.

Criteria can be individually weighted to reflect particular client motives and community requirements. The weight depends on the requirements of the client and other stakeholders for each project and the importance of the facility in support of the missions, goals, and purpose of the organization, or in support of the objectives of an individual or family. Different methods can be used, such as paired comparison, ranking, rating, etc. The Figure 2 illustrates the evaluation matrix.

Criteria	Alternative of Project P_1 P_2 … Pj	Weights
C_1 C_2 C_3 . . . C_i	Criterion scores	w_1 w_2 w_3 .. . . w_j

Fig.2. The Evaluation Matrix

2.3. The Sustainability Indicator Model

The criteria can be incorporated into a decision making model. The sustainability indicator model can be expressed as follows:

$$I_i = \sum_{j=1}^{m} V_{ji} w_j \qquad (i=1,\ldots,n)$$

where I_i is the sustainability indicator for an alternative *I*, w_j is weight of criterion *j*, V_{ji} is the value of alternative *I* for criterion *j*.

$$V_{ji} = f\left(BC, EC, EB, EI)\right)$$

where V_{ji} is the value of alternative *I*, BC is financial return, it means benefit – cost ratio during the life cycle of building, *EC* is energy consumption, *EB* are external benefits and *EI* are environmental benefits (impacts).

Benefit – cost ratio during the life cycle of building can be expressed as follows:

$$BC = \frac{\sum_{t=0}^{LC} B_t /(1+r)^t}{\sum_{t=0}^{LC} C_t /(1+r)^t}$$

where *BC* is benefit – cost ratio, *B* are benefits during the life cycle of building, *C* are costs during the life cycle of building, *r* is discount rate, *t* is time, *LC* is life cycle of building.

Energy consumption *EC* consists of embodied energy (manufacturing energy of building materials and component, energy for transportation, energy used in processes) and operational energy.

External benefits *EB* consist of functional and technical layout, maintenance, economic and process performance, aesthetics impact, heritage preservation, social benefits. External benefits can be, for example, rated using formula:

$$EB = \sum_{j=1}^{J} U_{ji} v_j$$

where U_{ji} is the value of an alternative i for sub criterion j, v_j is weight of sub criterion j.

Environmental impact *EI* consist of manufacture (recycled materials, hazardous materials, greenhouse gas, pollution, manufacturing waste), design (evaluation of products, energy consumption, energy efficient), construction (air and noise pollution, water run off, construction waste), site context (groundwater, natural, rare/endangered species, transport system, traffic noise, access to site), disposal (non-recyclable waste, demolished waste/materials).

3. The Proposal of Criteria - External Benefit

3.1. Functional Benefits

Functional benefits describe and assess how well activities and processes can be performed in the building. Functional benefits are closely related to the needs of the building users and others – visitors, public community. Criteria include:

- suitability of the surface and space program for planed use,
- accessibility, barrier-free design,
- adaptability to changing user requirements and uses, etc.

3.2. Technical Benefits

Technical benefits describe structural, physical and other technical characteristics. Criteria include:

- suitability for planed service life,
- load capacity,
- maintenance and revitalization capability,
- structural resistance to fire,
- control of noise transmission,
- heat insulation, etc.

3.3. Social Benefits

The description and assessment of social benefits can be based on criteria:

- health, comfort and safety of users, visitors, residents and neighbours of the building,
- building's cultural value, etc.

3.4. Process Benefits

The overall building performance is influenced by the quality of processes involving planning, construction, use and facility management. The description and assessment of process benefits can be based on criteria:

- quality of planning,
- quality of construction on site,
- quality of management,
- quality of building related services, etc.

4. Conclusion

The parties involved in the building process each have a specific scope of interests with various resulting information requirements. Each of the actors involved view and assess to building differently. The investor is primary interested in the economic point of view. The user and facility manager have an interest in operating cost. Authorities and regulators are interested in environmental impacts because of an interest in protecting the environment, health, safety, security, fire, and compliance with current codes and regulations.

Traditional building's appraisal considering only economic returns, does not adequately and readily consider environmental effects, social, and environmental issues. This approach is shown to be no longer feasible. Buildings have a long life, so any improvement in their appraisal techniques can reduce their future environmental impacts and can satisfy the requirement of sustainable development. The sustainability index includes financial return, energy consumption as well as social and environmental issues in decision making framework. Presented project (building) appraisal does adequately and readily consider economic, environmental and social effects and therefore does satisfy the requirement of sustainable development.

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The Development of Facilities Management Education in Malaysia: Universiti Tun Hussein Onn Malaysia (UTHM)

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Abstract:
Information relating to Malaysian education in Facilities Management (FM) is difficult to come by and has led to a less than comprehensive understanding of the current market in the minds of FM practitioners. As a fast developing country, Malaysia spends billions of Malaysian Ringgit (RM) to build world class facilities. Though the prospects of FM seems to be raising due to the accomplishment of Vision 2020, since 1997 the development of certified FM education programmes has been formed to cope with the current and future demand of FM. Efforts towards FM excellence, particularly in the Higher Education Institute (HEI), have not been advanced and progressed in academic programmes or Research and Development (R & D) activities. Furthermore, there is also a lack of awareness within the area of built environment about the importance of FM disciplines and skills to be applied. For these reasons, considering the importance of national physical and human development, the Universiti Teknologi Tun Hussein Onn Malaysia (UTHM) has started to establish FM academic programmes and to develop the Centre of Excellence of Facilities Management (CEFM), as well as the Malaysian Association of Facilities Managers (MAFM) in response to the demand of FM practitioners in Malaysia. Before these have been developed, a comparative study has been prepared to understand how it is being delivered within the HEIs and other institutions in Malaysia. Hence, this paper provides the reader with an overview of FM education in Malaysia, particularly the involvement of UTHM, and how it has evolved accordingly.

Keywords:
Facilities management, higher education institution (HEI), facilities management programmes

1. Introduction

Higher education is about taking the public's education to the next level: learning new things, being in charge of choices and getting to where you want to be in the future, at whatever stage people are now and whatever age they are. With the advent of the K-economy, the embracing of the concept of life long learning takes priority everywhere because people will have to continuously update their knowledge and skills to maintain a competitive edge in the global economy. In the field of built and human environment, Facilities Management (FM) is one of the fastest growing professions in the UK. The British Institute of Facilities Management (BIFM, 2007) defined FM as "an integration of processes within an organisation, to maintain and develop the agreed services which support and improve the effectiveness of its primary activities". The International Facility Management Association (IFMA, 2007) then defined FM as "a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology". The Facilities Journal academically summarized FM as "a hybrid management discipline that combines people, property and process management expertise, to provide vital services in support of the organisation. It is interested in all areas relating to briefing, design, construction and use of facilities and in the emerging technologies that support organizational functions at the workplace" (Emerald, 2007). Due to these definitions of FM, the paper is trying to draw the emergence of FM in Malaysia within the HEIs since it was introduced in 1997. The discussions will primarily enlighten on the roles of UTHM, as a new public university towards the development of FM excellence in Malaysia.

2. Facilities Management in Malaysia

Effective FM, combining resources and activities, is vital to the success of any organisation. At a corporate level, it contributes to the delivery of strategic, tactical and operational objectives. On a day-to-day level, effective FM provides a safe and efficient working environment which is essential to the performance of any business, whatever its size and scope of work. In Malaysia, the awareness of the importance of FM is not often being discussed, either at public or private sector organisations. However, initiatives are being taken by many institutions to ascertain an approach to improve the management of national assets and facilities management throughout the nation. Retrospectively, the first FM Masters programme was introduced in Malaysia by the University Technology Malaysia in the year 1999. In 2001, the first conference in FM was organised by this university in Kuala Lumpur. The theme was "FM-KL. Where are We Heading?" and was considered as the first step of the FM programme held at international level in Malaysia. In the first place, the conference succeeded in introducing FM to the nation. The awareness of the importance of FM then created the launching of the next FM academic programme in 2002, which the other public university known as Universiti Teknologi MARA (UiTM) also began at the Shah Alam Campus. In 2004, another public university known as Universiti Tun Hussein Onn Malaysia (UTHM) crafted its proposal for the development of its FM masters programme to be approved by the Ministry of Higher Education (MoHE). At present, this programme is still at the first stage of finalisation and seeking an approval by the Senate of UTHM. Besides the development of this programme, UTHM has been moving forward by initiating the development of the Malaysian Association of Facilities Managers (MAFM) and the establishment of the Centre of Excellence for Facilities Management (CEFM). Due to the fact that FM is becoming more mature in Malaysia, last year, the first inaugural National Asset and Facility Management Convention (NAFAM) was held in August 2007 to address the current issues and future challenges in managing national assets and facilities. This convention showed that the FM profession matures and adapts to meet the demands of a fast growing built and human environment industry. Agreeing to have an annual convention on NAFAM, the Prime Minister urged the public and private sectors to come up with a more effective and efficient procedural framework to continuously improve the management of national assets and facilities. This convention was a major revolution to the future changes with regards to the perception of FM professions and practices in Malaysia. In the academic world, it is particularly important for the HEIs to keep abreast of changes in practice and use the institutions as a proper channel and mechanism to develop a good FM academic syllabus. Hence, the HEIs in Malaysia should perform their function to provide an integrated approach to professional practice and offer a strong platform in order to build a candidate's FM knowledge base formally.

3. Universiti Tun Hussein Onn Malaysia (UTHM): Contribution to Facilities Management Excellence

Originally, it was known as the Pusat Latihan Staf Politeknik (Polytechnic Staff Training Centre) set up in 1993. Due to its significant role and contribution in producing qualified polytechnic lecturers as well as the government's trust towards the capability of the organization, the training centre was officially upgraded to the Institut Teknologi Tun Hussein Onn (ITTHO) in 1996 under the assistance of Universiti Teknologi Malaysia and the Ministry of Higher Education (MoHE). With the government's trust as a motivation, ITTHO kept on moving ahead with excellent, creative and innovative programmes. Finally, the inaugural announcement of Kolej Universiti Teknologi Tun Hussein Onn (KUiTTHO) was made on 30th September 2000. Later, in February 2007, KUiTTHO has been finally upgraded to the country's 15^{th} public university known as Universiti Tun Hussein Onn Malaysia (UTHM). It was set up with specialisation in engineering, engineering technology, technology management and technical and vocational education. As the 15^{th} public university, UTHM has leapt to a new era and ready to shoulder its responsibility as a centre of academic excellence and respected nationally, aligned with the mission of the University, "To produce and train technologist as well as professionals who are creative, innovative, competent and responsible and able to apply, explore and lead new technologies through the world class teaching and research, based on 'Tawheed' for the benefit of mankind". Tawheed means the realizing and maintaining of God's unity in all of man's actions which directly or indirectly relate to Him for the benefit of universe. In this university, the courses relating to built and human environment are conducted by the Department of Construction and Property Management in the Faculty of Technology Management. At the moment, three levels of academic programme are being offered by the Department:

3.1 Department of Construction and Property Management, Faculty of Technology Management

3.1.1 Certificate Programme in Facilities Management

This programme has been proposed by the MoHE to help graduates in Malaysia who still have not obtained a job after graduating. This unique graduate programme was initiated in collaboration with the Ministry of Finance (MoF) and known as a national Industrial Skill Enhancement Programme (INSEP). The aim of this programme is to equip current graduates with the right competencies and innovative capabilities based on their undergraduate background. Working in partnership with the Continuing Education Centre (CEC) at the UTHM, the faculty members have to deliver the course within a three months period. It is specifically designed for the students who graduated within the area of built and human environment and seeking to obtain greater understanding of FM professional practices. Students who attend this programme will be paid by the government about RM500.00***** (€ 105.00) per month considered as their monthly allowance. Ever since it was introduced, this programme is conducted every year as a national graduate programme under collaboration between the MoF, the CEC and the Faculty. Table 1 shows the learning outcomes and model structure for the certificate programme.

Table 1: Certificate Programme in Facilities Management

Learning Outcomes	Model Structure
At the end of the programme, a graduate should be able to:	The module of this programme has been developed as follows:
i. Identify and understand the responsibility of facilities management	i. English Communication and Interpersonal Skills
ii. Undertake the job of a facilities manager by the application of current technology or software	ii. Entrepreneurship
iii. Apply strategic planning in facilities management confirmed by acceptable guideline and practice	iii. Introduction to Facilities Management
iv. Practise knowledge skills gauged from industrial training in a major property or facilities management firm	iv. Facilities Management Practice
	v. Facilities Management Services
	vi. Facilities Management and Business

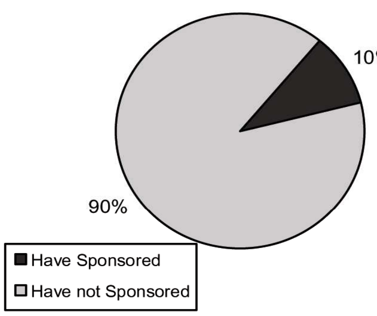
***** RM is Malaysian currency known as Ringgit Malaysia. RM1.00 is equivalent to €0.20.

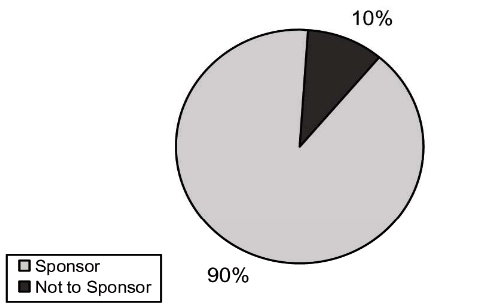
3.1.2 Master of Science in Facilities and Assets Management

This programme is being developed at the post-graduate level which is ideal for more experienced managers and senior management officers who wish to consolidate and expand their knowledge in FM. The focus of attention has been given to those who practise FM and those who work in organisations supplying FM related goods or services within the built and human environment particularly. The developed subjects are reflecting FM professional practice across the Asian Countries; the United Kingdom and the United States of America, because a comparative study had been undertaken before the programme could be proposed to the Senate of the UTHM. After it is approved by the Senate then the proposal can be sent to the MoHE for the accreditation process. The objectives of the programme are;

(1) To generate graduates in the context of FM disciplines and skills to meet the demands of a fast growing FM industry;
(2) To formally enhance and develop the science and understanding of FM knowledge and practice through academic institution;
(3) To provide a platform and an opportunity for students to consolidate and expand their knowledge at post-graduate level;
(4) To be recognised as a source of expert pool of knowledge and practices in FM academic programme towards FM excellence in Malaysia;

Earlier in 2003, market research was conducted to study the feasibility and marketability of the programme. A group of industry experts was invited to participate by the department to represent various industry sectors and constituencies of the FM profession. The report then indicated that only 3 out of 30 respondents had sponsored students to study in this programme. On top of that, 90 percent of respondents believed that this programme can add value into their organisation based on the structure of syllabus. See Figure 1 and Figure 2.





Source: Sulaiman (2004d)

Figure 1: The current sponsorship in FM education programme

Figure 2: The prospect of sponsorship in FM education programme

The integration of theory, management, ICT, practical engineering, and mathematics and science components also convinced them to welcome graduates from this programme to work in their organisation. Off the total, 90 per cent of respondents then strongly agreed to sponsor their staff if they want to continue their study in this programme. Moreover, after answering the survey questions, 50 per cent of respondents agreed to establish a FM unit in their organisation. Based on the report, department of meetings and workshops, the main outcome to the Department is the structure of the FM Masters programme titled as Master of Science in Facilities and Assets Management as mention in the Table 2.

Table 2: Master of Science in Facilities and Assets Management

	Programme Name	Master of Science Facilities and Assets Management
	Period of Programme	1 ½ years
	Mode of Study	Lectures, assignments, downloadable modules, international visits
	Method of Assessment	Assignments, examinations, simulation projects and final project
	Core Subjects	**Learning Outcomes**
i.	Professional Trends in Facilities Management Best Practices	*At the end of the course, students should be able to understand the current professional trends, skills and knowledge relating to facilities management best practices.* **[Management Component]**
ii.	Quality and Value Management in Facilities Management	*At the end of the course, students should be able to describe the benefits achieve through quality and value management can bring to Facilities Management.* **[Management Component]**
iii.	Economic and Financial Evaluation of Facilities	*At the end of the course, the students should be able to understand the principles, tools and techniques of economic and financial evaluation of facilities to minimize risk and maximize return on investment in relation to Facilities Management.* **[Mathematics & Science Component]**
iv.	Computer Aided Facilities Management & Information Management System	*At the end of the course, the students should be able to understand the applications and benefits of IT and CAFM (Computer-Aided Facilities Management) systems which Facilities Management organisations may wish to utilize for the benefits of the organisations* **[Information & Communication Technology Component]**
v.	Facilities Maintenance and Operation of Built Assets	*At the end of the course, students should be able to understand how to demonstrate and implement a managerial process of facilities maintenance and operation of built assets.* **[Practical & Engineering Component]**
vi.	Risk and Disaster Management	*At the end of the course, the students should be able to describe the principles, theories and applications of risk and disaster management techniques.* **[Practical & Engineering Component]**
vii.	Environmental, Health and Safety Management	*At the end of the course, the students should be able to understand the issues, basic principles, theories and applications of managing environment, health and safety (EH&S) in their areas of responsibility.* **[Management Component]**
viii.	Planning and Design in Facilities Management	*At the end of the course, the students should be able to understand the principles and techniques of facilities planning and design and how they apply to and impact Facilities Management best practices.* **[Practical & Engineering Component]**
ix.	Comparative Study on International Facilities Planning and Management	*At the end of the course, the students should be able to differentiate various concept, principles, techniques and related matters in the framework of international facilities planning and management.* **[Practical & Engineering Component]**
	General Subjects	(i) Research Methodology; (ii.) Philosophy of Science & Social Development; and (iii.) Seminar on Development & Global Issues
	Percentages of Component	(i) Practical & Engineering Component: 50 percent; (ii.) Management Component: 38 per cent; (iii.) Mathematics & Science Component: 6 per cent (iv.) Information & Communication Technology Component : 6 per cent
	Qualification	Bachelor Degree with Honours in Facilities Management or relevant academic disciplines within the built environment studies or any degree from institution of higher learning recognised by the UTHM Senate

Source: Sulaiman (2004a)

These subjects comprise a balance of special FM subjects and general management modules. It is intended to provide the student with a thorough grounding in both facilities and general management theories and practice. The Department believes that the introduction of the syllabus represents a positive and exciting content for FM academic development. As well as having the full-time programme, a part time programme will also be conducted. The part-time programme may take up to two years, consisting of five semesters. Altogether, nine subjects will be offered, which is each tailored to the current needs of facilities managers. As universities move towards the future, the integration of global perspectives into the curriculum is essential for providing a meaningful international understanding for students (Spanier, 2007). Hence, the application of this new shape of curriculum can help to create global understanding on the insight and standards of facilities management practices been achieved in other countries or organisations. This will drive the student to think globally and make her/him capable to reflect on the best for local built and human environment needs. Prior to this attempt, the final project was also designed as a comparative international study in which the students should experience an international technical visit at any FM organisation outside Malaysia within the area of built and human environment. The report will be considered as an International FM Comparative Study and can be produced as a dissertation. Table 3 shows the particulars on this programme and also summarised the master programme offered by the public universities in Malaysia. Equally important as in the UK, in Malaysia, the Quality Assurance Division of the Higher Education Department, MoHE is responsible for the academic accreditation and evaluation offered by the public universities. A code of practice entitled “Code of Practice Quality Assurance in Public Universities in Malaysia” has been designed to achieve that purpose and to promote public confidence that quality in higher education is being maintained. It contains guidelines on criteria and standards for higher education in Malaysia and the procedures for quality assurance. It is also to ensure the HEI has sufficient and adequate resources to deliver the course to an adequate level of satisfaction. Thus, before the accreditation can be done, the programme evaluation must also involve the governance and administration of the University, the institution itself at the Faculty/School/Department level, representatives of the community, employers, education and government agencies, professional organizations and postgraduate educators nationally. As stated earlier, the programme is being reviewed at the faculty level before it can get an approval by the Senate of UTHM. Hence, it is soon to be accredited by this Division. With regards to professional accreditation, academic programmes may be accredited for their academic standing or they may be accredited to produce graduates with professional competence to practise, usually referred to as “professional accreditation” (Harvey, 2004). Prior to this requirement, the Department is now also preparing the document for BIFM, Royal Institute of Chartered Surveyors (RICS) accreditation as well as trying to seek the IFMA recognition. This exercise would be a great benefit for the national and international recognition of the Department as well as UTHM particularly.

3.1.3 PhD in Real Estate and Facilities Management

Until now the Faculty has produced four PhD students in Real Estate and Facilities Management since it was established in 2004. The Department is continuously welcoming more students to join the Faculty as a PhD candidate, especially those who are interested in gaining further knowledge in FM and to excel the contribution to the FM knowledge through research activities. Unfortunately, in terms of PhD supervision, the deficiency of PhD holders in FM has become an essential issue within academia in built environment study in Malaysia. Since the government encourages the public universities to hold at least 75 per cent of their lecturers with PhD, the academic high-flyers in FM has still very small number in and FM was given a very low priority compare to the other academic programmes such as engineering, business and information technology. As the Faculty is trying to enhance the FM academic courses at various levels, a diverse international collaboration has also been made to create a better understanding from the universities outside Malaysia such as in the United Kingdom and European countries. Significantly, this collaboration will help further the appointment of external examiner, Visiting Professor and Contract Professor from the developed countries. In the meantime, the Department is also consistently sending lecturers to pursue their PhD in FM at well known universities around the globe predominantly for the purpose of transferring FM knowledge.

Table 3: Comparison of Taught Programme Structure for the Master Programme in Facilities Management offered by universities in Malaysia

Higher Education Institution (HEI)	Mode of Course	Length of Study	Total Credit	Subjects	Percentage of Components %				Final Project
					M	ICT	P & E	M & S	
University Technology of Malaysia Faculty of Engineering and Geoinformation Science	Taught course and lectures. Student needs to complete an assignment for each subject	Full time (1 year) and Part Time (2 years)	34	1.) Value & Risk Management **[P & E]** 2.) Project Management **[P & E]** 3.) Computer Aided Facilities Management (CAFM) **[ICT]** 4.) Quality Management **[M]** 5.) Environmental Management & Support Service **[M]** 6.) Facilities Management **[M]** 7.) Dissertation*	50	15	20	15	* Student should submit a dissertation in the final semester
University Technology MARA (UiTM) Faculty of Architecture Planning and Surveying	Taught course and lectures. Student needs to complete an assignment for each subject. Exam is compulsory for each subject	Full time (1 year) and Part Time (2 years)	37	1.) Framework of Facilities Management & Research Methodology **[M & S]** 2.) Information Technology & Communication **[ICT]** **3.)** Human Resource Management & Organisational Behaviour **[M]** **4.)** Value Management & Finance **[P & E]** 5.) Risk and Strategic Management **[P & E]** **6.)** Planning and Facilities Management in Fabric Building **[P & E]** **7.)** Environmental Management and Services **[M]** 8.) Computer Aided Facilities Management (CAFM) **[ICT]** 9.) Integrated Simulation Facilities Management Project/Dissertation*	25	25	37	13	* Student should submit a dissertation in the final semester
Universiti Tun Hussein Onn (UTHM) Faculty of Technology Management	Taught course and lectures. Student needs to complete an assignment for each subject. Exam is compulsory for each subject. Comparative study with foreign country has to be completed during the short semester.	Full time (1 year) and Part Time (2 years)	34	**1.)** Professional Trends in Facility Management Best Practices **[M]** **2.)** Quality and Value Management in Facilities Management **[P & E]** **3.)** Economic and Financial Evaluation of Facilities **[M]** **4.)** Computer Aided Facilities Management & Information Management System **[ICT]** 5.) Facilities Maintenance and Operation of Built Assets **[P & E]** **6.)** Risk and Disaster Management **[M]** **7.)** Environmental, Health and Safety Management **[P & E]** **8.)** Planning and Design In Facilities Management **[M & S]** 9.) International Comparative Study/Dissertation*	37	13	37	11	* Student should undergo an international technical visit at any FM's organisation outside Malaysia within the area of built and human environment. Report will be considered as an International FM Comparative Study and should be produced as a dissertation.

*Note: The components of subject are consisting of **M**-Management; **ICT**-Information & Communication Technology; **P & E** -Practical & Engineering; and **M & S**- Mathematics & Science

Source: Sulaiman (2004a)

3.2 Centre of Excellence for Facilities Management (CEFM)

Fig. 1. CEFM Corporate Logo

On the 1st January 2004, the Centre of Excellence for Facilities Management (CEFM) was officially announced as one of the centres of excellence in UTHM. This centre is the only centre developed with a vision to lead for knowledge sharing and development to achieve FM best practice through innovation and cutting edge technology across the country. The establishment of this centre is important as stated by Alexander (1998) that "if FM is to be acknowledged as a profession with its own rigorous discipline, it needs to sow the seeds for a strategy and infrastructure to promote development. "Centre of Excellence" should be created and linked into a network, to provide the focus of all this". This statement demonstrates that a centre of excellence is an important hub in creating a network within the academic based institutions and a particular field of profession such as FM. The establishment of the centre of excellence can also attract worldwide interest within the same intellectual background, multi-disciplinary knowledge sharing (preferably comparative) carried out by teams networking internationally across research sites, academia, industry experts and policy jurisdictions. Since 2004, CEFM has been trying to consolidate its role and diversify its activities across the nation. It has been working actively to create awareness throughout the nation about the FM roles, skills and functions. Also, the perception on FM practices have been promoted through the national and international collaboration that provides a ladder of opportunity to bridge CEFM with the FM centre of excellences and HEIs around the world as well as FM professional institutes such as IFMA and BIFM. In addition to this, CEFM is also trying to build its reputation and image within public and private sectors organisations as well as strengthening links with other major researchers and FM consultants locally. Figure 1 shows the CEFM's corporate logo. Considering the importance of strategic and long term planning, CEFM has laid its strategy as below:

3.2.1 Vision

To serve as a leading edge centre of excellent for knowledge sharing and development to achieve Facilities Management best practice through innovation and cutting edge technology.

3.2.2 Mission

To continuously promote the development of total quality in Facilities Management as a critical, professional and strategic business discipline to deliver Facilities Management excellence.

3.2.3 Objectives

(1) To develop, demonstrate and disseminate best practice expertise and experience across different sector and facilities types;

(2) To identify and prioritise key issues for research & development and consultancy through expert position statements and discussion documents;
(3) To establish a consolidated knowledge base, supported by secure techniques, sound criteria and accountable expertise on which to develop practical theories in the field;
(4) To encourage cross-disciplinary collaborative research initiatives in key areas of opportunity and to help apply research finding and techniques;
(5) To promote national and international standards and benchmarks for Facilities Management best practice;
(6) To promote networking, events, training, research and access to knowledge as an aid to continuing professional development;
(7) To enhance and disseminate knowledge through publication on Facilities Management;
(8) To establish and maintain best practice of Facilities Management that will support rising performance and requirement levels and promote excellence in Facilities Management through innovation and creativity.

3.2.4 The Structure of the Centre

The structure of the CEFM is portrayed in Figure 3 below. It is led by a Head of Centre and supported by the six of strategic units known as Research; Consultancy; Training & CPD; Publication; Corporate Relation and ICT. For academia, the ability to influence policy depends on undertaking research and making conclusions that are ‘politically practicable’, while governments have only been prepared to fund research that is seen to be ‘useful’ (Ball, 1986). Hence, this research unit is the essential unit though which knowledge is developed through innovation and discovery to solve problems in FM world. The government has given various researchers funding to excel their research activities by offering a long term research, collaboration or contract research to the centre.

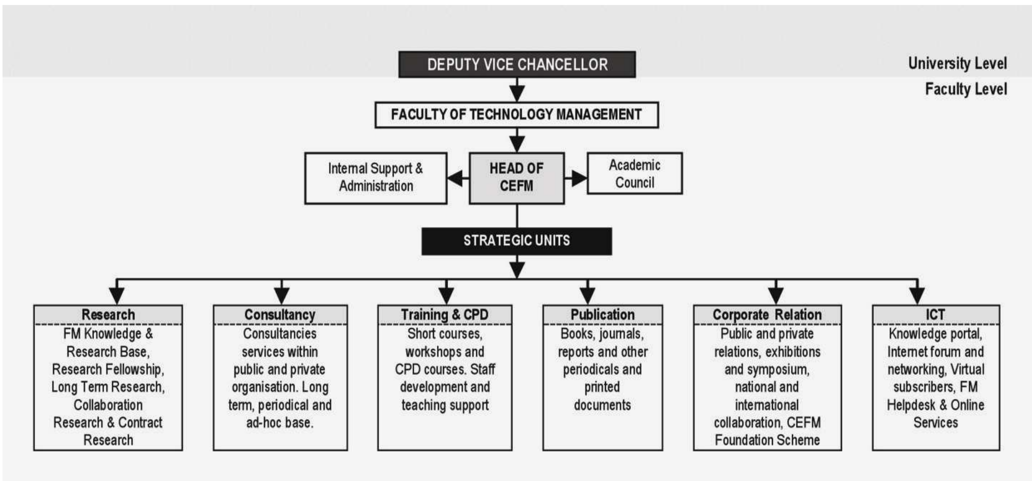


Fig. 3. The Structure of the Centre

CEFM has also been acting as a referral centre for FM research activities throughout the nation as policy-making is actually needs to be based on solid empirical evidence. The consultancy activities are also conducted within the public and private organisation base on long-term, periodical and ad-hoc bases. The demand is created by the ogranisation who seeks for intellectual consultancy. On top of this, the short courses, workshops and Continuing Professional Development (CPD) are also delivered by the CEFM members to the public and private organisation to assist the development of FM skills and practices within the clients. The members are encouraged to produce books, journal articles and other periodicals considered as printed documents to boost the sources of FM knowledge in Malaysia. They have been participating in national and international exhibitions, symposiums and international conferences in a way to promote the function of the centre and to acquire a wider recognition from the industries, government department as well as academia. The FM knowledge portal is also developed to create a virtual discussion, forum and to invite virtual subscribers to utilise the FM sources of knowledge and information assisted by the helpdesk and on-line services.

3.3 Malaysian Association for Facilities Management (MAFM)

Malaysia needs a change in the management of asset and facilities. The formation of the MAFM in 2004 by the CEFM's members and the identified representatives from FM industry showing the concern of UTHM towards the fundamental changes of FM practices. Ever since then, it has been the responsibilities of the MAFM to promote FM through the membership of the MAFM and other facilities managers within the FM industry. It was formed to correspond to the function of IFMA as well as BIFM in the UK. This association is now recognised as the first and the only FM association in Malaysia validated by the law of association and society in Malaysia under the Societies Act 1966; Societies Regulations 1984; and Societies (Application for Vesting Order) Regulations 1993. The constitution of MAFM was successfully documented in January 2004 and legally protected by this act. Basically, as stated in the constitution, the aim of MAFM and the objectives are;

3.3.1 Aim

The Executor of Development Aspiration and Global Facilities Management

3.3.2 Objective

(1) To provide a forum for MAFM members to share best practice in the field of FM;
(2) To provide networking opportunities for facilities managers;
(3) To organise CPD events for members in all subjects related to facilities management;
(4) To develop an understanding of FM at strategic, tactical and operational levels;
(5) To examine the concept of total building life and ways in which construction professionals can 'add value'; and;
(6) To be recognised as an expert pool of knowledge.

Having reviewed the role of Institute Surveyors Malaysia (ISM) and Board of Valuers and Estate Agents (BOVEA), it is revealed that the FM position in Malaysia is still governed by none of any professionals' bodies. ISM (2007) stated the professional examinations can be obtained for professionals in land surveying, quantity surveying, property consultancy and valuation surveying and finally building surveying. Unfortunately, the FM profession is not considered to be positioned under the Act and still in ambiguous concern within the other professions under the ISM and BOVEA. In its own way, the RICS, UK Chapter has already recognised the FM as one of the 20 'specialisms' or Faculties offered as clustered in the Table 4 below. The 'Faculties' represent the key market sectors within which surveyors practice. The Faculties' primary role is to develop technical standards and generate professional and technical guidance and information. Also, they are responsible for setting and maintaining the Assessment of Professional Competence (APC) or the Assessment of Technical Competencies (ATC) that make up the APC/ATC pathways for the practice area groupings of Built Environment, Land and Property as in the **Table 4** below. All but one of the Faculties are also responsible for maintaining alternative designations, e.g. chartered quantity surveyor; chartered facilities management surveyor (RICS,2008).

Table 4**:** The Faculties: Representing the Specialists

	BUILT ENVIRONMENT	LAND	PROPERTY
Practice Specialisms	1. Building Control 2. Building Survey 3. Project Management 4. Quantity Surveying & Construction 5. Taxation Allowance	1. Environment 2. Geomatics 3. Mineral and Waste Management 4. Planning & Development 5. Rural	1. Arts and Antiques 2. Commercial Property 3. Facilities Management 4. Finance and Investment 5. Housing Management & Development 6. Machinery and Business Assets 7. Management Consultancy 8. Residential Property Practice 9. Residential Survey & Valuation 10. Valuation

Source: (RICS, 2008)

In the same way, while FM is achieving a wider recognition in USA, UK and other developed countries, it should deserve the same in Malaysia. Pursuant to the Memorandum of Co-operation (MOC) and long term understanding between RICS and ISM, with regards to FM profession, the route to ISM membership and assessment of competencies should concurrently be aligned within the MAFM criteria too. Indeed, the RICS, ISM, BOVEA and MAFM should work out on how the partnership can be created smartly towards the recognition of FM competencies in Malaysia as well as the position of FM profession within these four entities. Also, the law governing the profession should also be unambiguous from the spectacles of public, private sector and academia.

Table 5**:** Core Business of the Organisation

Area of MAFM		
1. Building services and maintenance	8. Retail and Franchise	15. Electric and Electrical Industry
2. Federal Government Services	9. Facilities Management	16. Manufacturing Industry
3. State and Local Government Services	10. Restaurant and Catering	17. Recruitment and Personnel
4. Education/Higher Education Institution	11. Events and Hospitality	18. Leisure, Resorts and Hotels
5. Healthcare and Pharmaceutical	12. Transportation, Fleet & Logistics	19. Professional Consultancy
6. Architecture and Landscape	13. Property and Estate Mgt	20. Security
7. ICT	14. Chemical Industry	21. Cleaning Services etc

Component of MAFM Practices		
1. Business Organisation • Organisational structure • Business and Organisational Strategy • Developing FM Strategy 2. Managing People • People Management • Communication • Working with Suppliers and Specialist	3. Managing Resources • Procurement • Risk Management • Financial Management • Quality Management • Information Management 4. Managing Premises • Property Portfolio • Building Design • Building Fabric Maintenance	5. Managing Services • Managing Building Services • Managing Support Services • Project Management • Managing Customer Services 6. Managing the Working Environment • Environmental Issues • Space Management • Energy Management • Climate Change Management

Source: Sulaiman (2004b)

In terms of FM roles, under the constitution, MAFM has set the area of FM functions into 21 groups as stated in Table 5. These types of core businesses have been identified and placed in the membership form. Besides, the component of FM practices has also been clustered into 6 components including business organisation; managing people; managing resources; managing premises; managing services and managing the working environment.

3.3.3 Corporate Image

Another essential part in creating and adding value of an organisation is a logo. The logo came from a Greek word *logotypos.* It is a graphical element for immediate recognition, inspiring trust, admiration, loyalty and an implied superiority of an organisation or one entity

(Alina, 2006). Therefore, the MAFM corporate logo was designed to make it unique by its letters, elegant colours and eye-catching graphic elements. Importantly, it is designed to carry the professionalism and the image of the association visually. Likewise, the theme of the logo colours are also based on the similar range of IFMA and BIFM colours. The meanings of the corporate logo have also been interpreted as in the Figure 4 below.

MALAYSIAN ASSOCIATION OF FACILITIES MANAGERS

Features	Visual Meanings
Alphabet 'M'	Acronym to the word 'Malaysia' and 'Managers'
Building corner	Three dimension of a part of building structure
Associate Colours (Red, Black, Silver Grey and White)	Combination of the colours of IFMA & BIFM logo or global colour of FM association
-Red	- courageous, spirit, desire, leadership in FM community
-Black	- foundation of the platform, professionalism and strength of the profession
-Silver Grey	- technological and ICT approaches, neutral and continuously being matured
-White	- clean, purity, trust and committed to the profession and association

Fig. 4. MAFM Corporate Logo, Features and its Visual Meanings

In order to protect the status and image of the association, under Section 3 of the constitution, the logo is protected intellectually and the usage has been permitted to the partner of the association only. As the establishment of MAFM proposed by the CEFM members, they are automatically being considered as MAFM member. The whole MAFM hierarchy and structure of membership is presided over by the President of MAFM assisted by a Secretary General, an Assistant Secretary General as well as a Treasurer elected from the board members annually.

4. Summary

In summary, teaching, research and providing expert services are three interrelated academic activities. Using a network between the Department of Construction and Property Management, CEFM and MAFM it can finally mark UTHM as a leader towards the development of FM excellence in Malaysia. Apparently, a higher support and encouragement from the upper management of UTHM as well as staff involvements and co-operation are imperative to ensure that the University can be a referral centre of FM studies nationally. Though not all academic staff can be equally involved in all three entities, the involvement of each staff member through the development of competitive academic programme, the centre of excellence and the association can absolutely enhance the role of UTHM as the first HEI in Malaysia for working enthusiastically in promoting FM practices throughout the nation. For each involvement, the University should provide a clear explanation about the responsibilities, roles and equitable workload distribution of the various roles in teaching, research, consultancy/expert services, professional association maturity and as well as community participation that contributes to the quality of education, civic responsibility and improvement of the sustainable quality of life of the community. The recognition of meritorious contribution for the purpose of promotion; salary determination; or other incentives of the academician who involves actively in these entities should be evaluated reasonably. With regard to curriculum development, for a good start, all public and private universities in Malaysia should endeavour to develop a competitive FM curriculum with an excellent undergraduate and post graduate programme and continuously benchmark over the reputable universities with the similar interest around the world. A systematic guideline for a thorough accreditation to access how well the curriculum content is also important to be monitored by the MoHE in respect of the requirement of the core competence in FM professional practices. For those who do not have basic FM official education, thus it is also crucial to apply systematic training or undertaking CPD courses for upgrading the lacking of FM skills and disciplines. Here, a close affiliation between the CEFM and MAFM should be able to bridge the lack of knowledge gap between academia and people in industries. With no doubt, the people innovations in research are also important to the ultimate users in the FM ecology. Instead of accelerating the research funding, the FM profession should be highly regarded as one of the experience or senior management skill worker within the scope of built and human environment. The MAFM, ISM and RICS should also working together to execute the national aspiration towards a better quality of living. Significantly, not only the management of physical facilities can have a large role in determining national built environment efficiency, but supporting innovation and knowledge discovery, and a greater academic partnering can absolutely gear the nation to a better place to live. Hence, the UTHM should act as a platform for all parties interested in FM to cooperate for the excellences of the future national development. UTHM has to make sure that the leading role can be maintained continuously and always at the highest level.

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The JOSEF Underground Educational Facility

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Abstract:
The Josef Underground Educational Facility (Josef UEF) is a new multidisciplinary facility employed primarily for the teaching of university students. Other activities include research and cooperation on projects commissioned by the private business sector. Almost 600 meters of renovated underground areas provide a wide range of research opportunities for young scientists involved in underground structures, geotechnics, geochemistry, engineering geology and material engineering. The aim of this paper is to inform students about the activities and diverse opportunities provided by the Josef Educational Facility. It is hoped that the authentic underground environment and the various research projects currently underway at the Josef UEF will both provide new information for students and inspiration for dissertation topics.

Keywords:
Education, multidisciplinary research, underground facility

1. Introduction

The Josef Underground Educational Facility (Josef UEF) is a new Faculty of Civil Engineering, Czech Technical University (CTU) in Prague facility which opened in June 2007. The facility is located about 50km south of Prague near the Slapy dam close to the village of Čelina in the Příbram district. The Josef UEF is employed primarily for the teaching of students from the CTU and other universities. Other activities include research and cooperation on projects commissioned by the private business sector. The main subjects are underground stuctures, rock mechanics, underground surveying and engineering geology.

In the Czech Republic young people´s interest in technical and science programmes is very low compared to other specialisations (Research and Development Council, 2007). In the number of university Science&Engineering students, as well as in tertiary education and life-ling learning the Czech Republic lags behind not only the EU-15 average, but also the EU-25 average (National Innovation Policy, 2005). Moreover, technically oriented universities usually provide students with a lot of theoretical knowledge but there are very few opportunities for students to use the gained knowledge in practical experiments or courses within their studies and to experience practical applications of the theory learned. The main objective of the Josef UEF is the innovation of the theoretical approach to teaching and its enrichment for practical elements that might be used by the students in their future jobs. This also demands a close cooperation with other institutions and private sector to be able to “tailor” university education to the current research and commercial sphere requirements. This intention fully corresponds to the strategy of the National Innovation Policy of the Czech Republic for 2005-2010 to establish well-functioning public-private partnerships.

The project of such a facility was inspired by a similar educational facility in the USA and by foreign underground laboratories. The combination of education and research as well as its multidisciplinary approach make the Josef UEF unique not only at the domestic but also at the European scale.

2. Description of the Josef UEF

The Josef UEF is situated in a former gold exploration gallery. This extensive underground complex is made up of tunnels and galleries with a total length of almost 8km, 600m of which have so far been renovated and are being used for educational and research purposes. It is planned that the rest of the tunnels and galleries will be renovated in the near future. The main exploration gallery is connected to various exploration workings by numerous insets, which follow ore formations and provide access to two further levels. 90% of the breakings are unlined (Pacovský et al., 2007). A plan of the gallery is shown in Fig. 1.

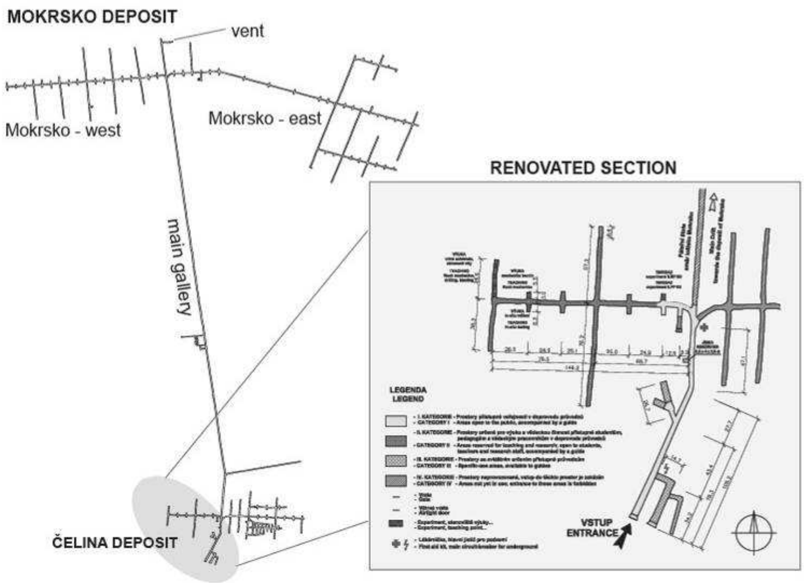

Fig. 1. Plan of the Josef gallery

2.1. Geology

The Josef gallery was excavated as part of the exploration of the Psí hory gold-bearing district which is located mainly in the proterozoic Jílovské belt, in rocks of more than 600 million years old. These rocks were subsequently penetrated by Central Bohemian Pluton granitoid rocks during the Variscan orogenesis. In the Psí hory area, the Jílovské belt consists of volcanic rocks of both basic and acidic composition (basalts, andesites, dacites and rhyolites) in the central area with subvolcanic plagiogranites at its eastern edge and gold-bearing acidic to intermediate tuffs. The overburden consists of a volcanic-sedimentary formation consisting mostly of tuffs and tuffitic shales. To the west, the Psí hory mining district extends to the margin of the biotitic-amphibolic granodiorite of the Central Bohemian Pluton (Morávek, 1992). Geological conditions in the area are depicted in Fig. 2.

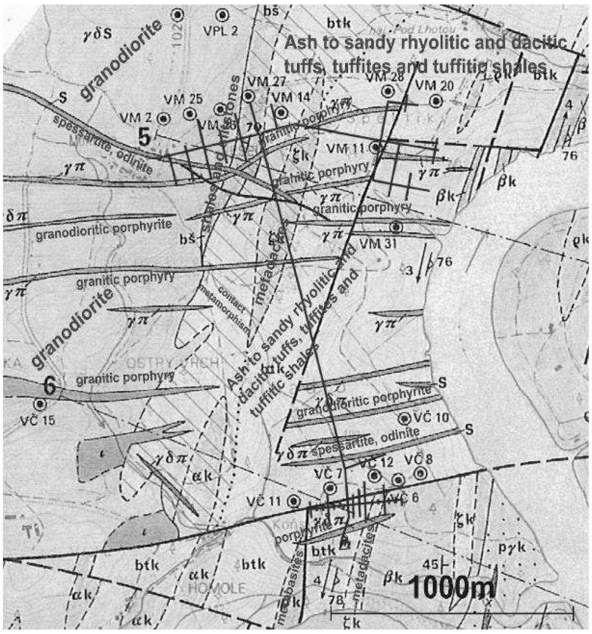

Fig. 2. Geological conditions of Psí hory area.

The gold reserves in this area are some of the richest in Europe. According to recent estimates, local deposits contain up to 130t of the precious metal (Morávek, 1992). At the end of the last century, the revival of gold mining in this area was seriously considered; however, the highest concentrations of gold occur at depths of up to 300m meaning that the gold would have to have been exploited by open-pit mining. Moreover, the separation of the gold would have required the use of the environmentally unfriendly cyanide process. Consequently, commercial gold exploitation is not currently envisaged and is not likely in the near future.

2.2. Josef gallery - past and present

The excavation of the Josef exploration gallery commenced in 1981 and the gallery was in operation for ten years. In 1991 exploration of the area ceased and the gallery was closed whereupon it began to deteriorate rapidly. The Faculty of Civil Engineering, CTU realised the potential that this by now somewhat dilapidated underground complex provided for educational and research use and in 2005 an agreement on the use of the gallery for such purposes was signed between the faculty and the Ministry of the Environment which owned the complex. The costs related to the operation of the Josef UEF are funded from the JPD3 European Structural Fund. Teaching programmes commenced at the Josef UEF at the beginning of the academic year 2007/2008. The main goals are to provide students both with practical experience and university courses which satisfy the demands of the commercial world. Besides teaching, several multidisciplinary research projects will commence in 2008.

3. Teaching

Currently, the Josef UEF's main activity is teaching. In September 2007 the underground complex saw the commencement of regular instruction following specially designed CTU study plans. It is envisaged that over 300 students will take advantage of the Josef facility in the first year of teaching.

To date, courses have focused primarily on various aspects of underground structures – e.g. underground engineering, rock mechanics, underground urbanism, geotechnics, engineering geology, an introduction to mining techniques and surveying. It is envisaged that the following academic year will see an expansion in the number of courses in cooperation with the Czech Technical University's partner universities (Charles University and Institute of Chemical Technology). In addition to underground structures and geotechnics, students will be able to gain practical experience in geology, mineralogy, geological mapping and applied chemistry. It is planned that the expansion project will be financed from European structural funds.

The courses are distinctively practically oriented, thus providing students with a unique opportunity to take real measurements and perform real experiments in an authentic environment (Figs. 1 and 2). Gaining practical experience will strengthen the position of students in the employment market as most of potential employers demand practical experience and not only theoretical knowledge. It is believed that the opportunity of practical experiments will attract more students and will help to bring up young specialists in nowadays overlooked Science&Engineering professions.

In order to provide support for both the practical and theoretical parts of the various teaching courses several innovative features have been installed in the underground complex with more in the pipeline. The geotechnical features installed to date include:

- a convergence polygon where students have the opportunity to learn and practice measurement techniques and to study their role in the NATM method
- a contact stress measurement demonstration as an element of the wider geotechnical monitoring process
- several blast hole patterns to demonstrate various blasting techniques
- rock and soil bolting and nailing demonstrations
- a replica of an historic wooden tunnel support system (1:1 scale, Fig. 3)
- an exhibition of mining equipment

Fig. 3. Replica of wooden support system

Student visits to the facility vary according to course requirements and are organized at several levels. A typical first visit to the UEF will aim to provide the student with an initial practical insight into issues involving soil and rock mechanics and underground structures.

Fig. 4. Practical course of underground geodesy

As the course progresses, the student returns to Josef for further practical training at which time the number of students is limited allowing each student more tutor time and resources to successfully complete the various demanding tasks involved in the course (e.g. drilling etc.).

The Josef Gallery is particularly suitable for experimental work on bachelor and diploma theses. Teaching programs are provided by three Faculty of Civil Engineering CTU departments - the Centre for Experimental Geotechnics and the Geotechnics and Special Geodesy Departments (Fig. 4 and 5).

As the facility is still new and not fully exploited to date, no serious analyses of its positive impact on the quality of teaching have been made so far. A detailed evaluation of the first year of its operation will be made after the end of the spring semester.

Fig. 5. Practical course of rock mechanics and underground structures

4. Research

The size of the Josef underground gallery and its geological diversity allow the participation of a wide spectrum of those interested in experimental research. Underground "in situ" research involving direct contact with the rock massif is an important aspect both in the research potential of the Josef UEF and in overall long term Faculty of Civil Engineering planning. Experimental projects carried out at the Josef UEF are focussed on the solution of practical problems and topics connected with underground structures, geotechnics, material engineering and radioactive waste management. These fields are developing rapidly and their significance will probably even increase in the near future.

The aim of the facility is to involve undergraduate, graduate and postgraduate students into the research activities as much as possible. The wide range of research topics as well as their interdisciplinarity and practical orientation offer an excellent field for students´ bachelor, diploma and doctor theses. While solving a practical problem the students will improve their skills, gain a university degree and the obtained results can be used and potentially developed by other institutions and companies. This kind of collaboration between universities and commercial companies is still not sufficient in the Czech Republic.

Below there is an overview of the research projects that are currently being carried out or are to commence at the Josef UEF. Students are currently actively involved in the first two of them as the remaining projects have not fully commenced yet.

4.1. TIMODAZ

Presently, the Faculty is actively involved in the TIMODAZ project which is supported by the EU's 6th Framework Programme. TIMODAZ is an acronym of the project's title "Thermal Impact on the Damage Zone around a Radioactive Waste Disposal Vessel in Clay Host Rocks". TIMODAZ is an international research project one of the participants in which is the Centre for Experimental Geotechnics, a Faculty experimental facility and the operator of the Josef UEF. The aim of the research is to investigate the effects of long-term thermal load on lining stability; the concept behind the research i.e., to determine the "ideal" form of spent nuclear fuel transformation technology in the mid- to long-term, follows extensive global discussion on this theme. Any eventual spent fuel transformation technology will require the safe removal of spent fuel from deep underground disposal. The extreme long-term functioning of the lining around the disposal vessel is one of the premises for the safe removal of spent fuel canisters from the engineered barrier. The long-term effects of heat could well bring about a severe reduction in the stability of the lining caused either by deterioration in the strength properties of the lining material or by the occurrence of deformations resulting in a collapse in the shape of the lining.

This experiment will simulate a thermally loaded lining (90°C) which is not permitted to deform towards the rock massif and which therefore will experience an increase in stress. Long-term continuous measurement performed on the fully-instrumented model will prove whether or not stresses exceeding the strength properties of the lining material are likely to develop within the lining. A short drift in the renovated part of the Josef gallery (the West Čelina belt) was chosen for the construction and performance of the experiment. The rock environment within which the experiment is being constructed consists of tuffites with high compression strength (230 MPa). Thermal conductivity is in the range of 3.6 W/mK; specific density is approximately 2740kg/m3.

4.2. Shot-clay Technology

A further project, which is being carried out at the Josef UEF in cooperation with the Radioactive Waste Repository Authority (RAWRA), is the Shot-backfill Technology project. The aim of the project is to develop an optimal shot technology and an optimal composition of the material used in the future Czech deep radioactive waste repository. An essential requirement for this material is reaching a high degree of compaction, e.g. reaching as high density of the backfill as possible. The bigger is the degree of compaction, the higher the swelling ability and lower permeability of the backfill (Pacovský, 2008). These two properties are crucial for the effectiveness of the backfill and the radionuclide escape prevention. Development of such materials demands long-term testing in authentic conditions and underground areas of the Josef UEF fit these requirements.

4.3. "In situ" study of gas transport in disturbed crystalline rock

The FORGE experiment is a further important project to be carried out at the Josef UEF. The proposed set of "in situ" tests combines both migration and large scale gas injection measurements the aim of which is to simulate and study those phenomena that might lead to gas-driven radionuclide transport. The experiment will consist of several parallel boreholes drilled into fractured crystalline rock and equipped for gas injection and/or monitoring with the use of piezometers. The baseline permeability of the rock and the fracture zone will be studied employing either the pressure decay test or constant head injection test techniques at the source borehole. The other boreholes will be used for monitoring purposes during the performance of the injection tests. In the later stages of the test programme, reactive gas injection measurements will be taken which will provide information on the fracture characteristics of the system and gas pathways inside the rock. Upon completion of the "in situ" tests new core samples will be taken at various distances from the source borehole to provide supporting information for the interpretation of the field data. The results from this study will provide both information which will lead to a better understanding of gas migration processes in fractured crystalline rock and a benchmark database for the development and validation of mathematical models.

4.4. ENEN-II

The Josef UEF is also involved in the ENEN-II project which will consolidate the results obtained by the European Nuclear Education Network Association (ENEN) and partners in the FP-5 ENEN and FP-6 NEPTUNO projects.

Work at Josef will expand ENEN involvement into other than nuclear engineering disciplines including radiation protection, radiochemistry, radio-ecology and the geological disposal of radioactive waste, attracting universities and other educational establishments currently active in these fields and by doing so will extend ENEN output from the purely academic to include practical professional training.

5. Conclusions

The Josef Underground Educational Facility has ambitions to become a unique European multidisciplinary facility providing high-level practically oriented courses for university students, special training for building company staff and high standard facilities for both domestic and international research projects. The full potential of the facility will be realised within the next two or three years by which time the whole of the underground complex will have been renovated. The Josef UEF's educational and experimental research activities coupled with the authentic environment provided by the former gold exploration gallery provide an excellent opportunity for students involved in underground structures, geology, geochemistry, underground geodesy, rock mechanics, mining engineering etc. to participate in multidisciplinary research projects or to further their own projects and ideas. The main objective of the facility is to contribute to better cooperation between universities and private companies and to attract more students to Science&Engineering programs. This is being carried out by the innovation of teaching, increasing the amount of practical student training and student experimental activities, adoption of teaching programs to the demands of commercial sphere and by the involvement of students into domestic and international research projects.

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The methodological development of a Benefits Realisation Management Process (BRMP) in the case of Manchester, Salford and Trafford (MaST) Local Improvement Finance Trust (LIFT)

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Abstract:
In recent years the UK government has made huge capital investment into the public sector in particular healthcare. One such initiative occurred in 2001 in the form of LIFT (Local Improvement Finance Trust) for primary care settings through a Public Private Partnership (PPP). LIFT has enabled a large amount of private spending to take place in primary care settings in deprived areas. However, LIFT has been subject to much criticism in areas such as overall costs, over-capacity, and lack of utilisation of spaces. Therefore there is a need for past, current and future government initiatives to be assessed on their benefit. HaCIRIC has started to address this first issue through a case study within the MaST LIFT. The findings of this case study aim to assess and review the degree to which the original planned benefits have been realized and what the actual benefits have been. This paper will present how the processes within the initial phases of the case study will be undertaken. As well as presenting the literature in the area of benefits management and related areas through a literature review of key texts.

Keywords:
Benefits Management, Primary Care, LIFT, Policy, methodology

1. Introduction

This paper is presenting one part of a larger project being undertaken by HaCIRIC Salford called 'BRMP in Healthcare'. It is presenting in detail the development of the methodology and the initial stages of the case study taking place with MaST LIFT. LIFT is a procurement route for primary care services, which was introduced in 2001. It is a partnership jointly owned, 50% by Department for Health (DoH) and 50% by Partnerships UK (PUK). PUK is a joint venture Public Private Partnership owned 49% by HM Treasury and 51% by private organisations including the Scottish executive. Community Health Partnerships (CHP) (originally known as Partnerships for Health - PfH) is fully owned by the DoH and is responsible for the delivery of LIFT. LIFT has delivered the following (CHP website, 2008):

- Improvement in primary and social care services and facilities.
- Generated over £1500m in investment to develop more than 210 new integrated community.
- Bought a number of services to one location, integrated them quickly, particularly to disadvantaged areas, these are specific to a community and its requirements
- Inspired partnerships between different agencies enabling innovation and new and different community care models.

- Promotes links between the NHS and social care as well as primary and secondary healthcare.

The aim of the case study is to assess what degree MaST Local Improvement Finance Trust (LIFT) is realising its intended aims and benefits, through undertaking a BRMP. This is needed as LIFT has been criticised for a number of things including (Baggott, 2004, Ibrahim et al 2006):

- The bureaucracy and complexity which causes confusion and delays,
- Private companies are profiting from tax payers
- little evidence that it will be more cost-effective than those funded entirely of public resources
- Distrust and lack of mutual understanding between the stakeholders
- Culture clashes
- Different time frames
- Lack of clarity and communication
- Lack of appropriate skills and competencies
- Expensive and time consuming

The paper will give the reader an understanding of what would be involved in the evaluation of a LIFT scheme, and guidance into the methodology involved within the BRMP. An overview of the wider project will be explained so that the relevance of the case study is understood.

1.1. The Bigger Picture: Benefits Realisation Management Process Project

The BRMP Project aims to develop a tool that will assist in managing projects driven by benefits through action research. Action research follows a cycle of planning a change, acting, observing the consequences, planning further action and repeating (Kemmis and Wilkinson, 1998). The process can also be used to assess past, current and future government initiatives in relation to the benefits they were set out to achieve in the original LIFT plan and individual SSDPs (Strategic Service Development Plans), LDPs (Local Development Plans) and Business cases. This assessment will take place through case studies at different stages of the lifecycle of a LIFT building, those stages are:

1. Policy Development
2. Programme Development
3. Business Case
4. Post Project
5. Post Occupancy
6. 5yrs, 10yrs

The findings from the different stage case studies will assist in better future planning, so that policy setting can be adequately informed by evidence with a fuller appreciation of potential outcomes and impacts. It will also feed into the development of the BRMP being developed by HaCIRIC. This BRMP aims to promote the use of knowledge sharing for successful monitoring of the benefits as they were originally conceived throughout the programme and manage new/reviewed outcomes (Sapountzis et al, 2007). The project is based upon the underlying assumption that that benefits planned at the business case stage of LIFT procurement are not routinely monitored throughout the project. It is necessary for the tool to be flexible enough that it is able to effectively capture the anticipated and unanticipated impacts that have an effect on actual benefits through a continuous improvement (CI) benefit review cycle.

In section 2 a review of what exists already in terms of literature on benefits realisation in general and within healthcare infrastructures as well as the related areas will be explored; this will identify the need for the Benefits Realisation Project to take place. Section 3 goes into detail about the MaST LIFT case study methodology on the basis of the protocol that was developed for this Post Occupation scheme. The conclusions are set out in Section 4.

2. BRMP Literature Review

2.1. A definition

It is important to have a full understanding of what is meant by the term Benefits Realisation Management Process. The term has been generated by HaCIRIC through the project, when a fuller understanding of benefits and realisation was gained.

A benefit is a noticeable improvement, advantage gained from an outcome (Payne, 2007, OGC, 2007 and Oxford English dictionary, 2006). Realisation is an adjective of realise, described as ‘become fully aware of as a fact; understand clearly’ and ‘cause to happen. Achieve (something desired or anticipated); fulfil’ (Oxford English dictionary, 2006, pp. 1197). Farbey et al (1999) keeps in mind that it is a process that realises the benefits that are achieved as well as managing the unexpected ones. Payne’s (2007) definition of benefits management focuses on the harder outcomes of a business, the process he believes identifies manageable business benefits and the required financial impact at the beginning of a project and through the process makes sure that these are actually achieved. Bradley (2006) defines the process of benefits realisation in 5 steps as illustrated in table 1.

Table 1: Benefits realisation process (adapted from Bradley, 2006)

Step	Process
1	Conceive benefit as real
2	Get more detail on the benefit so it is fully understood
3	The benefit’s dependencies are mapped, taking changes required and earlier benefits into consideration so it becomes more realistic
4	The changes are made making the benefit actual
5 (not always)	Benefit is transformed into money

Therefore benefits realisation could be defined as one becoming fully aware of the positive impact as a result of a change. From these plus much more analyses into the subject area HaCIRIC consider the Benefits Realisation Management Process (BRMP) to “*To increase the predictability of realising maximum benefits for all stakeholders of healthcare infrastructure programmes and projects through the utilisation of a robust benefits realisation process.*”

2.2. A Background

Benefits Realisation Management has been discussed in terms of finance and IT since the late eighties, early nineties (Farbey et al, 1999). It is only recently that the topic has been theoretically linked to healthcare through writers such as OGC (2007) and Bradley (2006). There have been some attempts by the government to use related tools for managing projects and their performance within the healthcare sector, such as:

- Gateway Review Process - 2001
- 18th Week Pathway - 2004
- The Integrated Service Improvement Programme (ISIP) road map for 'Transformation Change' - 2005
- PCT Fitness for Purpose and Development Programme - 2006
- Benefits Realisation Plan (BRP) for all of the 'integrated change programmes proposed in their ISI Plan' - 2006
- NHS Integrated Service Improvement Plan web page - 2007

However these tools do not drive projects through benefits, many occur at the end of a project acting only as an evaluation, from which lessons are not learnt. As presented in Sapountzis et al (2007) there is a need in the healthcare sector for a process that is integrated into business planning as well as:

- Appropriate for those who operate it and those that use the information produced;
- Robust enough to withstand change;
- Balanced in its assessment of hard and soft benefts;
- Cost effective by producing performance information that realises benefits in proportion to the investment required to collect it;
- Simple to Implement

The need of such a process is being addressed through the development of a BRMP, through a review of literature, consultation with a multi stakeholder group related to healthcare procurement, case studies and action research. Section 3 goes into detail about the methodology being undertaken within the case studies, providing guidance for those undertaking an evaluation of a LIFT scheme in terms of benefits.

3. MaST LIFT Case Study

3.1. Protocol Development

To develop the protocol for this study and to help advise and steer the project, MaST Project and Steering Group meetings have taken place. Both groups gave HaCIRIC access to all stakeholders involved in the MaST schemes from the top level Partnership Director to the operational level such as Centre Managers. Both of these groups and the different stakeholders within them had the same key objective, to evaluate the LIFT schemes. This helps the groups to be successful and effective, having conflicting objectives within a team can cause problems for a project (Barnard, 1938, Ayuso, 2006,). The Groups undertook the following activities and exercises:

- Through their own experience the original LIFT proposal and MaST business case they identified the benefits that were planned and not planned for the scheme.
- Identified the most appropriate method to be used to measure the benefits; a section of this is shown in table 2.
- Undertook a benefits relationship mapping exercise, which is a key exercise in a BRMP in identifying the dependencies and relationships between the different benefits (OGC, 2007).

Table 2: Methods and Measures table

Ref	Strategic Benefits	Outcome or further benefit	Method of measurement Q = questionnaire				
			Patient Q	Centre-user Q	Staff Q	Interview	Secondary Data Collection/ Analysis
A	**Improved Patient Services**						
A1	Product	Improved patient experience	X				
A2		Better Access to facilities	X	X		X	
A3		Greater Privacy	X		X		
A4		More services in 1 place (Co-location)	X	X		X	X
A5	Service	Improved health outcomes					X
A6		Greater access	X	X		X	X
A7		Less waiting	X				X
A8		New services	X	X		X	X
A9		Care closer to home				X	X
A10		Increased patient choice	X	X		X	X

Both groups have been consulted and will continue to be consulted to advise and ensure the research being undertaken is addressing the need of the healthcare industry.

The information for the project will be gathered through multiple case studies. Multiple case studies allows findings to be compared between the different cases, which allows the study to be more robust than if a single case study were to be used (Herriott and Firestone, 1983). The case studies will take place within three schemes in MaST LIFT: The Energise Healthy Living Centre Douglas Green in Salford, The Partington Health Centre in Trafford and The Wythenshawe Forum Health centre in Manchester. The findings from each post occupancy case study will be used to enhance the development, implementation and evaluation of a BRMF across and within different primary care settings. This multi–site approach enables the transferability of the BRMP to be measured at the same time as capturing wider user perspectives (Yin, 2003 and Kagioglou et al, 2000).

Inside of the three case studies a variety of quantitative and qualitative methods will be adopted, these include questionnaires, interviews and focus groups. These will be used to develop, implement and evaluate the BRMP from the perspective of both service providers and users. It is anticipated that the combination of techniques will capture the perspectives of the case study target population and the activity inside of the case study site to measure the effectiveness of the BRMP implemented. The advantages of using two methods known as polarity of methods is that claims for the validity of conclusions are improved if the findings support one method can be counterbalanced with the strengths of the other another (Bryman, 1988, Punch, 2005).

Douglas Green's Energise Healthy Living Centre has been chosen to be the pilot case study site. Pilot study is the pre-testing of a tool or method or scaled down version of a full scale study (Teijlingen and Hundley 2002). It is necessary to undertake a pilot to determine the effectiveness of the research method chosen and to test and refine the methods and data collection tools (Yin, 2003). This is accomplished by analyzing the significance of questions and/or hypothesis testing, using non-parametric/parametric statistics in Statistical Package for the Social Sciences (SPSS) for closed questions, and Non-numerical, Unstructured Data

Indexing, Searching and Theorising (NUD*IST) software to explore the validity of comments provided within open questions. The outcome of these will aid in finalising the questionnaire and interview methodology for rolling out to the other case study schemes; this is why the pilot is so important and that more resources in terms of time and money are often spent to this stage than any other of the other case studies (Yin, 2003). How the questionnaires, interview and patient/community forums will be undertaken and why, will now be discussed.

3.2. Questionnaires

The main bulk of the data collection for the case studies will be done through questionnaires one for the staff of the schemes and one for the patients. The bulk of the data being obtained through quantitative methods are that these "have the ability to use smaller groups of people to make inferences about larger groups" (Holton and Burnett, 1997, p. 71).

Questionnaires are tools used to collect quantitative data, they gather numerical data through which patterns and causal relationships are discovered, the findings are seen to have high reliability. Questionnaires are a good way to gain an insight into 'characteristics, attitudes, and beliefs' of many people (Marshall and Rossman, 1999). In this case the questionnaires will gather an insight and assess the different groups' views and perceptions of the services, facilities and overall effects of the LIFT scheme. The questions will be addressing benefits identified through earlier meetings that are specific to the group as illustrated in table 2. The AUDE (Association of University Directors of Estates) and CABE (Commission for Architecture and the Built Environment) best practice guidance has been used for developing an effective questionnaire involved in Post Occupancy Evaluation. Within the best practice guidance are recommendations of the kind of questions that should be used when addressing client satisfaction. This is relevant to the work being undertaken within the case studies as a large focus of the studies is on the experience of the staff and patients. Through analysis of the questionnaire findings it will be possible to see if the MaST has delivered these benefits in the view of the staff, patients and community.

3.3. Interviews

Interviews are the most important qualitative methods to provide information to a case study (Easterby-Smith et al., 2002, Yin 2003). Therefore semi structured interviews will be used to collect qualitative data from the staff for these case studies. Semi structured interviews are have some predetermined questions, but these can change dependant on the answers given and how the researcher interprets the conversation (Robson, 2003). They are used to provide guided but open discussion (Yin, 2003). Due to this openness interviews discover new areas that should maybe looked into. There will be multiple interviewers for this study, each will undergo training before the interviews begin to ensure they understand how to obtain consent, the approach, purpose and strategy, they will also receive a guide to follow as this is a way in which the interviewer can be sure that they are following the same lines of inquiry (Patton, 2002). Throughout the period of interviewing interviewers will meet regularly to discuss both the data collection and analytical techniques to make certain that researchers are not bringing there own interpretations on the data but rather an objective view that they all share making the results more valid and holistic.

3.4. Patient/Community Forums/Focus groups

Some of the schemes use patient and public forums to communicate with the patients and centre users. Patient and public involvement forums were set up officially to (Department of Health website, 2008):

- Monitor and review NHS delivery
- Seek the views of the public about those services
- Make recommendations to the NHS accordingly
- Other issues relevant to organization

Therefore these forums will be an ideal setting to gain the views of the patients and discuss their perceptions of the service, facilities and knock on effect of LIFT in their area. Focus groups provide information that may not be obtained through other tools as they give attendees opportunities to disagree or develop a shared perspective (Hakim, 2000). The will also give those with low literacy unable to complete the questionnaires an opportunity to be involved in the study. The discussions will be tape recorded and after which will be transcribed into detailed notes and the project representative will write a research summary directly following the forum, ensuring that specific details and key elements are recorded.

3.5. Data Analysis and Evaluation

From the different techniques there will be quantitative and qualitative data that needs to be analysed, both primary data (obtained from the questionnaires, patient/community forums and interviews) and secondary (obtained from the data collection of PCTs records). To save time and drudgery through many details (Robson, 2003) analytical software will be used for the analysis. The qualitative data will be analysed using NUD*IST (Non-numerical, Unstructured Data Indexing, Searching and Theorising) software. This software is based on a code-and-retrieve facility, which means that the data it holds can be coded and then from this retrieved through using 'Boolean, context, proximity, and sequencing searches' from these searches qualitative matrices, relationships and patterns can be discovered (Richards and Richards, 1994). NUD*IST can also be used to develop and influence new ideas and hypothesis. SPSS (Statistical Package for the Social Sciences) would also be used for statistical analysis. This is a computer package used by market, education and health researchers, survey companies, the government and more. This analysis will be undertaken by members of the research team at the University of Salford.

Data will be compared and contrasted on different levels, both within and across case study sites to identify similarities and differences which inform the BRMP. The methodology will be applicable and transferable to primary care settings where schemes are at different stages of implementation. The findings will help LIFT schemes to identify criteria needed to achieve the benefits.

The methodology for the case studies will also be subjected to an extensive evaluation once completed e.g. was the mapping exercise a success? How could it be improved if repeated? From this lessons learnt will be identified, and this will aid to refine the process and methodology for the future projects.

3.6. Ethical approval

A paper on the process of case studies being undertaken within a healthcare setting cannot be done without mention of the different ethical approval processes that need to be obtained:

- NHS Ethical approval
- University of Salford Ethical Approval
- Research Governance from Salford PCT
- NHS Research Passport
- PIAG
- Pan Manchester

These are all necessary as the research involves developing a new tool through consultation with NHS staff and patients, both of whom have not agreed to be contacted by independent bodies such as ourselves.

4. Conclusion

The evaluation of the original MaST LIFT business case, project and steering group meetings, a review into research methodologies and Benefits Realisation literature resulted in the protocol and methodology presented in this paper. This methodology informs the BRMP, where part of the process is the identification of required benefits, appraisal and evaluation throughout the lifecycle of a project or programme (Farbey et al, 1999). It will also feed into the development of a BRMP Framework which aims to promote the use of knowledge sharing for successful monitoring of the benefits as they were originally conceived throughout the programme and manage new/reviewed outcomes even through times of change.

The next step for this research is to begin the research and use the findings to not only inform the BRMP and BRMP framework, but also to evaluate if MaST LIFT has realized its intended benefits and how, and if not, why? This will help MaST LIFT to take any necessary action where the benefits are not being realised. Where planned or unanticipated impacts and benefits and dis-benefits have occurred the research will be able to evaluate why, feeding into recommendations for future LIFT projects and acting as guidance for future evaluations of similar projects. They will also help to identify any unanticipated benefits and dis-benefits that have occurred. These findings will ultimately assist in better future planning so that policy setting can be adequately informed by evidence with a fuller appreciation of potential outcomes and impacts of using LIFT.

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Towards a Risk Management Framework for Libyan House-Building Projects

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Abstract:
Time and cost overrun problems are commonplace throughout the world in the construction industry. Libyan House-Building Projects experience the same dilemma and often to a greater extent. This is attributed to both unexpected and expected factors in which risk and uncertainty were not effectively dealt with. Focus on risk management is therefore necessary to improve the current project's poor performance. The purpose of this study is to provide an exclusive and comprehensible risk management framework to improve the performance of the construction project management process in Libyan House-Building Projects through investigating and analysing time and cost overrun causes. Also, to establish a potential and comprehensive risk response to eliminate or mitigate the major threats in these types of projects. The proposed framework will be developed to critically reflect a synthesis of the international risk management frameworks, the available literature regarding time and cost overrun factors, and expert's professional knowledge and expertise of working in the Libyan Construction Industry.

Key words:
Cost and Time Overruns, Libya, Risk Management Framework.

1. Introduction

The construction industry is one of the most dynamic, risky and complex businesses (Kangari, 1995; Mills, 2001). However, the industry has a very poor reputation for managing, with many major projects failing to meet deadlines, cost, and quality targets (Thompson and Perry, 1992; Smith et al, 2006). These projects are often influenced by variations in weather, productivity of labour and plant, and quality of material etc. All too often, risks are either ignored, or dealt with in a completely arbitrary way; simply adding 10 percent contingency onto the estimated cost of a project is typical (Thompson and Perry, 1992; Smith and Bohn, 1999). In a business as complex as construction, such an approach is often inadequate, resulting in expensive delays, litigation, and even bankruptcy (Mills, 2001).

Risk management is therefore an important part of the decision-making process of all construction companies as it determines the success or failure of any project. Successful decisions are made against a predetermined set of objectives based on knowledge, data, and information, whereas decisions that are made without a logical assessment of project-specific criteria may lead to difficulties in project delivery. Thus, risk and uncertainty can potentially have damaging consequences for all construction projects. The ineffective handling of risks can be damaging not only to the contractor, but also to the project as whole. Risk can affect productivity, performance, quality, and the budget of a project. Risk sometimes cannot be eliminated, but it can be minimized, transferred or retained (Smith, et al., 2006).

Since their origin in the 1970s, Libyan House-Building Projects (LHBP) in the Libyan Construction Industry (LCI) have continuously faced great difficulties in controlling time and cost overruns. An example of the industry's poor performance can be found in the Project of Constructing 2870 Housing Units in Tripoli. The project was started in the late 1980s to be completed within five years. As of February 2008, the project has not been completely delivered yet, and has incurred incredible cost increases. A recent report conducted by the Public Committee of Project Monitoring and Follow-up (2004) in Libya showed that time and cost overruns are a common problem in the LCI. Therefore, this research aims at improving the present project's poor performance in LHBP. Hence, the core objectives of this study are:

- To determine the current level of project performance measures (time, cost, and quality) in the Libyan House-Building Projects;
- To identify the major risk factors that have a significant effect on project performance measures in LHBP;
- To provide a risk management framework for a systematic and structured assessment of these risks within LHBP;
- To establish a potential and comprehensive risk response to eliminate or mitigate these major threats in LHBP.

2. Libyan Housing Sector

Before the oil discovery in the mid-1960s, the country did not have any housing problem despite the small number of houses. This is attributed to the fact that the overwhelming majority of Libyan people were nomads, shepherds and wanderers following the rain with their animals, therefore they lived in temporary tents rather than permanent houses. After the oil revolution, the Libyan economy started to flourish, and urban development, especially, in coastal cities began. The immigration of people to these cities commenced, as the chances for jobs became available. Moreover, emigrants from neighbour countries such as Egypt, Tunisia, Algeria, and many other countries have moved to Libya looking for better job opportunities. As a result, the demand on housing units has rapidly increased.

It is obvious that the housing sector in Libya is a relatively young industry. It grew considerably only in the early 1970s (after the Alfateh Revolution in 1969). However, this industry plays an important role in the country's economic development. Before the United Nations sanctions on Libya in 1992, the average spending on the housing sector contributed about 11.1 percent of the Gross Domestic Product (GDP) (Sheibani, 2004). In 1970 alone, the expenditure on the housing sector contributed 25.7 percent of the GDP (Planning Secretariat (cited in Sheibani, 2004)). Therefore, it is very important to the Libyan economy to manage house building projects effectively and efficiently.

House-building projects throughout the world face a variety of challenges concerning time and cost overruns. Of course, Libyan House-Building Projects have the same challenges and often to a greater degree. The lack of sufficient experience of Libyan contractors in executing house-building projects has been an ongoing problem since their start in the early 1970s. This has been proven by the reports of The Public Committee of Projects Monitoring and Follow-Up – The Division of Projects and Contract Management (The Public Committee of Project Monitoring and Follow-up, 2004) and also by most of the court cases between contractors and owners; in Libya the government is generally the client for all house-building projects. Effective risk management has become a major problem that confronts this industry and as a result affects the entire Libyan economy.

3. The Current Status of Risk Management in Libya

In view of the current practice of risk management in the Libyan Construction Industry it is evident that neither qualitative nor quantitative risk analysis techniques have been utilized. The Public Committee of Project Monitoring and Follow-up report (2004) revealed that most

Libyan local contractors have failed continuously to achieve the project goals of time, cost, and quality. Hence, Libyan construction firms must understand the construction risks they are subject to, so that they can reflect the risk impacts in the expected projects durations and costs, and plan the mitigation actions more effectively. This study is intended to be a first step towards enhancing the risk management process for contractors working in the Libyan House-building projects.

4. Research Methodology

The research methodology is the systematic and orderly steps taken towards the collection and analysis of data (Collis and Hussey, 2003). Developing a framework for a systematic and structured assessment of risk and uncertainty that can help contractors and project managers working in LHBP to better understand the main causes of project underperformance, and hence, control the major risks associated with projects is the main goal of this research. This framework will be considered to essentially reveal a combination of the international risk management frameworks, the available literature regarding time and cost overrun factors, and expert's professional knowledge and expertise of working in the Libyan Construction Industry. The plan that provides the necessary steps for carrying out this research is shown in figure (1) "the proposed research design" and a brief explanation of the research methodology which has been adopted in this study is summarized below.

This study tries to understand and explain a phenomenon based on opinions and subjective aspects. Therefore, the research philosophy which will be adopted in this research is the phenomenological paradigm. The rationale for choosing this approach is that the topic under investigation is not well understood in the Libyan Construction Industry, and better understanding will be fundamental to improving the risk management of Libyan House-Building Projects.

Orton, (1997) claimed that, informally most researchers readily admit that research is a function of both inductive and deductive analyses. The use of induction and deduction is also supported by Bryman and Bell (2003) who argue that grounded theory is an iterative process which includes elements of both induction and deduction. Further, Saunders et al. (2007) point up, 'not only is it perfectly possible to combine deduction and induction within the same piece of research, but also it is often advantageous to do so'. Thus, both approaches (inductive and deductive) will be utilized in this research.

When examining the type of research questions of this particular research, it is evident that it contains exploratory "what", "how", and "why" questions, since it is intended to develop a theory. Exploratory "what" questions are generally favoured by any of the research strategies and "how" and "why" questions are generally favoured by case studies, histories, and experiments (Yin, 2003). However, it should be mentioned that even though each research strategy has its distinctive characteristics, there are large overlaps among them (Yin, 2003). In this particular research, the nature of the study requires the researcher to obtain information from experts and professionals working in the Libyan Construction Industry based on opinions and subjective judgement, hence, a survey strategy would be appropriate for this research.

Deciding on which method of research to follow, depends on the purpose of the study and the type and availability of information which is required (Naoum, 2007). For the purpose of this study, the data will be gathered and analysed qualitatively as well as quantitatively to support and give more validity and reliability of the study.

Hence, the group expert evaluation and contractors' survey will be used as the main sources for data collection in this particular research. Semi-structured interview is the best method for data collection of this study as it aims to subjectively obtain information and risk assessments based on experience of professionals working in the Libyan Construction Industry. Thus, data will be collected from random samples of small and medium contractors working in Libyan House-Building Projects.

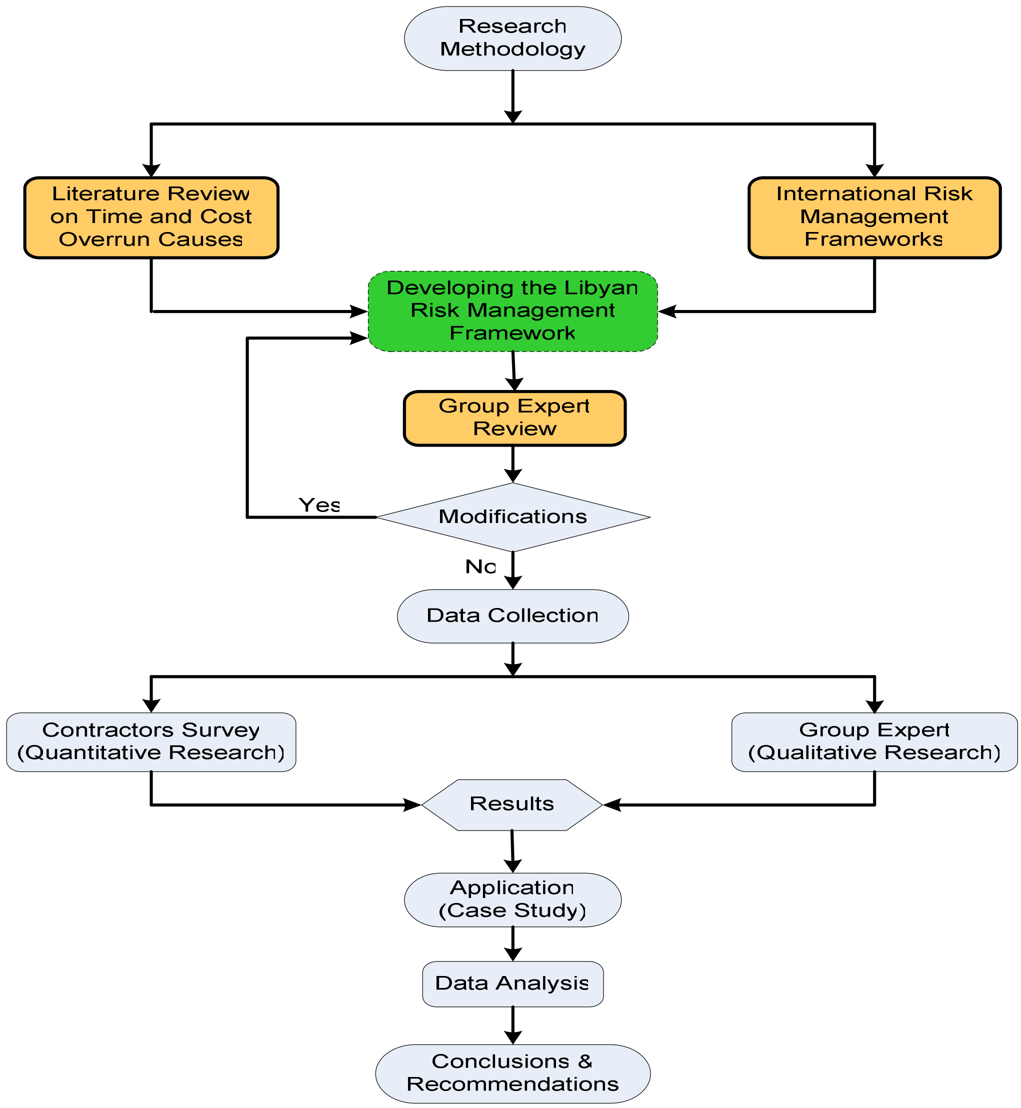

Fig. 1. The Proposed Research Design

5. The Proposed Risk Management Framework

Construction projects are unique in terms of design, construction methods, personnel, location, etc. Variations in these factors will induce different types of risk factors into construction projects. In addition, risk factors could come from many different directions, such as social, legal, economics, environmental, political, and technological sources. Therefore, any international risk management framework can hardly accommodate all these factors since it must be exclusively applicable for the situations for which it was developed. Hence, developing a Libyan Risk Management Framework is undoubtedly required. In this research, the literature related to international risk management frameworks developed by professional institutions (CIRIA,1996; APM, 1997; ICE,1998), those that are concerned with time and cost overrun causes (Perry and Hayes, 1985; Al-Khalil and Al-Ghafly,1999; Santoso et al., 2003), and knowledge of professionals and experts working in the Libyan Construction Industry are synthesised in order to develop the Libyan Risk Management Framework. A brief explanation of this framework is described as follows: the risk management process is broken down into risk management system in figure (2) which shows the sequence for dealing with risk. Naturally the risk management system must be applied to each risk factor under consideration.

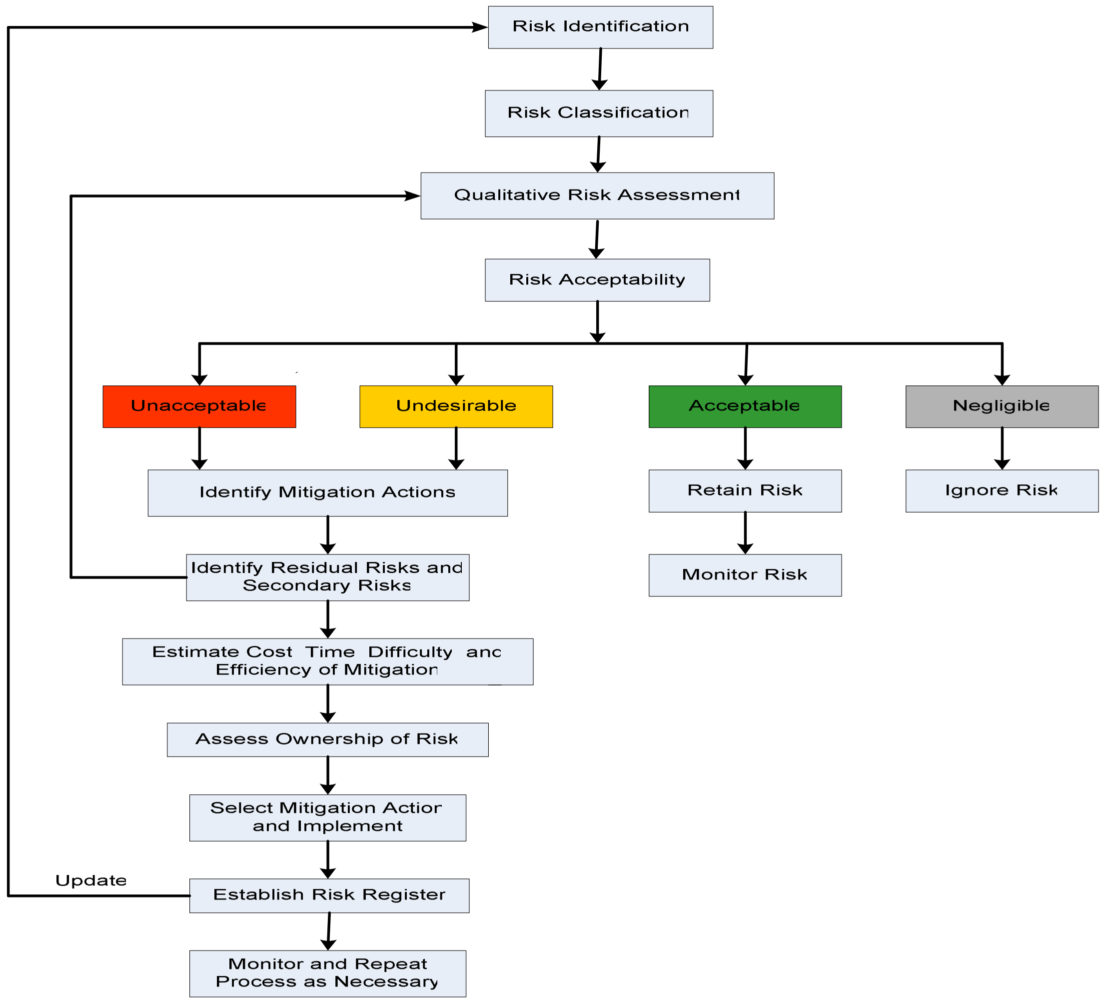

Fig. 2. The Proposed Risk Management Framework

5.1. Time and Cost Overrun Causes

Risk management always starts with risk identification, which may be considered the most important phase of the risk management process (Baker, 1998). Its purpose is to compile a list of risks affecting construction projects. Many researchers (Perry and Hayes, 1985; Al-Khalil and Al-Ghafly, 1999; Santoso et al., 2003) have given an extensive list of risk factors generated from different sources. These factors are generalized to cover those experienced by various parties. This study, however, focuses on investigating risk factors from the contractor's perspective. Therefore, the major risk factors that affect construction firms executing Libyan House-Building Projects were extracted and considered. In addition to the literature review, these factors were also compiled based on interviews and discussions with government authority representatives, contractors, and consultants.

Risk classification is an essential step in the risk management process, as it aims to categorize the various risks that may affect construction projects. Many approaches have been suggested in the literature for classifying risks. (Tah and Carr, 2000; 2001) use a risk-breakdown structure to classify risks into those that are related to the management of internal sources and those that are prevalent in the external environment. Also, they claim that external risks are relatively uncontrollable, and internal risks are those, which are relatively controllable and vary between projects. The internal risks are further broken down into local and global risks. The local risks are those related to individual work packages or categories within a project, whilst the other are global to an individual project and cannot be associated with any particular work package.

(Eaton, 2003) defines risk in construction as a potential event, either internal or external to a project that, if it occurs, it may cause the project to fail to meet one or more of its objectives. Also, Eaton (2003) suggested that risk factors should be classified as: Social; Legal; Economic; Environmental; Political, and Technological.

This research will adopt a combination of the hierarchical risk-breakdown structure of Tah and Carr, and the risk classification of Eaton with some modifications to suit the purpose and nature of the study. Hence, risk factors are classified as Internal and External to a project. However, this particular research will focus only on the external risk factors that affect Libyan House-Building Projects since the causes of internal risk factors are prone to be unique to individual project, and hence, any examination of these risks will not inform the development of Libyan risk management framework

In viewing the literature on time and cost overrun causes in the construction industry, it is noticeable that numerous risk factors belong to the technological sources; therefore, this research will further classify this category. Hence, technological risks are grouped to: Labour; Material; Equipment; Client, Contractor; Sub-Contractors; Material Suppliers; Design Firms; Consultancy Offices, and Government Agencies as illustrated in figure(3).

5.2. International Risk Management Frameworks

Recently, the construction-related professional institutions, The Institution of Civil Engineers (ICE), The Association of Project Management (APM), and the Construction Industry Research and Information Association (CIRIA) have individually taken the initiative to develop frameworks for systematic project risk management. Their goals are to provide the construction industry with a structured, practical, and comprehensible approach to handling risks, and more significantly, to promote the general use of a systematic approach to manage risks more effectively. These frameworks will be examined to gain an understanding of the essential steps required for successful risk management, hence, acquire the knowledge for building the Libyan Risk Management Framework.

5.3. Experts and Professionals Knowledge

In this particular research, the nature of the study requires the researcher to obtain information from experts, professionals, and contractors working in the LCI based on their experience and subjective judgement, hence, one-to-one interviews, and group expert review are thought to be appropriate for this purpose. Therefore, an individual discussion is first conducted with professionals and highly experienced human experts, working in the LCI, who are able to think creatively and imaginatively to assist in developing the Libyan Risk Management Framework. Afterwards, group expert discussion sessions, with the same group, will be carried out to reach a consensus about developing the Libyan risk management framework, validate the risk identification phase, obtain qualitative assessments based on their experience, and hence plan risk valid responses.

6. Conclusion

Libyan House-Building Projects are continuously plagued by time and cost overrun, and poor performance has often been the result. Hence, the intention of this work is to provide a structured, systematic, and comprehensive framework for in-depth understanding the root causes of project poor performance, and accordingly minimizing factors that cause time and cost overruns. While it may be unrealistic to believe that all causes of time and cost overruns can be brought under control, it would be sensible to determine the most important factors so that efforts can be made to control these factors. A planned research methodology has been developed, and a comprehensive Libyan Risk Management Framework is being evolved.

This paper outlines the proposed study. It commences with an introduction to the study, research aim and objectives. It reviews the Libyan Housing Sector, then, it examines risk management practice in the Libyan Construction Industry. In addition, it presents an overview of the research methodology. The paper concludes by presenting and discussing the proposed risk management framework. An individual and group discussion sessions will be conducted among professionals and experts working in the LCI to elicit knowledge and experience which will help, with the literature, for developing the Libyan Risk Management Framework.

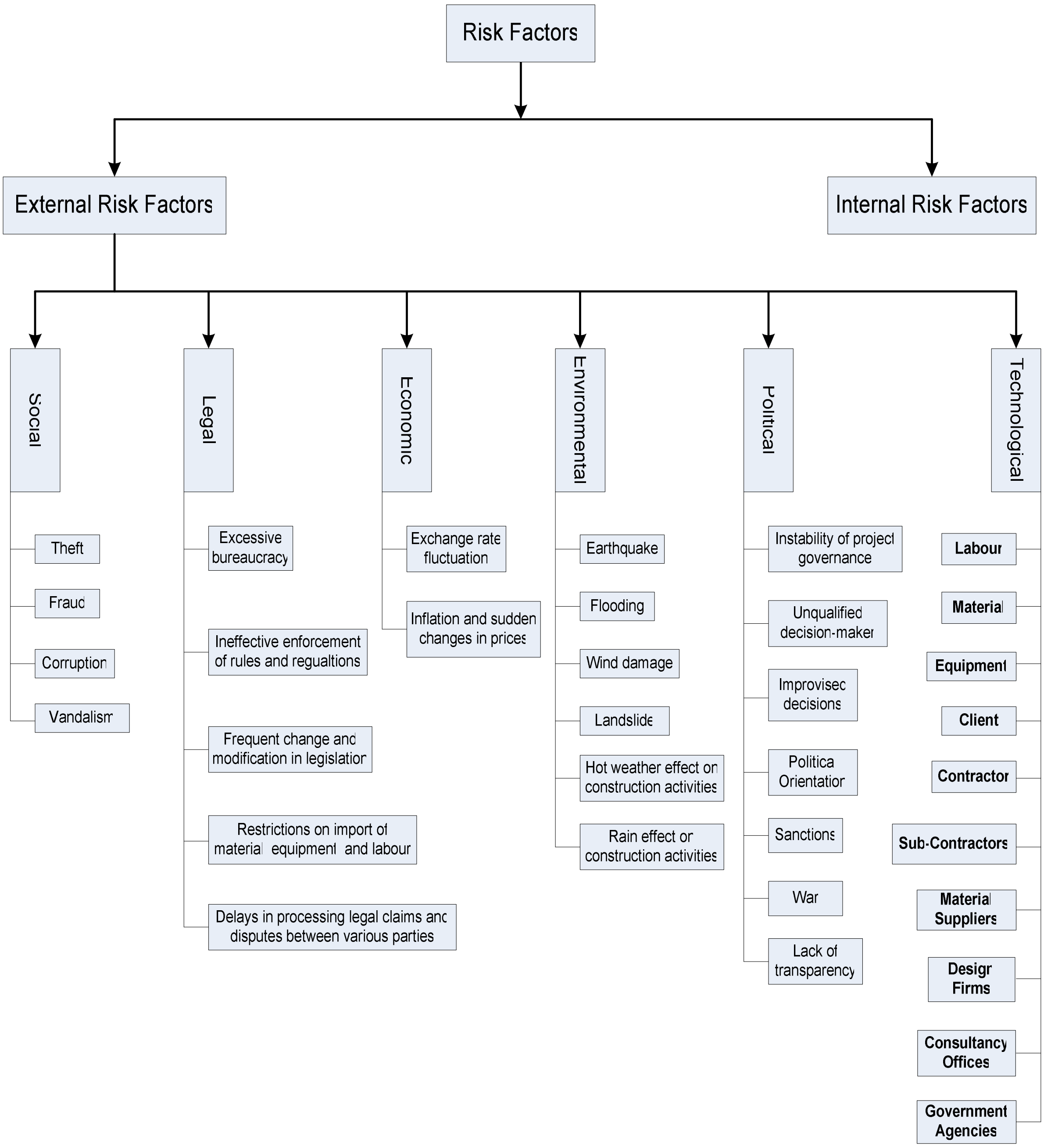

Fig. 3. Risk-Breakdown Structure

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Understanding FM Processes Using Hierarchical Process Map in Estate Division of Higher Education Institution

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Abstract:
The facilities management processes are drafted under Part X ‘Guidance on the development and improvement of processes’ for CEN/TC 348 European Standard in 2007. This standard provides high-level generic FM process definition, with examples of process maps at a strategic, tactical and operational level for application by client and service provider organisations and their inter-relationships. Process maps can present different levels of detail on the process being modelled. The difference approach of process map such as decomposition (top down) and composition (bottom up) required a deep understanding in selecting the appropriate approach for FM processes. This paper presents the method of hierarchical process mapping (top down approach) in a complex organisation such as higher education institutions that has many processes. The paper first explains the literature on processes approach. The paper then discuss and describe the development of FM processes mapping methodology using hierarchical process maps in understanding the processes for the Estate Division of higher education institutions as part of a major research study.

Keywords:
Facilities management, hierarchical process map, higher education institutions, methodology, processes

1. Introduction

A complex organisation such as higher education institutions (HEIs) had many different processes required to make these organisations work. Examples of HEIs processes include student recruitment and admissions, course or program development, research activities, community engagement and other various processes. Process mapping offers an organised way to record all the activities performed by HEIs. In creating process maps, it is importance to distinguish between a main process (i.e., a core process that supports the mission of the organisation and creates a product or service for the customer) and supporting processes (i.e., those that support the operation of the main process). Optimisation of facility management requires a broad and clear understanding of the interdependencies of the organisation’s processes and facility management processes (BSI 2007). The facility management model provides a framework describing how facility management supports the primary activities of an organisation. It deals with the demand and supply relationship and presents the different levels of possible facility management interaction. An organisation should rely on its primary processes to achieve its strategic objectives. The difference approach of process map such as decomposition (top down) and composition (bottom up) required a deep understanding in selecting the appropriate approach for FM processes. The paper aims to show, through a top down approach, how FM processes can be adapted by HEIs in understanding its organisation. This paper is divided into three main sections. First, a literature review of process mapping and FM processes. Second, the proposed generic FM processes CEN/TC 348 Part X (Guidance on the development and improvement of processes). Third, the adoption of the generic FM processes to the exploratory pilot study on higher education institution sector focusing at Estate Division, University of Salford as a case study.

The study presented in this paper is intended to understanding the facilities management processes in higher education institutions focusing on Estate/ FM Division in supporting the aim and objectives of the organisation.

2. General Literature on Process

While a variety of definitions of the term processes have been suggested in management literature, this paper will use the definition first suggested by ISO9000 Introduction and Support Package: Guidance and Concept and use of the Process Approach for management system which defines process as a 'set of interrelated or interacting activities which transform inputs to outputs'. These activities require allocation of resources such as people and materials. The basic definition of process often carries with it elaborates text referring to outputs, value and customers. Anjard (1998) describes a process as a series of activities (tasks, steps, events, operations) that takes an output, adds value to it, and produces an output (product, service, or information) for a customer. A process map can act as visual aid for picturing work processes which show how inputs, outputs and task are linked. Cousins (2003) describe a process map as a picture showing how the transformation is carried out. It shows the inputs and outputs, (best described using nouns) the activities in between (best described using verbs) and for each of the activities, the inputs and outputs used and produced. Process maps are a hierarchical set of diagrams that depict a process in ever greater detail as they descend through its levels (Pojasek 2003). Two broad types of process maps can be found in the literature, i.e., true maps of what happen (as-is models) and protocols of what ought to happen ('to-be models) (Winch and Carr 2001). Okrent and Vokurka (2004) add the third phases in process mapping and consequently business process re-engineering: creating the "As-Is" model, creating the "To-Be" model and "Bridging the Chasm," or in other words, getting from the here and now to the future state. To date various methods have been developed and introduced for process model. The generic high level (phase or high level) provide an overview of the whole process, describing the main stages and/or activities (Chapman and Austin 2002). This model focuses on flows of information within an organisation and between different actors in a broad perspective. The generic development process proposed by Ulrich and Eppinger consists of two dimensional maps, describing a dimension of sequence, of stages in one axis, and actors or functions responsible for each sub-process on the other axis (Ulrich and Eppinger 2000). The sub-processes representing specific activities or tasks are usually described through different levels of detail. The detailed level can be developed using structured approaches to modelling IDEF0 – integration definition language zero for functional model. It derived from information technology system engineering which focuses on information flows. The IDEF methodologies were devised in the 1970s for use in the US aerospace industry. By the mid-1970s they were in use in Europe and are now notable among modelling techniques for their wide range of usage, particularly IDEF0. The business approach focuses on actual flows of information within an organisation between the different actors involved. This approach typically have a two-dimensional map compared to one dimensional context-free maps preferred in the engineering approach (Winch and Carr 2001). The developers of the process protocol (Aouad, Cooper et al. 1998) found that their industrial collaborators preferred to focus on the overall principle of the process, rather than the details at the level of the IDEF description. The Generic Design and

Construction Process Protocol (GDCPP) were created by the University of Salford in 1998. It is a high-level process map that aims to provide a framework to help companies achieve an improved design and construction process. Process Protocol Level 2 being developed later with the primary deliverables is to create sub process maps of the eight Activity Zones that exist within the original Generic Design and Construction Process Protocol model.

The Architecture of Integrated Information System (ARIS) model is a framework of methods for modelling enterprises, which was developed at the Institute for Business Related Computer Science of the University of Saarland. The basic idea behind ARIS is to break down the company to be represented into different views for reducing complexity. It consists of the following elements of organisational view, functional view, data view, process view and service-related view (Scheer 1998). ARIS varies three main perspectives of techniques such as modeling language knew as Event-driven Process Chains (EPC). The EPC method was developed within the framework of ARIS by Prof. Wilhelm-August Scheer. Second, on conceptual description ARIS can model and structure Business Process Models. Furthermore, ARIS House has been developed to implement business models in information system.

3. Facilities Management Processes

The established definition presents the FM as 'the *integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities'* (BSI 2007). Figure 1 below shows the facility management model with the relation of its primary processes and support processes.

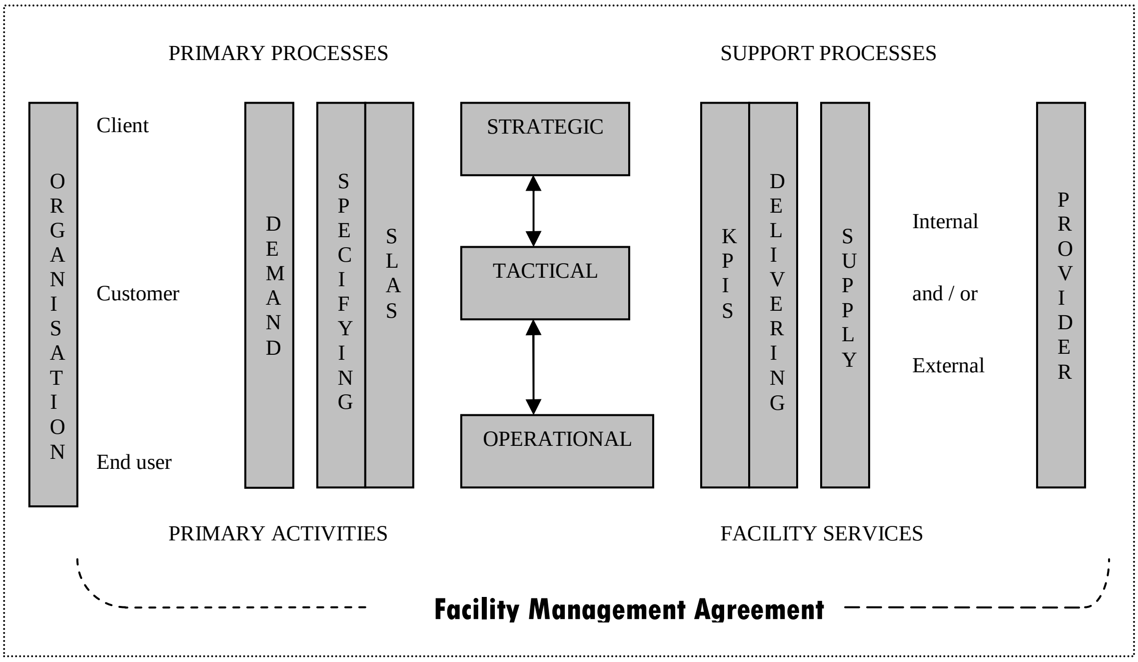

Fig. 1. Facility Management Model (BSI 2007)

Numerous studies have attempted to explain FM processes and its relation to the organisation. Hinks (1998) investigated a conceptual framework for describing the relationship between the FM processes and FM IT, and a model for the dynamic mechanisms of their co-operation. The SPICE FM project is one of the example of process improvement which modified for FM to managing customer requirements, service planning etc.(Amaratunga, Sarshar et al. 2002). Svensson (1998) studied how to develop suitable information structures to support main processes of facilities management (FM). The approach chose to create these structures was to develop a generic FM process model and a building product model. Redlein (2003) analysed the methods of modelling reference processes within facility management through a case studies of companies and suggested the use of the business process reengineering method for modelling FM processes. Wiesinger (2006) introduced a process oriented method for facility management using process orientation, process chain paradigm of Dortmund and process analysis for fitting to business objectives and restrictions of company. Atkin and Bjork (2007) have recently found the FM processes using top-down approach, how service provision must be set in a wide context if decisions and their outcomes are to be consistent with the delivery of best value and customer satisfaction. The process is driven by client needs and not the availability and supply of services and goods. The output of process or result of process based on 1SO 9000 is requirements satisfied (ISO 2004). Facility management processes should be considered as business processes initiated by a client, and are subject to the normal business planning cycles of the organisation. If FM is a demand driven, FM processes should begin with an understanding of the organisation. Level of FM processes can be map as Figure 2 below:

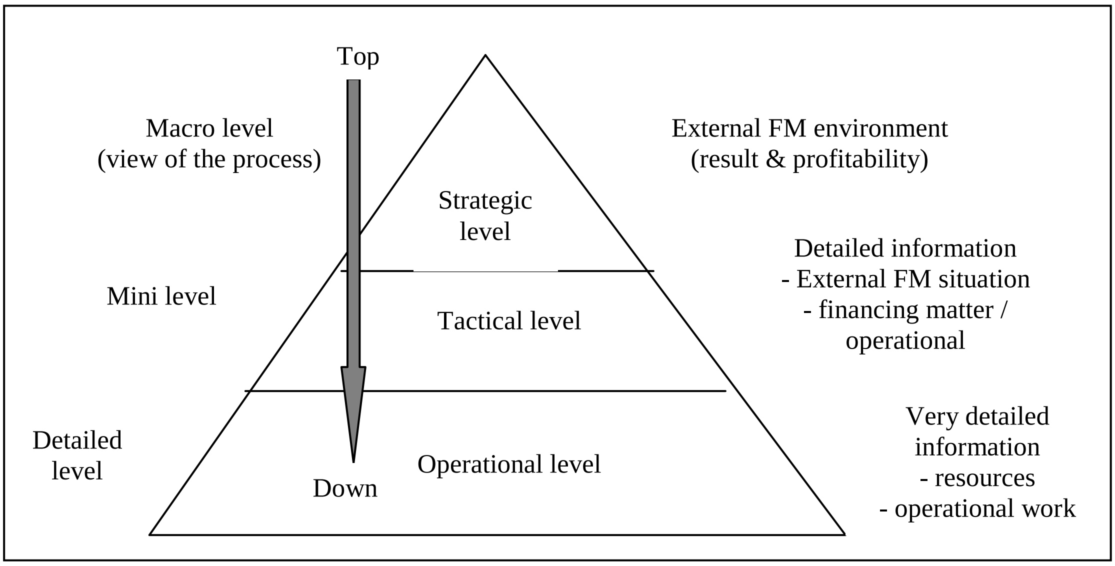

Fig. 2. Level of FM process mapping

FM processes can be of different kinds and correspond with the various ways in which a process can be modeled. First, a strategic FM processes which investigate alternative ways of doing a thing and eventually produce a plan for doing it. These processes are often creative and require human co-operation; thus, alternative generation and selection from an alternative is very critical activities. At a strategic FM processes in achieving the objectives of organisation in the long term, the organisation should identify the process such as alignment process, FM strategy process, input to decision making process, risk analysis process, quality process, PDCA process (plan, do, check, act), external relation process and controlling process. These FM processes are driven by changes in the business strategy and have to fulfil the predicted demands in the future. Second, a tactical FM processes which help in the achievement of a plan and are more concerned with the tactics to be adapted for actual plan achievement. At this level, to implement the strategic objectives in the organisation in the medium term through monitoring process, business planning process, specification process, quality assurance process, auditing process, controlling process, leadership process, continuous improvement process, change management process and communication process. Third, an implementation or operational FM processes which is the lowest level processes

and directly concerned with the details of the and how of plan implementation. At this level, to create the required environment to the end users on a day to day basis through delivery activities, process evaluation activities, surveillance activities, service request activities, information collection activities, reporting activity and communication activity. Based on CEN WG5 UK Mirror group discussion, the proposed FM processes will be start at the generic high level (top down) or at the macro level of the processes.
MS Visio 2000 has been selected by the group to map the proposed FM processes. The model presented is using IDEFO modeling method. The proposed generic FM processes CEN/TC 348 Part X (Guidance on the development and improvement of processes) currently still under the draft stages.

4. Why Hierarchical (Top Down) Process Map

It is difficult to determine the level of detail that will be included in the process map. Before conducting process mapping activities there is a need to define clearly the process to be mapped; then designate the boundaries of the process (Galloway 1994; Langdon 1999). Hierarchical process mapping is a system thinking tool that helps determine how organisations seek data, how they can turn it into useful information, and how they can use it to reach conclusions (Pojasek, 2005). Process map can be start at a high level of the organisation showing the main stages along a supply chain. Each of stages can then be broken down into sub-processes to activities or tasks below the top level. This process can be identified as top-to bottom structure or hierarchy. From the top-level perspective, the HEIs should have an understanding of how its main processes work as a complete system, cross-functionally across whatever organisations are involved, to achieve the HEIs business objectives. It is importance to understand the linkages among processes involved within the organisation. At the highest levels the relationship among the key business objects and the key business processes are of prime interest (Ford, Goodyear et al. 1996). The process map enables us to obtain comprehensive macro and micro-views of operations. Figure 3 shows the level of process map from macro level to micro level.

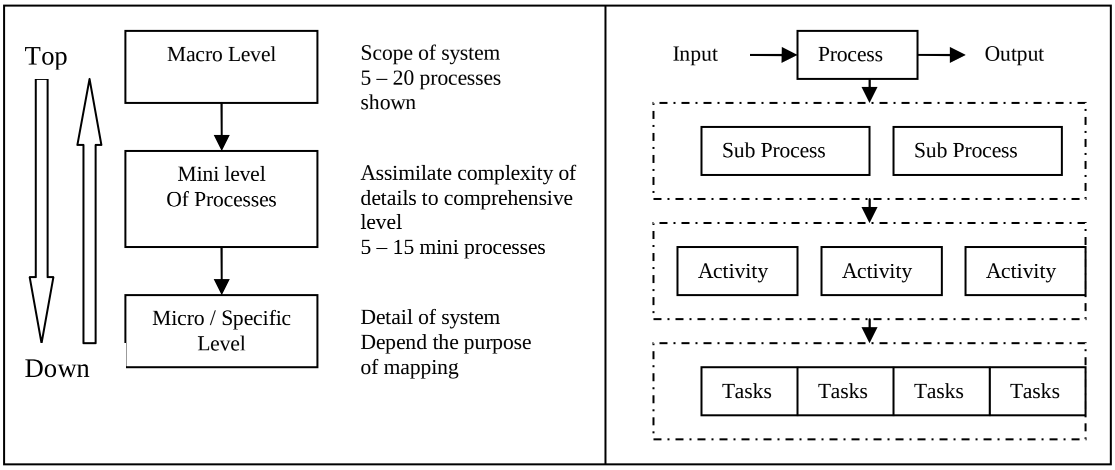

Fig. 3. Level of process map/ hierarchy of process levels

Process maps can present different levels of detail on the process being modelled. This increased visibility improves communication and understanding, as well as providing a common frame of reference for those involved with the work process (Pojasek 2005). If the process involves a complex entity such as a business unit, a series of maps may be produced beginning at the highest level, for example, the business unit, and then proceeding to lower levels such as division and work group (Langdon 1999). The top-level view is useful in scoping process improvement projects and establishing boundaries. (Anjard 1998) suggested that all process maps should be developed from the top-down approach. From the quality management system (QMS) perspectives processes have to be capable of achieving top down driven organisational objectives. By starting at the bottom organisation only replicating what they already have and not seriously challenging the appropriateness of the processes in the context of meeting business goals (Batalas 2006).

The process approach is to engage top management and to demonstrate that an effective quality management system is capable of delivering continual improvement of business performance. Activities are parts of the business process that does not include any decision making and thus are not worth decomposing (although decomposition would be possible), such as answer the phone, produced an invoice and other activities. Difference benefits from the use of process models can be described and classified under three generic themes such as the client i.e. potential improvement of the product, the process (focusing on its characteristics and on the way it is developed) and benefits for the organization as a whole (Tzortzopoulo 2004). A hierarchical process map makes it easy to understand the relationships among various processes, and among the steps within processes. Hierarchical process mapping offers several of benefits to companies as shows below : (Pojasek 2006)

- provides visualization of the process functionality
- is less complicated in format, and easier to read, than other commonly used tools, such as value stream maps
- encourages participants to ask questions about the process
- involves employees in looking for process improvements
- creates a sense of “system exploration” by showing how every aspect of the process is linked to everything else
- provides a common platform for communication
- creates a template for storing and sorting all process information by work step
- focuses all process improvement efforts on actually changing the process, not just controlling it
- allows suppliers to be considered as supporting processes
- enables the “voice of the customer” to be considered a supporting process

5. Mapping FM Processes in Estate Division

FM processes are a top-down decomposition, which begins with broad goals and objective of the organisation. FM processes approach begins with a high-level customer focused process map and works from there to build increasing levels of decomposed detail. Figure 4 provides a generic example of University of Salford process model.

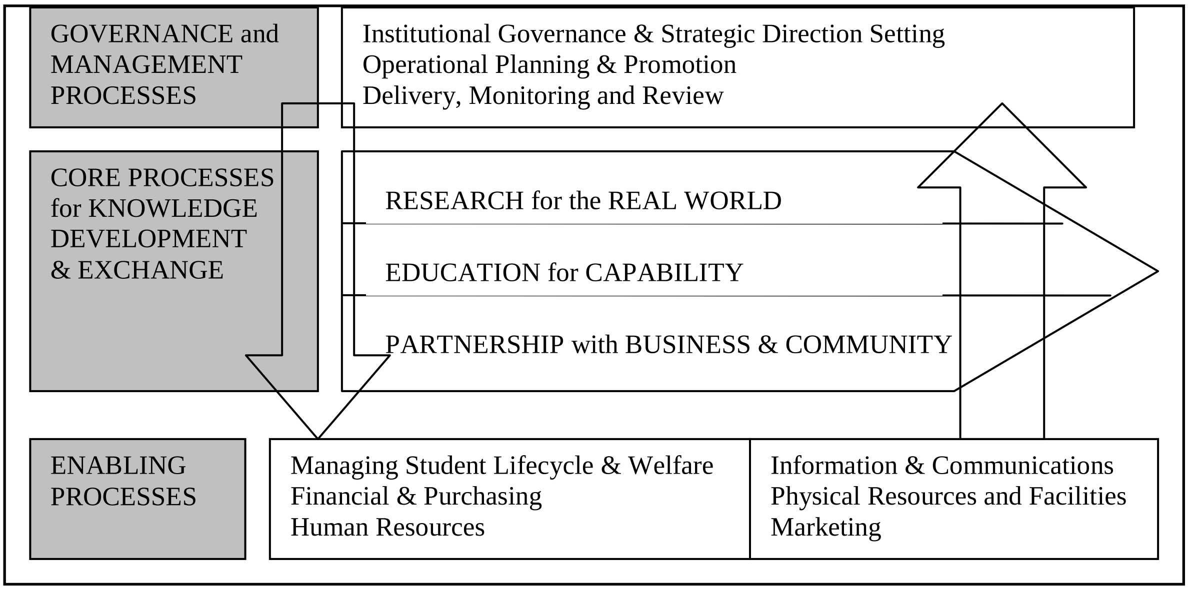

Fig. 4. A University High Level Process Model (Source: Report of the deciding the future working group, University of Salford, 2005)

Using the map in Figure 4, process measures can begin to be developed as well as identifying process owners accountable for these measures. At this level, each high level process listed on the map should have an owner that is responsible for building the next step in process view. This map also serves as a personality profile of the university, the markets it serves and the interactions with its customers. For this paper the proposed generic CEN/TC 348 processes model has been adapted within the University of Salford organisation. The adoption of strategic FM processes in term of understanding the organisation processes has been chosen. In understanding the organisation according to the suggested strategic FM processes model it list eight aspects to be considered as follow:

1. Identify and review business organisational strategy
2. Establish and consider stakeholder management framework
3. Identify and review business organisational management
4. Identify business organisational deliverables
5. Identify organisation business critical issues
6. Identify and review organisation business model
7. Identify drivers of primary business activities
8. Identify support requirement of primary business activities

Example of strategic FM processes mapped within University of Salford is attached per Appendix 1. One of the most fundamental findings of this exercise was the importance of understanding the University of Salford organisation, its primary processes, activities, support processes, external factors and internal capabilities. It is recognised that a key factor in the success of this process map is a complete understanding of the university processes. The Estates and Property Services Division, as a major support service, contributes significantly within the strategic framework of the higher education institutions. Table 1 below shows the processes found in this division.

Table 1: Processes Found in Typical Department of University Estate Division

Administration Department	Development Group
• Office activities • providing PA/secretarial/office services • organising and servicing meetings • updating personnel records • processing mileage and expense claims • managing records • processing all tendering undertaken in the Division • processing all orders and invoices • keeping the Divisional accounts • dealing with Business Rates • audit inquiries/ activities • keeping the space database • servicing the University Estates Committee • servicing the Transport and Sustainable Development Policy Sub-Committee • preparing bids for estates funding from the Higher Education Funding Council (HEFCE) and other funding bodies • promoting links with other support units in the University and with Faculties/Schools ***Facilities Division*** • Care taking services • Car Parking services • Cleaning services • Customer services • Mail services • Reception services • Disposal and campus recycling schemes • Security	• Space planning and design • Minor works of alteration • Major construction work • Major maintenance • Relocation • Initial investigation and feasibility studies • Preparation of an order of cost • Defining a detailed brief • Preparing a detailed design and specification • Obtaining Statutory Approvals, such as Planning Permission and Building Regulations approval • Obtaining tenders • Project implementation and management • Cost control • Commissioning • Post contract evaluation ***Operational Services*** • Property Maintenance • Building & Mechanical Services • Electrical Services • Landscape & Transport Service • Residential Services • Technical support and stores • Maintenance funding arrangement • Energy and waste management • Planned maintenance ***Health and Safety*** • Safety monitor • Internal procedure • Training

A complex organisation such as a university does not need to know the details of every process. Estate Division can select its key processes and use them to take a process view of the university. The first thing that is required is to figure out the mission of the university and analyses whether this division actually contribute to the mission of the overall university. Base on the list above it should separate the processes that are core processes and that are supporting processes of the division. At this stage, it is beneficial to prepare hierarchical process maps for each core processes. Most of these processes can be detailed at the second level of the process map. Once the key processes have been selected and there is some good hierarchical process mapping completed, there will be in a better position to select projects for a process improvement program (Pojasek 2005). There is a need for processes improvement in FM (Hinks 1998; Amaratunga and Baldry 1999).

6. Conclusion

This paper presented the overview of the development of FM processes using hierarchical process mapping in estate division of higher education institution. The proposed methodology of FM processes has been discussed and will be used during the exploratory case study. The paper concluded that the process should be aligned with the organisation’s strategic goals. It is very importance for FM processes to demonstrate a business case that proves the processes has positively impacted the strategy. By considering the benefits of using this hierarchical decomposition process mapping in Estate Division of HEIs, this research will contribute in the methodological approach for developing and improvement of FM processes at the strategic level. There is a need for further research on the adoption of facilities management processes in higher education and suggest a different way to demonstrate the strategic facilities management in managing university estate.

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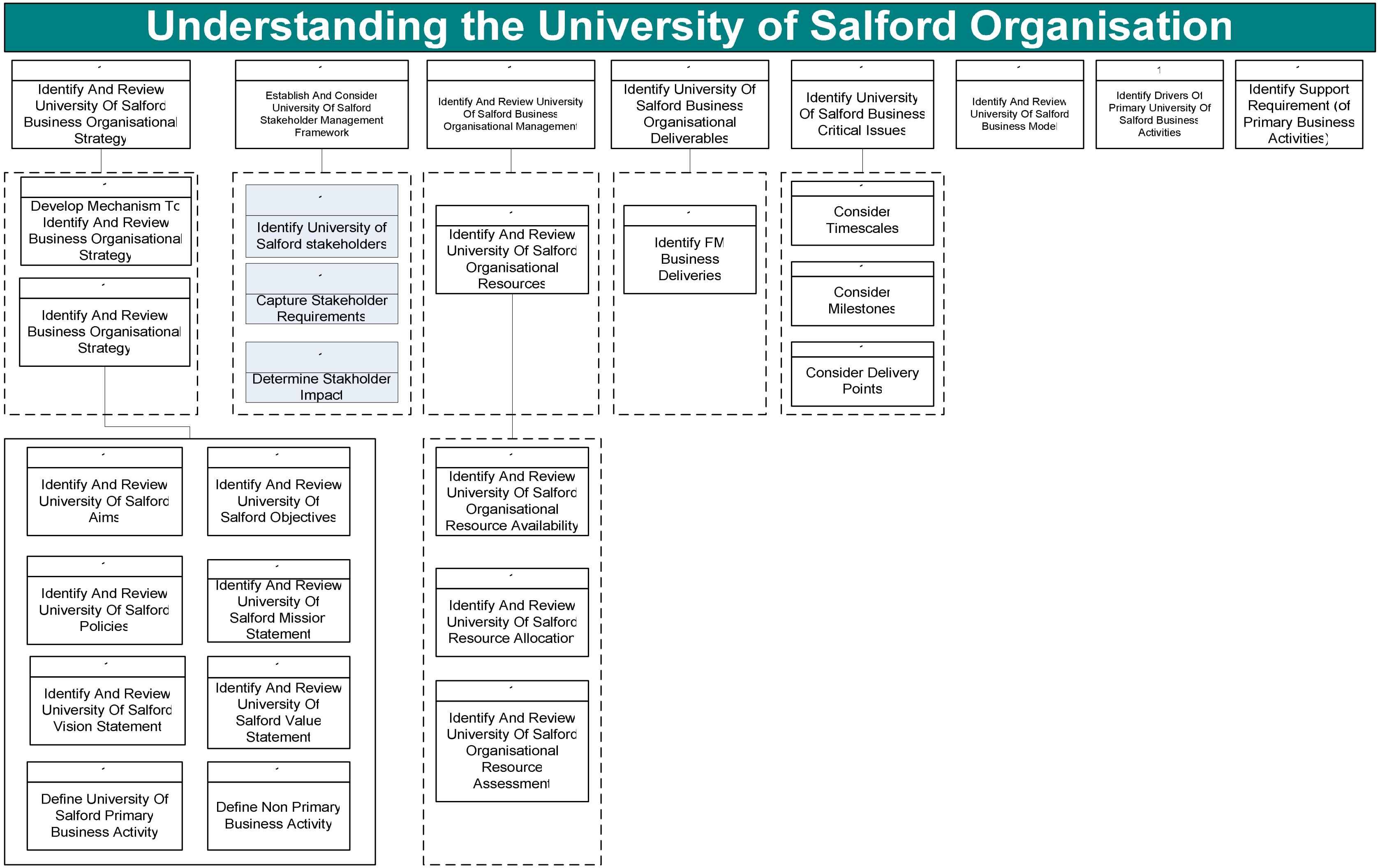
Appendix 1: Example of Strategic FM Processes Mapped Within University of Salford



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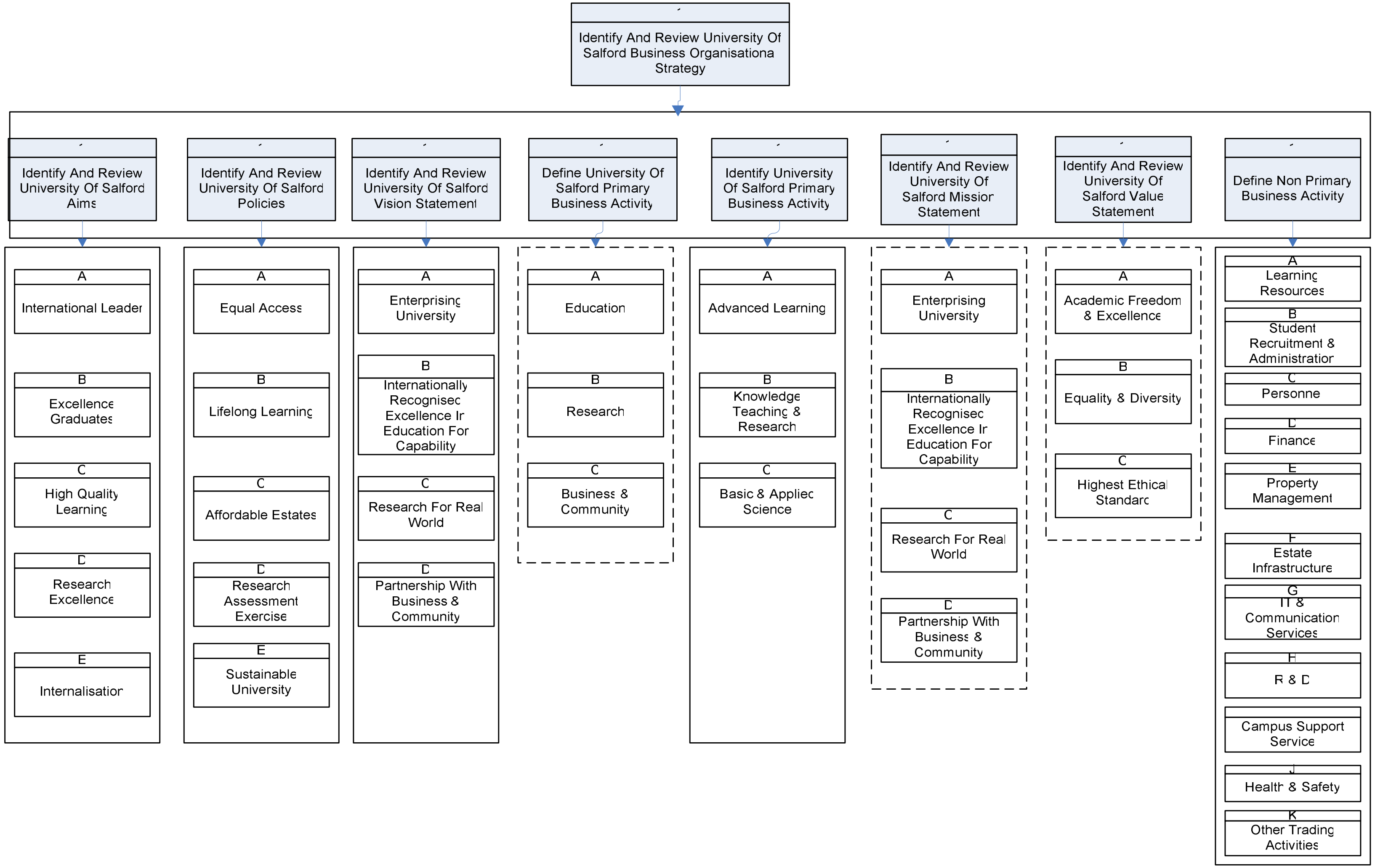

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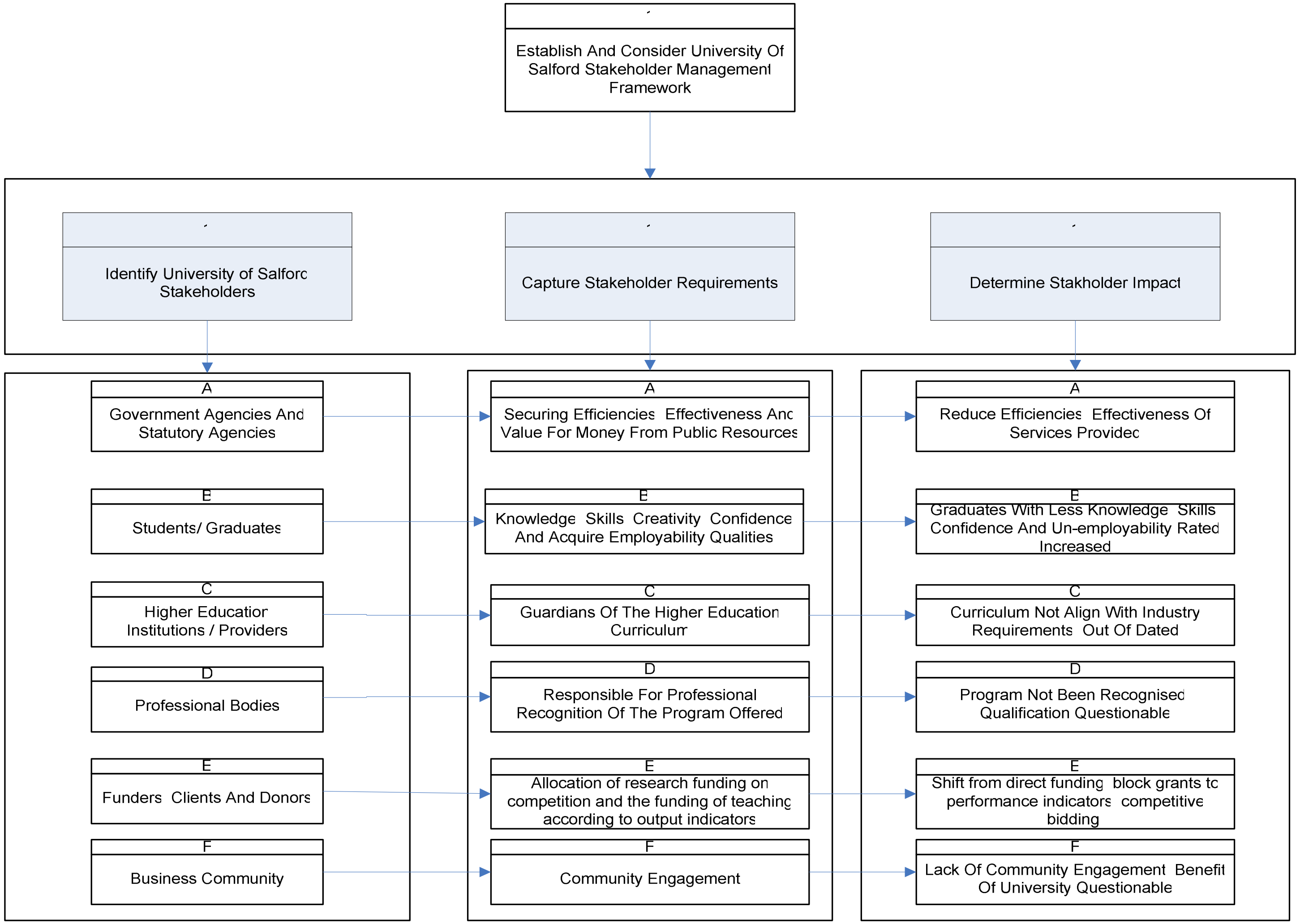

Theme 9:
Sustainability

Building Sustainability Rating Index

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Abstract:
This research aims to deliver a building sustainability rating system which will easy to apply and will focus on macro as well as micro levels of building construction. Also this system will be focused on owner's sustainability perspective. The criteria's and indices in BSRI will be well defined in order to reduce confusion and misunderstandings. Also this research will be focused on helping the designers during the design stage itself minimizing assessment procedures.

Keywords:
Building construction, Green Buildings, Sustainability Assessments, Weighted Point system.

1. Introduction

During the ancient times, structures were designed and built by builder-architects popularly known as Master Builders, had an ability to understand the entire building from design through construction and lifetime operations. They incorporated enduring passive design and simple mechanical systems to heat, cool and light buildings. Architects in the 21st Century will look back upon these ideas to relearn the basics of climatic design. At the beginning of 20th century new building technologies began to transform urban landscape. Advent of air conditioning, low-wattage fluorescent lighting, structural steel, and reflective glass made possible enclosed glass and steel structures that could be heated and cooled with massive HVAC systems, thanks to availability of cheap fossil fuels. These technologies began a sadly regressive movement in architecture in which architects began to ignore climate issues and their effect on buildings and occupants. Increasing complexity in the industry also brought about specialization in professionals, leading to the loss of the generalists, the builder-architects. This specialization led to an increasing lack of communication between the professionals and therefore of lack of whole systems thinking in designing the various parts of the building. This problem will only begin to be addressed by the start of the 21st Century through the integrated design process. Later a combined effort of various organizations like UN, AIA, several federal agencies and USGBC encouraged development and application of green building practice globally as well as nationally.

There is concern about how to improve construction practices in order to minimize their detrimental effects on the natural environment (Cole, 1999; Holmes and Hudson, 2000). The environmental impact of construction, green buildings, designing for recycling and eco-labeling of building materials have captured the attention of building professionals across the world (Johnson, 1993; Cole, 1998; Crawley and Aho, 1999; Rees, 1999). Building performance is now a major concern of professionals in the building industry (Crawley and Aho, 1999) and environmental building performance assessment has emerged as one of the major issues in sustainable construction (Cole, 1998; Cooper, 1999; Holmes and Hudson, 2000). According to Cole (1998), the definition of building performance varies according to the different interest of parties involved in building development. For instance, a building owner may wish his building to perform well from a financial point-of-view, whereas the occupants may be more concerned about indoor air quality, comfort, health and safety issues. Using a single method to assess a building's environmental performance and to satisfy all needs of users is no easy task. Therefore, an ideal environmental building assessment will include all the requirements of the different parties involved in the development. The phrase built environment refers to the man-made surroundings that provide the setting for human activity, ranging from the large-scale civic surroundings to the personal places. The built environment has a profound impact on our natural environment, economy, health, and productivity. Green building is the practice of increasing the efficiency with which buildings use resources — energy, water, and materials — while reducing building impacts on human health and the environment, through better siting, design, construction, operation, maintenance, and removal — the complete building life cycle.

Building designers and occupants have long been concerned about building performance (Cooper, 1999, Kohler, 1999, Finnveden and Moberg, 2005). Considerable work has gone into developing systems to measure a building's environmental performance over its life. They have been developed to evaluate how successful any development is with regards to balancing energy, environment and ecology, taking into account both the social and technology aspects of projects (Clements-Croome, 2004). Separate indicators, or benchmarks based on a single criterion, have been developed to monitor specific aspects of environmental building performance such as air quality and indoor comfort. However, these benchmarks serve to emphasis the need for a comprehensive assessment tool to provide a thorough evaluation of building performance against a broad spectrum of environmental criteria.

The building research establishment environmental assessment method (BREEAM) in 1990 was the first such comprehensive building performance assessment method. BREEAM was the first environmental building assessment method and it remains the most widely used (Larsson, 1998). The Building Research Establishment developed the system in 1990 in collaboration with private developers in the UK. It was launched as a credit award system for new office buildings. A certificate of the assessment result is awarded to the individual building based on a single rating scheme of fair, good, very good or excellent. The purpose of this system is to set a list of environmental criteria against which building performances are checked and evaluated. This assessment can be carried out as early as at the initial stages of a project. The results of the investigation can be fed into the design development stage of buildings and changes can be made accordingly to satisfy pre-designed criteria (Johnson, 1993). Since 1990, the BREEAM system has been constantly updated and extended to include assessment of such buildings as existing offices, supermarkets, new homes and light industrial buildings (Yates and Baldwin, 1994).

Crawley and Aho (1999) suggest that the system is successfully alerting building owners and professionals to the importance of environmental issues in construction. BREEAM has made an impact worldwide, with Canada, Australia, Hong Kong and other countries using the BREEAM methodology in developing their own environmental building assessment methods. Following the launch of BREEAM in the UK many other assessment methods have been developed around the world to undertake environmental building assessment. Table 1 summarized the old and new environmental building assessment methods used in different countries. Most of the environmental building assessment tools cover the building level and based on some form of life-cycle assessment database (Seo et al., 2006). Tools are basically in two categories: assessment and rating tools. Assessment tools provide quantitative performance indicators for design alternatives whilst rating tools determine the performance level of a building in stars. EMGB, NABERS and BASIX are operated by the government while the others have a private, voluntary and contractual origin and are guidance type only. They essentially aim at showing those involved in the building process the potential for improvement. Most building evaluation methods are concerned with a single criterion such as energy use, indoor comfort or air quality to indicate the overall performance of a building (Cooper, 1999; Kohler, 1999). As environmental issues become more urgent, more comprehensive building assessment methods are required to assess building performance across a broader range of environmental considerations. An environmental building assessment method reflects the significance of the concept of sustainability in the context of building design and subsequent construction work on site. The primary role of an environmental building assessment method is to provide a comprehensive assessment of the environmental characteristics of a building (Cole, 1999) using a common and verifiable set of criteria and targets for building owners and designers to achieve higher environmental standards. It also enhances the environmental awareness of building practices and lays down the fundamental direction for the building industry to move towards environmental protection and achieving the goal of sustainability. It provides a way of structuring environmental information, an objective assessment of building performance, and a measure of progress towards sustainability.

Table 1: Summary of various sustainability assessment tools

Sr. No.	Assessment Method	Origin	Characteristic	Reference
	ABGR- Australian Building Greenhouse Rating	Department of Commerce, NSW, 2005	- Performance based assessment tool - Star rating on the scale of 1 to 5 - National approach to benchmarking - Based on 12 months of energy consumption	Seo et al. (2006)
	BASIX- Building and Sustainability Index	Department of Infrastructure, Planning and Natural Resources, 2004	- Web-based planning tool for residential development - To assess the water and energy efficiency of new residential developments - NatHERS and AccuRate are simulation packages used to assess energy performance - It is mandatory for all new residential development and a BASIX certificate is required for development approval	Seo et al. (2006)
	BREEAM- BRE Environmental Assessment Method	Building Research Establishment, UK	- First environmental assessment system used internationally - Used four levels of ratings- excellent, very good, good and pass. - Sustainability assessment system - Each criterion weighted based on its	Shakoorian, A.

			importance.	
	CASBEE- Comprehensive assessment system for building environmental efficiency	Japan, 2004	- A co-operative project between industry and government - Applicable in accordance with the stages of a development in pre-design, new construction, existing building and renovation - It is based on the concept of closed ecosystems to determine the environmental capacities - Consideration for regional character	Cole (2005), Yau et al. (2006), Seo et al. (2006)
	GBTool - Green building challenge	International, 1995	- The most comprehensive framework - International collaboration of over 20 countries - Absolute performance indicators to complement the relative scores - More than 90 individual performance assessment - Four levels of weighting - A comprehensive evaluation method that can be used by different regions with the adjustment of regional variations	Cole (1998), Larsson (1998), Kohler (1999), Larsson and Cole (2001), Rohracher (2001), Todd et al. (2001), Yau et al. (2006), Seo et al. (2006), Shakoorian, A.
	LEED- Leadership in energy and environmental design	USA, 2000	- Developed by the US Green Building Council - A certification process developed to create an industrial standard - Self-assessing system awards rating of certified, silver, gold and platinum - Use simple checklist format to rate building performance - For new and existing commercial, institutional, high-rise residential & major renovation - Comprises 5 areas of sustainability - A voluntary tool	Crawley and Aho (1999), Larsson (1999), Yau et al. (2006), Seo et al. (2006)
	SPeAR- Sustainable project appraisal routine	ARUP	- A project assessment methodology within Ove Arup's consulting projects - To enable a rapid review of project sustainability - Use a graphical format to present sustainable design	Clement-Croome (2004), Cole (2005), Yau et al. (2006)

2 Problem Statement

The purpose of this research is to develop building sustainability rating index matrix.

2.1. Sub-Problems

1. To categorize various types of buildings and identify critical processes for each project type.
2. To assess weighted score for the sustainability of each process.
3. To determine Sustainability index for respective category of the building.

2.2. Delimitations

The scope of this study is limited to building construction.

2.3. Literature Review

Literature review indicates that the task of understanding and translating strategic sustainability objectives into concrete action at project level has become a very challenging task for construction professionals (Viitaniemi & Haapio, 2007). The process has been exacerbated by the multi-dimensional perspectives of sustainability such as economy, society, environment, combined with a lack of structured methodology and information at various levels. Also, while discussing environmental issues in the building sector, the use of terms is not well established. This inconsistent use of terms ma cause confusions and misunderstandings (Viitaniemi & Haapio, 2007). Over the past few years, the increased concern over the deterioration of our environment has motivated the development of various sustainability assessment systems across the globe. Although most of them are based on the concept of life cycle assessment, they have been basically focused on the evaluation of the environmental performance during building operation (Cole, 2000). According to Cole (2000), the limited attention given to the onsite construction impacts is a consequence of the perceived relatively lower significance of construction impacts compared with the lifecycle impacts associated with building design and management.

The environmental assessment methods all have limitations that may hamper their future usefulness and effectiveness (Ding & K.C., 2007).According to Ding (2007), current assessment methods do not adequately and readily consider environmental effects in a single tool and therefore do not assist in the overall assessment of sustainable development. Also the inflexibility, complexity and lack of consideration of weighing system are still major obstacles to the acceptance of sustainability assessment methods. Use of a sustainability index should simplify the measurement of sustainability and therefore should make a significant contribution to the identification of optimum design solutions and facility operations. (Ding & K.C., 2007)

3. Proposed Methodology

The objective of this research is to develop a rating system which will have an ability to satisfy present as well as future requirements of sustainability. The most significant problem facing everyone who attempts to study the future is how to sift effectively through the myriad of information sources and pull put those trends worthy of future study and tracking. Researchers use number of techniques to think about and sketch out future opportunities. Trend Analysis is one of those techniques used by researchers which give reliable outputs. Trend analysis is nothing but collecting and analyzing local, regional or global conditions. Researchers can develop forecasts of future conditions through simple exploration by collected data. (Wallace, 2005)

The proposed methodology for the development of activity list consists of the following aspects:

1. Data collection for assessment and benchmarking purpose. (The data will be collected through the combination of literature review first and then by sending the draft list in the form of questionnaire to the experienced industry professionals for review purpose.).
2. Reference classification system to define objectives and indicators.
3. Trend analysis to foresee the future requirements.
4. Evaluation procedure, including benchmarking, scoring and weighting; (Peretti & Grosso, 2004).

It is very important to set benchmarks during the development of any system. The benchmarks will be set for each activity with the evaluation of its impact on the buildings sustainability. After reviewing published literature and following above stated aspects, the research will move ahead with development of a matrix comprising of various activities that affects the sustainability of the buildings at the most. Hence the activity list will be modified in context to the trend analysis. This list will be then sent to various organizations such as owners, contractors, sustainability certifying professionals as well as to academicians for their review. They will be asked to rate each activity from 0-5 (0=doesn't affect sustainability, 5= affects sustainability the most)

After receiving the reviews, next step in this research is to reorganize the matrix as per the review results and furnish it for the sustainability assessment stage.

In assessment stage, we will select 3 sets, each with 3 ongoing building construction projects for assessment purpose as follows -

- Set 1: Buildings with higher sustainability values
- Set 2: Buildings with medium sustainability values
- Set 3: Buildings with lower/no sustainability values

BSRI will be applied with these three sets and the results will be prepared for the next stage, which is the validation stage. Validation of the BSRI will be carried out through the workshops and surveys. In those, the BSRI results will be reviewed and analyzed by industry experts. And with their reports BSRI will be modified for final delivery.

4. Future Research

Research in the field of building sustainability is a never ending process as technology and environmental conditions are changing with respect to time. BSRI will demand continuous research and development in the system with changing technology and environmental requirements. Future research could be carried out by trend analysis and industry outputs to modify the sustainability matrix. There is much scope for future researchers to modify this system to make designer friendly assessment system in order to reduce the assessment procedures in the post-design phase.

5. Conclusion

In a nutshell BSRI will deliver a building sustainability rating system which will be easy to apply and will focus on macro as well as micro levels of building construction. Also this system will focus on owner’s sustainability perspective. The criteria’s and indices in BSRI will be well defined in order to reduce confusion and misunderstandings. Also BSRI will be focused on helping the designers during the design stage itself minimizing assessment procedures.

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Constraints of Implementation of Stabilised Earth Construction in Zimbabwe – Some Sustainable Solutions

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Abstract:
Several studies have shown that earth construction is the potential solution to solve the low cost housing crisis in the developing world. The current by-laws and house standards required in Zimbabwe need to be reviewed to incorporate and promote the use of indigenous construction material. The major constraints of implementation of stabilized earth construction in Zimbabwe are known to be the lack of standard criteria to evaluate finished product, lack of political support discourages relevant government department promoting earth construction; there is misconception among the users that, 'earth houses are only used by the poor people'. Of course there are some limitations of the performance of earth as a building material, such as: - it is not suitable for multi storied building, and poor in resistant of tensile stress. However, the Zimbabwean Government does not have any well structured and effective program to address the global agenda of sustainability through the use of appropriate construction material in Zimbabwe. But political support enables facilitation, citing the example of existing rammed earth houses in Zimbabwe, which were built directly by the government after the Second World War. First, this paper identifies and discusses the constraints of stabilized earth construction as a sustainable solution of low cost housing, and secondly, it analyzes some sustainable solutions of these identified constraints.

Key words:
Stabilised earth construction, low cost housing, sustainability, constraints

1. Introduction

Available statistics indicate that the urban housing backlog which was estimated at 670000 housing units in 1995 (NTFH, 1999, p3) has now increased to over 1 million housing units in Zimbabwe (Tibaijuka, 2005, p24). The Zimbabwe National Housing Delivery Policy of 2000 recognised the need to adopt a more flexible approach to housing delivery and the lack of security of tenure as a causal factor of the housing crisis in Zimbabwe (Tibaijuka, 2005, p24). A subsequent policy document, the National Housing Programme of 2003, further acknowledged the inability of the Government to provide decent and affordable housing. It noted that Government plans for housing fell far short of the annual target of 162,000 units between 1985 and 2000 with actual production ranging between 15,000 and 20,000 units per annum. It further noted that the formal sector housing production rate was decreasing and that by 2002, only 5,500 plots were serviced in eight major urban areas compared to an estimated annual demand of 250,000 units (Ministry of Local Government, Public Works and National Housing, 2003). This is evidence by the extent of overcrowding in existing housing schemes which manifests itself in backyard structures. The consequences arising from this situation are to be overloading the existing infrastructure, an upsurge of contagious diseases and a rise in crime and if immediate measures are not taken to address this issue, the situation will soon degenerate into massive urban squatting which is unknown in this Zimbabwe and will be very costly to correct (Ministry of Local Government, Public Works and National Housing, 2003). There is, therefore, a need to establish a locally based and sustainable housing delivery system that any donor driven housing programmes will complement a system that addresses the needs, interests and aspirations of the Zimbabwean people (NTFH, 1999, p7). Indeed the use of appropriate building material (indigenous building material, e.g. earth) and implementation of appropriate construction technologies in the construction of low cost housing can contribute to sustainable housing delivery system. One may ask why indigenous building material needs to be promoted to achieve sustainable development in low cost housing and the next section is going to explain the reasons.

2. Reasons for implementing earth construction in Zimbabwe

According to Easton (1996, p3), 50 percent of the world's inhabitants still live in shelters made of earth. In every continent of the world, from the dry deserts of the Middle East to the rain forests of South America, from impoverished Asia to affluent Europe, examples of mud building are abound, and apart from their regional variations, mud is the predominant building material all over the world, especially in rural areas (Lal, 1995, p115). Africa, specifically Zimbabwe is not an exception in using earth as a construction material. But it is important to explain economic reasons of implementation of earth construction technology in Zimbabwe. The cost of building materials has sky rocketed in Zimbabwe making it very difficult for the majority of the people to build houses. The unprecedented boom in the construction industry since Independence resulted in the high demand of building materials that superseded the production capacity of the manufacturing sector. In the period between 1989 to 1992, the estimated demand for bricks was 1250 million yet only 1002 million were produced, and the production levels of cement have only been able to satisfy 84% of the demand, most of which was utilised by commercial and industrial sectors (MPCNH, 1993). The high demand in basic building materials caused the prices of these materials to significantly rise. For instance, the cost of constructing a $50m^2$ four roomed house in urban areas rose from ZW $3,800 in 1983 to about ZW $22,000 in 1990, and more than doubled to be pegged at ZW $50,000 in 1993 (MIPTP, 1993). According to MIPTP (1993), only 23% of the urban population could afford to buy a house that cost ZW $50,000 in Zimbabwe. Kuchena & Chakwizira (2004) reported that the government of Zimbabwe in 1996 had the aim to build houses for all by the year 2000 which unfortunately was never achieved, and by 2004 approximately 50% of the population in Zimbabwe lived in urban areas. Inflation in August was at 200% in September 2003, at 400% in December and by 2004 it was 600%. To date, the official inflation figure has reached 8000% in Zimbabwe (SW Radio Africa, 2007). According to the MPCNH (2004), a bag of cement was priced at ZW $15 in 1991; ZW $450 in 2002; ZW $9,000 in June 2003; ZW $30,000 in December 2003 and ZW $40,000 in May 2004.

The use of common and established construction materials, such as, cement has contributed to drive the cost of housing beyond the reach of most Zimbabweans, and therefore many are seeking for more affordable alternative materials and construction techniques (Mubaiwa, 2002; Zami and Lee, 2007). Apart from the high cost, the availability of building materials has become a cause for concern and this has led to the import of some materials. On the other hand, the import of construction materials is practically impossible because of the lack of foreign currency in Zimbabwe. It is in the light of such arguments that it seems appropriate to consider looking into a materials approach to the housing issue. The notion of promoting earth as an alternative building material for comfortable, affordable and sustainable housing seems to be a noble one given the prevailing circumstances since the earth approach could prove a solution to the housing crisis in Zimbabwe. The question may arise from here that, what is meant by sustainability and sustainable development in low cost housing in this paper. The next section is going to demystify these questions.

3. Sustainability, Sustainable Development demystified

According to Edwards (2005, p3), fifty percent of all resources consumed across the planet is used in construction, making it one of the least sustainable industries in the world and the World Health Organisation estimated in 2003 that global warming was causing 150000 deaths a year. Edwards (2005, p9) also stated that by 2050 it is anticipated that the human race will have four times the environmental impact it had in 2000 (based on a 2 percent annual economic growth and a global population of 10 billion). The EU estimates that air pollution from traffic is the second biggest killer in Europe, leading to 60000 deaths a year from bronchitis, asthma and heart disease (European Environment Agency, 2001). In Africa on the other hand, water pollution is the killer; unsafe drinking water kills more people than AIDS, and according to UN (2003), only one third of Africa’s population has adequate drinking water. According to Edwards (2005, p22), buildings are big users of raw materials and the environmental capital locked in them is enormous, as is the waste footprint:-

- Materials: - 60% of all resources globally go into construction (roads, buildings, etc.).
- Energy: - nearly 50% of energy generated is used to heat, light and ventilate buildings and a further 3% to construct them.
- Water: - 50% of water used globally is for sanitation and other uses in buildings.
- Land: - 80% of prime agricultural land lost to farming is used for building purposes and much of the remainder has been lost through flooding due to global warming.
- Timber: - 60% of global timber products end up in building construction and nearly 90% of hardwoods.

Therefore, environmental damage resulting from current construction practices is clear and this environmental damage in the form of Global Warming needs to be addressed if we want to avoid disaster. The terms ‘Sustainability’, ‘Sustainable Construction’, ‘Material and Sustainable Development’ are some of the terms which deal and address the solution to Global Warming and are demystified below.

There are many different definitions of sustainability. To engineers, their definition of working is to maximize uses of materials, skills, and energy for the benefit of mankind (McCarthy, 1998). According to Du Plessis (2002), sustainability is “the condition or state which would allow the continued existence of Homosapiens and provide a safe, healthy and productive life for all generations in harmony with nature, local culture and spiritual values”. Sustainability is defined as an interdisciplinary, holistic and integrated process in the way things are thought, measured, implemented and managed. Balance and integration of economic, social and environmental dimensions of life demands changes in patterns of production, consumption, life styles, social relationships among other dimensions and concept of sustainability is not having a “system” in which economy is against ecology but a system in which all human actions are integrated to be effective (Orsatti, 2006, p1). According to Edwards (2005, p1), the definition of sustainability for the architect is a complex concept; a large part of designing sustainability is to do with addressing global warming through energy conservation and using techniques such as life-cycle assessment to maintain a balance between capital cost and long-term asset value. He also stated that, designing sustainably is also about creating spaces that are healthy, economically viable, and sensitive to social needs, respecting natural systems and learning from ecological processes, which is reflected on the three perspectives on sustainable design (Fig 01).

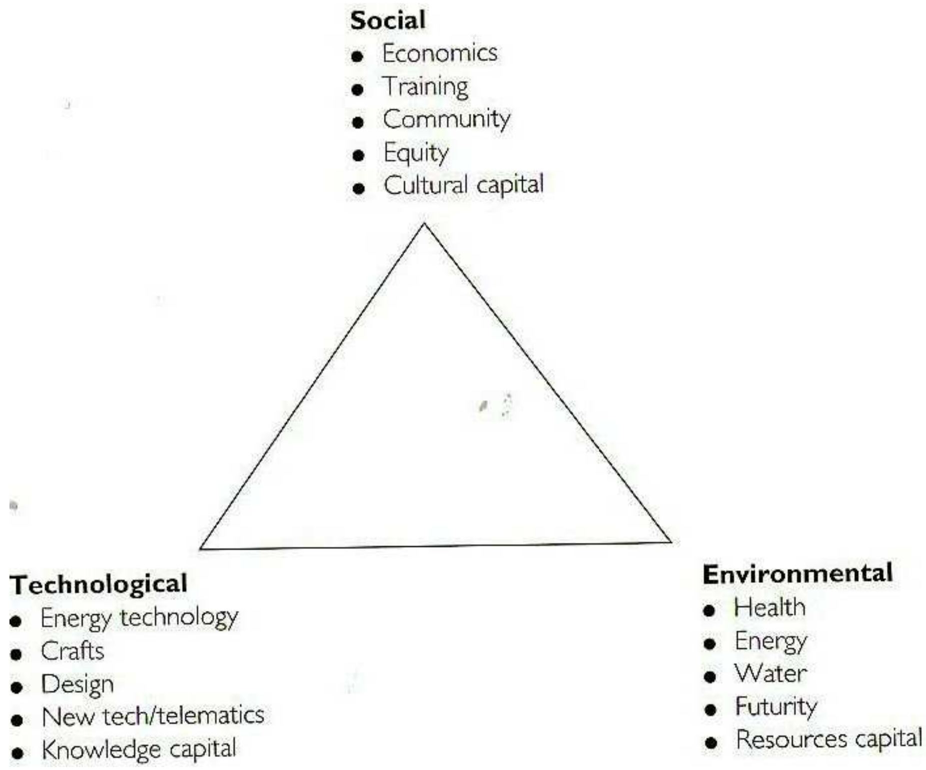

Fig. 1. Three Perspectives on sustainable design: social, technological and environmental. Source: Edwards, 2005, p10.

The Brundtland Commission (1987) defined 'Sustainable Development' as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This definition has spawned a series of sub-definitions to meet particular sector needs, typical of these is that used by the practice of Foster and Partners (Edwards, 2005, p19, Fig 02). It defines sustainable design as creating buildings which are energy-efficient, healthy, comfortable, and flexible in use and designed for long life (Foster and Partners, 1999). Thus, according to Brundtland Commission's definition, sustainable development focuses on improving the quality of life for all of the Earth's citizens without increasing the use of natural resources beyond the capacity of the environment to supply them indefinitely. It requires an understanding that inaction has consequences and that we must find innovative ways to change institutional structures and influence individual behavior. It is about taking action, changing policy and practice at all levels, from the individual to the international. McLennan (2004) in Philosophy of Sustainable Design states that, sustainable design implies responsibility; and implies a far-reaching respect for natural systems and resources, respect for people and respect for the cycle of life. The opposite of respect is contempt. Our current system of construction, materials manufacturing and design are done in such a way that it may as well be contemptuous of natural systems and if one respect something, he honors it and act as its protector, as a steward or parent. It is in this vein that we describe sustainable design. When one has contempt for something he abuses it, neglects it, ignores it and uses it up. From the above definitions of 'Sustainability' and 'Sustainable

Development' (SD) it is understood that, sustainability is the process and its ultimate goal is sustainable development as illustrated in Fig. 03.

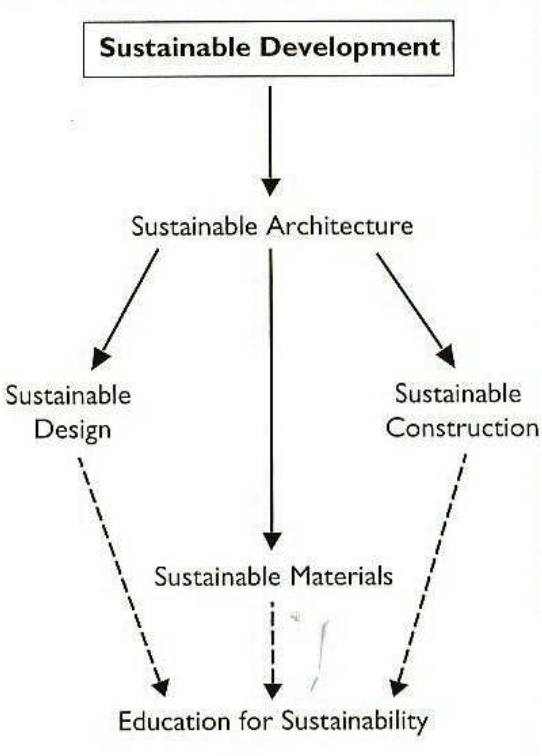

Fig. 2.
The concept of Sustainable Development spawns Development
several sub-definitions relevant to building design
Source: Edwards, 2005, p19.

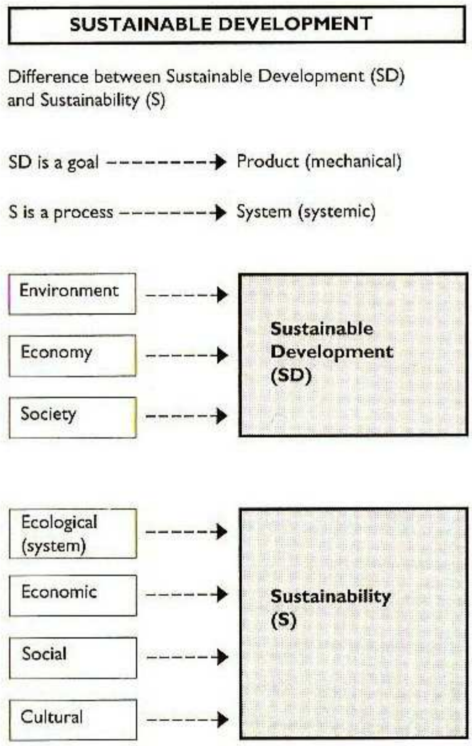

Fig. 3.
Difference between Sustainable
and Sustainability.
Source: Edwards, 2005, p11.

The Building Services Research and Information Association (BSRIA, 1996) have defined sustainable construction as the creation and management of healthy buildings based upon resource efficient and ecological principles. Edwards (2004) defined sustainable materials as materials and construction products which are healthy, durable, resource efficient and manufactured with regards to minimising environmental impact and maximising recycling. The draft for consultation of the Urban Thematic Strategy in 2004 saw sustainable construction as: "a process where all the actors involved … integrate functional, economic, environmental and quality considerations to produce and renovate buildings and a built environment that is: -

- Attractive, durable, functional, accessible, comfortable and healthy to live in and use, promoting the wellbeing of all that come into contact with it.
- Resource efficient, in particular with respect to energy, materials and water, favouring the use of renewable energy sources and needing little extra energy to function, making appropriate use of rain water and ground water and correctly handling waste water and using materials that are environmentally friendly, that can be readily recycled or reused, that contain no hazardous compounds and can safely be disposed of.
- Respects the neighbourhood and local culture and heritage.
- Competitively priced, especially when taking into account longer term considerations such as maintenance costs, durability and resale prices."

According to Ngowai (2000), as development goes on, it seems that humans lose their relationship with the environment, and the necessary feeling for its protection and, possibly, enhancement. In construction, the spread of modern techniques of building and the use of materials without reference to context, climate and culture is a legitimate target of the effort to attain sustainability. A closer look at the traditional building practices will reveal that the main materials that were used were either stone or soil in one form or another. These materials can be considered sustainable because of the possibility of recycling them. In the light of the above definitions of sustainability, sustainable development, material, and construction it can be posit that, sustainable development in housing can be achieved by the use of sustainable material and sustainable construction contribute to achieve environmental sustainability. Following the definition of sustainable material and criteria of sustainable construction (as discussed earlier) building material earth can be considered as sustainable building material. But there are lot of constraints and barriers which makes stabilised earth construction technology not implemented commercially in most part of the world. Next section is going to discuss these constraints.

4. International experience of constraints of stabilised earth construction

It is evident that, experimented stabilized earth construction projects are a success in Zimbabwe (Mubaiwa, 2002; Zami and Lee, 2008). But there are some potential constraints of stabilized earth construction technologies in Zimbabwe. There is no structured research, to date; carried out in Zimbabwe to identify the potential constraints and possible solutions of stabilized earth construction technology. Therefore it is imperative firstly to look at the international constraints of stabilized earth construction technology and the possible solution prescribed by different research literatures. International experiences gathered from the existing literature will then make a foundation to identify the constraints of earth construction in Zimbabwe and possible solutions to the identified problems. The experience of the last three decades has thrown up considerable information on the process of dissemination of earth technologies and it must be admitted that the spread of earth technologies has not been smooth process (Jagadish, 2007, p25). There are various reasons which prevent earth construction from being universally accepted by clients and practicing professionals. Some of them are discussed here with possible solutions prescribed by different researchers: -

1. According to Morton (2007), the principal reason for the loss of vernacular earth construction was cultural rather than technological, and earth buildings were usually appropriate for use and were durable, but they suffered an image problem. People did not aspire to live in earth buildings and they became denigrated as a product of the past, a product of poverty, not a product of progress. In many places there is a social stigma attached to earthen houses; in Peru, for instance, masonry brick houses are regarded as a status symbol of progress, especially in urban dwellers consider adobe houses only as temporary solutions, not worthy of any special additional construction effort (Blondet and Aguilar, 2007).
2. Earth construction is considered as ‘taboo’ in the modern context and The National Building Code of India prohibits the use of earth buildings (Jagadish, 2007, p26). Jagadish further stated that, the professional community of builders, engineers and architects are basically against the use of earth and this situation needs to be corrected by a systematic campaign among construction professionals. According to Blondet and Aguilar, (2007, p8), many people who have traditionally used soil as a construction material are reticent to change the way they build and in many cases it is because the

communities have an adverse reaction to interference in their traditional way of life from persons extraneous to the community.

3. One very important reason for the rejection of modern earth construction techniques is certainly economical, because these techniques necessarily imply a higher cost, either in money to buy extra reinforcing materials, or in time because training is required or the new building process is more elaborate (Blondet and Aguilar, 2007).
4. According to Morton (2007), the most significant technical barrier of earth construction is the lack of a recognized earth building standard. Morton further stated that, the quality control and marketability that an industry-recognized standard for earth construction would give is the gateway through which the sector can move from one-off demonstration projects to everyday use in everyday buildings and once this has been achieved, will earth masonry really begin to deliver on its potential to improve the sustainability of construction.
5. According to Jagadish (2007), inadequate understanding of the process of stabilization is a barrier to the spread of adoption of earth construction. He explained that, the suitable type of soil, correct stabilizer quantity, and the right degree of compaction is a necessity if one wants to achieve satisfactory performance of stabilized earth construction, although this is not always correctly explained by all the earth construction promoters. In fact, a majority of the users of the stabilized earth technology are unaware of these requirements for fine tuning the technology. He also proposed that, training programs for construction supervisors where this information can be transmitted can solve this problem of ignorance of earth construction.
6. Lack of appropriate skills is another potential barrier of earth construction and clay plaster, in particular require different skills than the ubiquitous gypsum plasters, which set quickly by chemical action and are usually polished with a steel float (Morton, 2007).
7. Jagadish (2007) explained that, substandard machines of compressed earth block production make earth construction unpopular to users and government decision makers. The lack of availability of a satisfactory and rugged machine for soil compaction is one of the biggest barriers to the wider dissemination of the earth technology. He alludes to establishing a number of manufacturing centers where machines of good quality are available will solve this problem.
8. Inadequate delivery system and the lack of information about the availability of stabilized earth block are the barriers of the spread of earth construction (Jagadish, 2007). One can easily find out, the selling price of brick or brick manufacturing factories in any place near the construction site but compare to that, it is difficult to find out the selling place of stabilized earth block. So there is need of decentralized earth construction training programs and local resource base to offer such delivery system and information of earth construction technology.
9. According to Chaudhury (2007), the issue of “acceptability” is critical to the success in promoting earthen structures in housing. He further stated that, it is difficult for the designer, planner and technologist to completely comprehend “acceptance” as their perspectives are never those of the user, however close such perspectives might actually be. The user allows acceptance primarily with the fear of missing out the favors from the promotion project. Once the favors are completed, as the project being completed, the user goes back to his/ her level of comprehension and aspires to have a permanent house one day, a house that is permanent because it is made of bricks and concrete.
10. Most engineering colleges are unaware of earth construction technology and so it is not promoted as a construction material. Converting the local engineering colleges as resource base is a possible way out of this impasse (Jagadish, 2007).

11. According to Houben et al (2007), many if not most of the barriers to sustainable housing are a direct consequence of ignorance and lack of information of the key housing operators on all levels. Accordingly, for effective implementation of sustainable development principles in the construction/ housing sector, it is essential to educate all stakeholders, such as public owners, artisans and contractors, architects, engineers, planners, and government decision makers. Therefore, an innovative approach in educational pedagogy for earthen architecture is necessary from all the relevant educational institutions.

In response to seismic risk and culturally unaccepted of modern earth construction technology, Blondet and Aguilar (2007) suggested that the challenges to be undertaken would involve educational campaigns to reach awareness of the seismic risk, cultural transformations to adopt better construction techniques with earth, and massive construction programs. These steps will contribute to solve in a safe and economical way the housing deficit in the most impoverished third world countries. The base of the diffusion of the earth architecture amongst architects and their clients is the awareness in the development of sustainable technologies in our daily life, as well as the exhaustive knowledge of these technologies, and that objective will be real only when the teaching of earth in included in the obligatory educational programs of all the schools of architecture in the world (Castells and Laperal, 2007). Most of the above discussed barriers and constraints of earth construction identified by different researchers lack empirical evidence. No structured research to date carried out to prove the above mentioned constraints whether they are real of speculation. The above mentioned constraints stated and prescribed possible solutions by different practitioners and researchers are from their experience. So it lacks empirical test. Besides it is observed that, there is still enough scope and room for research to justify and testify the above identified constraints and solutions of modern earth construction technology and find practical solutions.

5. Constraints of stabilised earth construction in Zimbabwe

Zimbabwe does not recognize the use of earth for construction of 'descent' shelter for the urban environment (Mubaiwa, 2002; Kannemeyer, 2006; Zami & Lee, 2007). The Zimbabwe Standard Code of Practice for Rammed Earth Structures was started shortly after publishing the Code of Practice in 1996. The In-situ Rammed earth Company led by Mr. Rowland Keable who has over 15 years' experience working with rammed earth in Africa, Australia and the UK, initiated the request to the Standards Association of Zimbabwe[SAZ] and was seconded by the then newly formed Scientific and Industrial Research and Development Council [SIRDC]. The In Situ Rammed Earth Company Founded and directed by Mr. Rowland Keable promoted the use of rammed earth as a green, sustainable material for the future. He pioneered many rammed earth projects in Zimbabwe among them some of the first officially recognized in Zimbabwe since the country's independence and worked largely in conjunction with the SIRDC in the late 90s to revive RE construction in Zimbabwe. There is no literature so far which states the constraints and challenges of spread of earth construction in Zimbabwe. Besides there is no research and field survey conducted to find out why modern earth construction technology is not implemented and commercialized as a solution of low cost housing crisis in Zimbabwe. According to Mubaiwa (2002), several studies show the potential in the alleviation of the housing situation but the current by-laws & house standards required in housing pose as a stumbling block in Zimbabwe hence the need for a review to come up with realistic ones that incorporate and promote the use of indigenous material. Anyway with the help of above identified constraints of modern earth construction technology, it is possible to logically identify the constraints of earth construction in Zimbabwe. The constraints are as follows stated in Fig 04: -

Constraints of Earth Construction in Zimbabwe

- The lack of standard criteria to evaluate the finished product. At present, one may need an exemption from the building code to erect an earth structure suitable for human occupation in Zimbabwe.
- The private sectors in Zimbabwe has not been interested in investing in this type of ‘unconventional’ construction.
- There are some technological limitations of earth as a building material, such as: - it is labour intensive, not suitable for more than double storied building, not suitable to resist tensile stress.
- Less accepted by the professionals (contractors, building traders, architects) in the construction industry; because there is very little money to be made from it collecting customary percentage on total cost, made less on this type of building.
- Earth is considered as poor construction material by the clients and users in general. There are misconceptions in societies that, ‘earth houses are only used by the poor people’.
- The local governments are not aware of the benefit of earth construction to enable their informed active participation.
- Lack of political support discourages relevant government department promoting earth construction in Zimbabwe. Political support enables facilitation, citing the example of existing rammed earth houses in Zimbabwe, which were built directly by the government after the Second World War.
- There is no system of including community participation in low cost housing delivery in Zimbabwe. The community needs to be made part of the whole process as inclusion of the community right from the onset ensures success as the challenge of acceptability of earth construction lies with the community.
- Local city councils in Zimbabwe do not take part demonstrating people the advantages of earth construction and global agenda of Environmental Sustainability.
- All in all government do not have any well structured and effective program to address the global agenda of sustainability through the use of appropriate construction material and low cost housing development in Zimbabwe.

Fig. 4. Constraints of use of earth as a building material in Zimbabwe. Source: Zami and Lee, 2008

6. Proposed sustainable solution of implementing stabilized earth construction

For earth construction projects it is important to educate the people on subject concerned. To ensure success, training is essential and target education and training programs could be implemented for specific groups so that once they are equipped with knowledge they can challenge existing delivery systems. The followings are some of the possible sustainable solutions of implementing stabilized earth construction for low cost housing in Zimbabwe: -

1. Local councils should take part demonstrating people advantages of earth construction and global agenda of sustainability in Zimbabwe. Experimental stabilized earth construction projects in Zimbabwe could encourage the use of materials at the same time changing people's view of the material concerned. Support by the local council (Chitungwiza) on the compressed block house would encourage other local authorities to do like wise.
2. The local governments are and need to be made aware of the benefit of sustainable housing and trained in stabilized earth construction technology to enable their informed active participation.
3. Political support will encourage relevant government department promoting earth construction in Zimbabwe. Political support enabled facilitation, citing the example of existing rammed earth houses in Harare and Bulawayo, which were built directly by the government after the Second World War. So, government decision makers should be included into the awareness campaign of environmental sustainability through sustainable construction and building materials.
4. Organizations like SIRDC can play a major role in establishing earth construction as a sustainable housing development and need to establish advice centers for information dissemination which could be coupled with locating building centers in close proximity to the people.
5. Educational institution like all polytechnic colleges, all state universities in Zimbabwe should start earth construction academic and training courses beside research activities. Beside the training programs all the above colleges and universities should serve as a resource centre of modern earth construction information.
6. All in all government should have a well structured and effective program to address the global agenda of environmental sustainability and sustainable low cost housing development in Zimbabwe. The government also can encourage the stabilized earth construction technology by giving incentives for sustainable methods and institute policies that promote exchange of information on modern earth construction technology.

The above solutions are in prescribed and stated in the light of the prescribed solutions given by various researchers discussed in the previous sections. Therefore, a structured research is essential to test the applicability and effectiveness of above solutions.

7. Summary

Stabilised earth is affordable and available and would be appropriate in the case of sustainable low cost house construction in Zimbabwe. This paper explained the necessity of implementing stabilised earth construction from environmental sustainability point of view and has argued the promotion and proved that the implementation of stabilised earth construction as an alternative material is worthwhile. The constraints and barriers of implementing stabilised earth construction is also discussed in which, there is a necessity to carry out a well structured research to come up with empirical evidence. One of the major challenges that prevent earth becoming the preferred choice of building material amongst the general population is the acceptability of this material by that same population. An awareness and understanding by people to environmental issues such as air pollution, deforestation, land degradation and energy conservation would help them change their attitudes and views towards earth building. The flexibility and simplicity in technology incorporated in earth building affords adaptability and easy transfer of knowledge between different stakeholders in the building industry. Individuals and community as a whole can easily participate in building their own homes in affordable ways.

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Corporate Social Responsibility in the Construction Industry

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Abstract
This paper investigates corporate social responsibility in the construction industry. Model approaches to environmental management and corporate social responsibility as applied in the industry are still under development. The paper draws on empirical qualitative and quantitative data from a sample of construction companies' reports and web-based materials. The approach followed used content analysis to identify common and differentiated themes and approaches to corporate social responsibility across the sector. The SPSS factor analysis methodology was used to extract a set of principal components from the content analysis.

Thus, the paper explores a set of themes by which we show how the industry can improve its environmental and CSR performance. In this way, the paper shows how environmental and corporate socially responsible investment can provide for social, environmental and property management concerns and in which the industry's responses to the EU Building Directive is of paramount importance.

Keywords:
Corporate social responsibility, construction industry

1. Introduction

The construction industry covers a wide area of building activities, supply facilities and management services. As few of the larger companies operate in one specific area of the industry, they form a variety of business and economic market structures that reflect their operational activities. They may for example, operate in a corporate group structure that include construction and services involving construction projects, civil engineering and mining projects, plant hire, support services such as facilities management, building maintenance for public and private sector clients. Companies within the group whose focus of involves large and super projects operates in oligopolistic markets while those involved with smaller contract work operates in competitive markets characterised by many independent operators. Both categories of companies operate in the residential and commercial property development markets. Some of the specialist companies manage portfolios of infrastructure and land investment. Construction activities consume resources - The extending and continuing consumption of resources will lead environmental degradation such as loss of agriculture land and decrease the available spaces.

There is no doubt that the industry has been conscientious of the immediate health and safety concerns due to regulations and enforcement activities of the HSE in the UK, and also importantly due to ethical obligations and utilitarian outcomes of good image. The industry has realised that the economic, environmental and social dimensions of the principles of sustainable development requires more than health and safety measures. Quite apart from occupational health and safety concerns within the industry, its activities give rise to wide ranging sustainability issues that affect human environments and societal living that it must assume responsibility for. Thus, environmental management and corporate social responsibility can provide the basis of action to mitigate the industry's impacts and improve its overall performance.

This paper explores the application of the concept of sustainable environmental management and corporate social responsibility set within the context of the construction industry. The principles of corporate social responsibility require that organisations design their operational activities to minimise environmental and health impacts to improve or even enhances environmental and societal benefits. Some of the environmental management and corporate social responsibility models that the industry applies are considered. Thus the paper examines the performance of the industry and the approaches that it developed to generate environmental and CSR improvements.

2. Characteristics of the construction industry

The construction industry comprises a wide area of interrelated activities. This includes, extraction, including sand, gravel quarrying, design, building, development, maintenance and redevelopment, trades and crafts, including electrical, mechanical and engineering services, surveying and highways (Figure 1). The industry's product consist large civil engineering projects, super construction projects, infrastructure, including rail and road construction of private and social sector housing, new build non-residential buildings, and, repair, maintenance and refurbishment to all sectors. The supply side of the industry covers a wide area and includes procurement and services supply chains of inter-related construction materials, products such as cement, aggregates and concrete, ready-mix, roofing products and services, bricks, gypsum blocks and plaster for construction finishing work, components and processes across a range of distribution channels at each phase in the construction process. The structure of the construction and linked supply chain industry reflects the infrastructural and service requirements from users' occupational demand and investors' demand. The industry comprises a large number of small companies that operate in users, repair, and supply and maintenance and the fewer concentrations of large civil and construction companies, sometimes multinationals, carrying out larger contract for both public sector and private sector projects.

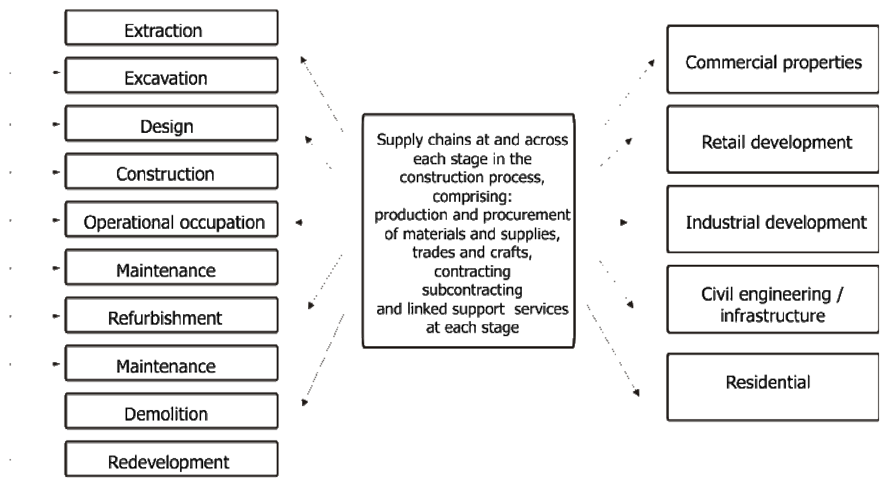

Fig. 1. Main areas of activities in the construction and supply chain industries

3. Methods

Methodological approaches involved reviewing quantitative and qualitative information were collected from reports from construction industry agencies and institutions, construction company reports and the wider research literature. The CSR element of the research design comprised a case study involving 19 construction companies whose paper and web-based reports were available for analysis. The companies embrace a wide range of businesses that include building contractors, construction material producers and professional services. The approach used content analysis as the tool by which to examine the CSR paper reports and web-based reporting and to identify common and differentiated themes and approaches in reporting corporate social responsibility. Various researchers have shown that this method of analysis and evaluation provide valid and reliable outcomes, as for example the approach of researchers such as (Unerman, 2000; Aerts, Cornier *et al.*, 2006; Giordano-Spring and Chauvey, 2006) who carried out investigations of web-based and paper-based CSR reporting. Web-based information of the companies supplemented the printable PDF version of CSR reports.

The research design developed a comprehensive set of review criteria for scrutinising the CSR information collected. The criteria were set into the four main categories of environment, marketplace, workplace and community for analysing the CSR information as shown in Table 1 and Table 2. A scale of 1 (very poor), 2 (poor), 3 (fair), 4 (good) and 5 (very good) represented the scoring criterion. The researchers inputted the scores inputted into an Excel spreadsheet to allow inspection of the dataset. They were subsequently exported to an SPSS data file in which the researchers declared missing data on variables for those cases for which company CSR information were unavailable to the public.

Table 1: Community and environment criteria

Categories		CSR indicators
Community review criteria	Charitable Donations	• Donations
	Community Consultation	• Regular meetings with the community • New project consultation • Impact assessment
	Impacts upon the Community	• Policy of community issue • Measurements of impacts • Monitoring of impacts
	Codes and Labels	• Voluntary schemes used • Corporate sustainability indexes
Environment and other issue review criteria	Environment	• Biodiversity impacts • Independent environmental audit • Environmental policy • Toxic hazards / COSHH • Energy conservation • Waste / recycling • Noise • Effluent discharges • Air emissions • Pollution abatement • Environmental awards • Carbon emissions • Environmental management system / ISO 14000

Table 2: Marketplace and Workplace criteria

Marketplace review criteria	Products and Services	● Product / service safety standards met ● Quality assurance methods
	Customer Relations	● Customer safety ● Customer consultation / feedback methods ● Feedback used to make improvements
	Suppliers	● Suppliers checked regarding social issues ● Suppliers checked regarding environmental issues
	Other	● Lifecycle assessment / design for environment
Workplace review criteria	Employee Training	● General training methods ● Training in social aspects ● Training in environmental aspects ● Training in health and safety
	Financial Information	● Pension commitments to employees ● Employee share scheme
	Health and Safety in the Workplace	● Health and safety policy ● Accident statistics ● Legal compliance
	Social Policies	● Equal opportunities ● Human right ● Disability ● Monitoring of policies
	Employee Benefits	● Healthcare ● Education ● Bonuses

4. Findings from CSR reporting analysis

4.1 Descriptive analysis:

The CSR reports of 19 companies were accessible and available for the reporting analysis. The analysis of the reports suggests that the construction companies were aware of their social responsibilities thus integrated the respective CSR meaning into their business policy. Various companies within the sample provided a CR report instead of CSR report. This suggests that they viewed corporate responsibility as an integral part of their core business values and strategy, rather than an isolated social function or role within the broader CSR concept.

Various reports emphasised respective commitments and responsibilities they had to local communities. Content analysis result of the community issue in Table 3 showed that all these companies had policies of charitable donations to communities. About 58 per cent of the companies had a good performance on donations issue while there were four companies (21 per cent of the sample) who did not report the details of their donations, such as the types and amounts of their donations. However, 53 per cent of the sample presented the poor performances on measuring their business impacts upon the community. This suggests that, in terms of taking responsibility upon communities, most of the companies set charitable donations as a higher priority in their CSR agendas instead of taking responsibility for their business impact on the communities.

Table 4 reports the content analysis results for the environmental issue reporting. Among 19 selected construction companies, ten companies (53 per cent of the sample) addressed their engagement to ISO 14000, and four companies (21 per cent) reported their plans of engagement with ISO 14000. Carbon emissions and energy conservation were the main agendas in most companies, about 42 per cent of the sample reports their improvements and policies on these two issues. Compared to the other indicators in the environmental management disclosure, companies presented a significantly good performance in waste management. Within the sample, 58 per cent of them performed well in waste management while 84 per cent of the companies were poor in dealing with the effluent discharge issue.

Table 3: Frequency table - Community

	Poor		Fair		Good	
	Count	%	Count	%	Count	%
Charitable donations	4	21%	4	21%	11	58%
Regular meetings with communities	10	53%	4	21%	5	26%
New project consultations	9	47%	4	21%	6	32%
Impact assessments	10	53%	4	21%	5	26%
Community issue policy	5	26%	4	21%	10	53%
Measurements of impacts	6	32%	7	37%	6	32%
Monitoring of impact	10	53%	3	16%	6	32%
Voluntary schemes used	7	37%	5	26%	7	37%
Use of corporate sustainability indexes	7	37%	2	11%	10	53%

Table 4: Frequency table – Environment

	Poor		Fair		Good	
	Count	%	Count	%	Count	%
Biodiversity impact	11	58%	1	5%	7	37%
Independent environmental audit	11	58%	4	21%	4	21%
Environmental policy	9	47%	3	16%	7	37%
Toxic hazards - COSHH	13	68%	2	11%	4	21%
Energy conservation	8	42%	3	16%	8	42%
Waste management	7	37%	1	5%	11	58%
Noise	12	63%	2	11%	5	26%
Effluent discharges	16	84%	2	11%	1	5%
Air emissions	15	79%	1	5%	3	16%
Pollution abatement	12	63%	3	16%	4	21%
Environmental awards	15	79%	1	5%	3	16%
Carbon emissions	8	42%	3	16%	8	42%
ISO 14001	5	26%	4	21%	10	53%

Table 5 offers the frequency result of companies' marketplace performance. It shows that 63 per cent of the companies reported good performances on the issue of the design for the environment. Within the sample, 63 per cent and 58 per cent companies reported a good system and standards for checking supplier's environment and social issues respectively. This suggests that these companies were concerned with the environmental management of their supply chain, which can help them to deliver a standard services and products to their clients and long-term income for their business

Table 5: Frequency table – marketplace

	Poor		Fair		Good	
	Count	%	Count	%	Count	%
Product / service H&S standards	4	21%	5	26%	10	53%
Quality assurance	7	37%	5	26%	7	37%
Customer safety	6	32%	6	32%	7	37%
Feedback method used	7	37%	5	26%	7	37%
Feedback improvements made	7	37%	4	21%	8	42%
Suppliers social issue check	3	16%	5	26%	11	58%
Suppliers environmental issue check	2	11%	5	26%	12	63%
Design for the environment	2	11%	5	26%	12	63%

Workplace issue looms large in the CSR agendas. The issue includes employee training, financial information, health and safety in the workplace, employee benefits and social policies. Table 6 presents a frequency table for workplace performance reporting among the selected companies. The table shows that 68 per cent of the sample reported a good performance in general training. According to the reports, these companies provided training on different aspects, such as, social, environmental, health and safety, and other general issues, including new skill development and leadership. However, only one company provided an employees training on relevant aspects of human rights.

Health and safety is a major cause of concern within the construction industry (Douglas, Meltzer et al., 2004; Jones, Comfort et al., 2006) within the sample, 63 per cent delivered a good performance on occupational health and safety policy in the workplace. All the companies in the sample have mentioned the accident reporting. However, 37 per cent of the sample were poor in accident reporting performance as they did not provide the detail of their accident records and control. In the sample, there are 53 per cent of the companies reported a good system for recording and notification of occupational accidents and diseases in their organisations.

Table 6: Frequency table - workplace

	Poor		Fair		Good	
	Count	%	Count	%	Count	%
General training	2	11%	4	21%	13	68%
Employee training on social issue	9	47%	5	26%	5	26%
Employee training on environmental issue	6	32%	5	26%	8	42%
Employee training on H&S issue	6	32%	5	26%	8	42%
H&S policy	4	21%	3	16%	12	63%
H&S accident report	7	37%	2	11%	10	53%
Legal compliance	3	16%	5	26%	11	58%
Equal opportunities	5	26%	5	26%	9	47%
Human right	7	37%	5	26%	7	37%
Disability	10	53%	5	26%	4	21%
Monitoring of workplace policy	9	47%	7	37%	3	16%
Pension commitments	14	74%	1	5%	4	21%
Employee share scheme	14	74%	1	5%	4	21%
Employee healthcare	12	63%	3	16%	4	21%
Employee education	5	26%	5	26%	9	47%
Bonuses	16	84%	1	5%	2	11%

4.2 Confirmatory principal components analysis

Table 7 presents the total variance explained using the principle components analysis. This analysis examines the relationships among the criteria. Component one presents the significant high loading among components. Taking component 1, loading greater than or equal to 0.75 represent CSR criteria having high loading on the principal components. Thus five of the 50 CSR criteria items including: Employee Training on Health and Safety Issue, Health and Safety Standard, Suppliers Environmental Issue Check, Suppliers Check for Social Issue and Design for the Environment formed the highest group of loadings on Component 1. These five criteria concentrate on the categories of workplace as well as the marketplace. This suggests that CSR for most of the sample is concerned with the issues of health and safety and supply chain, which help companies to provide good services or products within the marketplace.

The finding shows that most companies, within this study, placed their primary focus on health and safety at the workplace, and supplier and community relationships in their approach to CSR within their respective organisations. A minority of the companies had demonstrated improvements on monitoring of workplace policy. In this study, environmental issues became a lower priority in the reports examined. Few companies have yet to have greater consideration for wider society in the environments within which they operate.

However, content analysis is in-conclusive due to difficulties in accessibility and transparency, also the important issues of consistency in CSR reporting approaches. The relatively small sample size limits the generalisations that can be made from the result (Peslak and Stanton, 2007). Thus, further study is necessary in the future in gaining insights into the fuller CSR situation within the construction industry.

Table 7: Principal components – Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	13.848	27.697	27.697	13.848	27.697	27.697
2	4.812	9.625	37.322	4.812	9.625	37.322
3	4.700	9.401	46.723	4.700	9.401	46.723
4	4.510	9.021	55.743	4.510	9.021	55.743
5	3.640	7.281	63.024	3.640	7.281	63.024
6	3.125	6.249	69.273	3.125	6.249	69.273
7	2.684	5.368	74.641	2.684	5.368	74.641
8	2.256	4.512	79.152	2.256	4.512	79.152
9	2.099	4.198	83.351	2.099	4.198	83.351
10	1.737	3.474	86.824	1.737	3.474	86.824
11	1.562	3.125	89.949	1.562	3.125	89.949
12	1.414	2.828	92.777	1.414	2.828	92.777
13	.910	1.821	94.598			
14	.901	1.802	96.399			

Extraction Method: Principal Component Analysis.

5. Conclusion

The paper has shown that sustainable development imperatives on the industry come from the wider environmental and societal impacts from its operational activities and from the consumption of the final product. Thus the paper has argued that corporate social responsibility can play an important role across the industry, at all stages in the construction and procurement process to mitigate these effects and enhance community development and values. They also need to develop policies by which those external to their day to day operations but affected by their decisions and activities can exercise a degree of influence. By extending their concerns to social issues, under the umbrella of corporate social responsibility, the industry can work towards providing social and environmental justice for its communities of stakeholders, be they shareholders, employees, financial institutions, customers and clients, government or local and global communities.

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Current Situation in Export and Import of Construction Works in the Czech Republic and the Factors Preventing a Quicker Increase of Export

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Abstract:
International construction business in conditions of Czech Republic was analysed from the perspective of last 15 years and the main factors of relatively unsatisfactory development were described. The problems in raising the construction export concentrate on relative low willingness of Czech contractors go abroad because of high domestic demand and the lack of qualified internationally oriented staff. The same time the other factors like discrimination in the neighbouring countries, lack of the strategic thinking and the high degree of foreign ownership of largest Czech contractors create obstacles for better utilization of existing potential. The latest development from 2004 however shows significant improvement.

Keywords:
International contracting, increase factors of construction export, export oriented strategy, success criteria of international projects

1. Review of Construction Export Tradition

Former Czechoslovakia, as a traditional industrial exporting country (from the times of being an industrial heart of the Austrian-Hungarian Monarchy), accompanied its export of plant and equipment by construction works for completing turnkey projects. In the 1920s and 1930s, the typical construction export was oriented the above said way and was, among others, connected with the Construction subsidiaries of Škoda Comp. (machinery and engineering) and Bata Comp. (shoe, rubber and machinery factories).

During the communist regime period, the export was territorially oriented mainly on the countries of the Soviet bloc, the Middle East - Kuwait, Syria, Iraq, Iran, Yemen, Egypt, Libya, Afghanistan and the African countries - Ghana, Guinea, Angola and Tanzania. This very often politically motivated territorial selection did not seem to be very profitable, but for the Czech construction industry it was at least a good opportunity to gain experiences in managing international projects in countries with a very different culture and environment. Refering to the projects' specialization and territory - most of the projects realized in the Soviet Union and Arabic countries were connected with building the infrastructure, that is, water supply systems (e.g., complete solution for Kuwait), gas and oil pipelines, roads and highways, soil meliorations. In the other parts of the world, there were projects involving technological plants, like breweries, sugar refineries, tanneries, cement factories (China, India, Soviet Union), oil refineries (Iraq, Syria) and many defense connected projects. Especially large portion of the projects was represented by turnkey system package solutions of power stations in Argentina, Brasil and China (according to the web portal of the Czech construction - www.ceskestavebnictvi.cz, 2006).

2. Development After 1990

After the collapse of communism in 1989 and the relatively rapid change to a market oriented and private economy, a new wholly privatised structure of construction industry was completed by 1995. Construction companies mostly left the Russian, Eastern European and partly even Middle East markets, mainly because of political and financial reasons: Russia because of its financial incapability after the fall of the Soviet Union, the Middle East markets gradually because of political changes after the Gulf War and a different attitude to local regimes. Nevertheless, some Czech contractors stayed active in the Middle East (namely in the Emirates) and some contractors entered the Israeli market for example in the early 1990s -

In the first half of the 1990s, the Czech contractors started to shift to European markets as well - mainly to its traditional market partner Germany and a bit to Austria too. Since 1994, the volume of export declined, mainly because of a permanent limitation of the Czech staff and workers' access to the German and Austrian labor market, consisting of many discriminative restrictions (like a limited possibility to act as a prime contractor) and in massive limitations on working permits in general. Construction projects in Germany were characterized by large difficulties in financing the foreign operations, because of the problems with collecting the construction billing and with the bad payment discipline of the public clients in particular. This problem is, as already mentioned before, still actual in Germany - see Annual Report of Hochtief for 2001, page 7, in the CEO´s Foreword quoted above. Similar problems were multiplied by a general lack of working capital, needed for performing the international project, which was usual for the Czech contractors in this period.

In the same period (1990-1995), it came to worsening of the economic state of affairs in Germany and to an accrual of unemployment in New Federal Lands. A high number of bankruptcies, which lasted untill the beginning of this decade (in 2001, 32.000 German firms went bankrupt), led to a situation, where also the clients of construction projects were not able to pay their contractual obligations. It also affected the Czech contractors and a large part of them left the German market.

3. Current Situation of the Czech Contractors in International Construction Business

The general condition of the domestic construction industry has always been considered to be an impetus for construction contractors to go abroad. In spite of the evident riskiness of international projects and activities, even contractors, unspecialized in foreign operations try to take part in this business in times of a weakening domestic construction market.

The last seven years of economic boom could not, however, motivate too many construction companies to start export activities. The present state of the Czech construction industry as a whole (i.e., domestic and international activities) may be characterised as very satisfactory in substantial aspects of the last six years' development. According to the Czech Ministry of Trade and Industry, the average annual increase was about 6,7 % in a six years positive numbers series. The total volume of construction production between 2000 and 2005 has grown from 258,9 billions Czech crowns (CZK) to the 362,1 billions (for better comparison in the fixed-prices of the year of 1999), which is, expressed in the current prices 422,7 bill. CZK (15 bill.€). The year 2000 is considered to be a turning point, starting the recent period of growth.

The shares of the domestic and international construction production and backlog (i.e., revenue to be realized from works still to be done on uncompleted contracts) can be studied from the following table:

Table 1: Relation of construction export and domestic market works including backlog

Source: Czech Ministry of Industry and Trade, 2006

	2001	2002	2003	2004	2005
total volume of construction works in bill. CZK (fix.price 1999=100)					
fixed price	283,8	290,9	317,0	347,7	362,1
curr. price	295,7	311,2	346,8	393,3	422,7
percent share of construction works total volume (current prices)					
abroad	2,0	1,4	1,2	1,5	1,6
domestic	97,7	98,6	98,8	98,5	98,4
backlog on contracts to the end of year in bill. CZK (current prices)					
abroad	3,242	2,420	2,589	11,315	11,350
domestic	115,670	134,081	155,862	201,184	194,040
percent share of total volume of backlog					
abroad	2,7	1,8	1,6	5,3	5,5
domestic	97,3	98,2	98,4	94,7	94,5

The interpretation of the above shown data implies that the international activities of the Czech contractors were absolutely growing in spite to the fact that their portion of the very rapidly growing total volume of construction works had diminished. The increase between 2001 and 2005 from 5,91 bill. to 6,72 bill. CZK (i.e., circa 14%) should be accelerated substantially by a very positive turning point in the years 2004 and 2005. The positive change has been proven by a more than four times increase of backlog´s volume between 2003 and 2004. This tendency in the total backlog was influenced by two major factors valid in general. Also, it will be illustrated in Chapter 4 by one of the contractors selected for my case studies - PSG International Corp.

The possible factors can be in essence characterised as follows:

- General improvement of the construction companies´ condition and rise of their production and orders resulting from the Czech economical growth have been enabling the better financial position and financial capacity required for formulating the strategies to go abroad.
- There are commonly two groups of the potential exporting contractors. The larger one is represented by large contractors controlled by international companies from the Top

100 of the European market - Skanska, Vinci, Spanish OHL or Portuguese Mota can be mentioned. In the past, their Czech subsidiaries´ activity used to be limited to the Czech market only, but the contemporary trend differs. Their international headquarters permit and support their Czech subsidiaries´ management in organising their international acquisitions or founding new firms in neighbouring countries, which they know from the earlier times (Slovakia, Poland, Finland, Russia, etc.). In these countries, the Czech contractors play the role of a General Contractor at private projects as well as public ones. Being part of a large company like Skanska has its importance - as an example, it is possible to mention two huge projects of the Finnish road tunnels which are executed by Skanska CZ International Division nowadays. These and similar activities are becoming a very important part of the overall business activity of the large construction firms. It becomes typical that such new international subsidiaries are developed more often in companies just with the prevailing Czech top management. Czech managers preponderate in Skanska (Swedish), SSZ (French), Mota (Portuguese) or in Zeleznicni stavitelstvi OHL (Spanish). In German/Austrian companies, there usually prevail top managers from mother country often without thorough knowledge of the region. If their HQs probably have a strategy to expand east they do it directly from mother country. This conclusion was formulated on the basis of my research of several corporate information sources like company newspapers or PR oriented journals of Skanska AB, Hochtief AG, SSZ a.s. or Metrostav a.s., published for the clients and own employees.

- Another part of exporters comprises Czech owned medium and small companies with mostly single construction projects or engineering and construction management type of activities. The activity of some of them is a follow-up of the larger export activity from the end of 1980s, which was mentioned in the earlier section named Review of Construction Export Tradition. These companies are predominantly oriented on the realization of individual international projects rather than on founding local limited subsidiaries abroad. Neverthless, the activities of the medium and small companies in the field are often very flexible and diverse and their participation in international projects varies significantly, from general contracting to consulting, engineering or supervising. The last named activities are typical for small design, engineering and consulting offices, which are relatively common in the long industrial tradition in steel construction. Typical projects delivered to the vast territory of Russia, Ukraine and Kazachstan are the steel construction hypermarket stores halls supplied for chains like Macro, Hypernova or Tesco. The standard contractors are often relatively small steel structural design and assembly companies cooperating with the large steel producers, providing them with financial packages in the form of commercial credit for supplied steel structures.
- Other factors enabling the gradual increase of construction exports are evoked by the growing export capability of the Czech engineering industry in general. This is enabled due to the synergetic effect of improved financing of mostly turnkey infrastructure or industrial projects by the Czech banks and by providing the necessary reinsurance support at the same time. The state owned electrical power producer CEZ plays an important role with its expansion to the neighbouring countries and the Balkan territory. The participation of the Czech construction companies in these projects and in more or less long-range activities should also be a long-lasting impetus for Czech construction growth.

4. Analysis of the Factors Preventing the Quicker Increase of the Czech Construction Export

There are many circumstances and aspects connected with the possible barriers against realizing the full potential of the Czech construction export capacity., but here is a short review. Formulation of the following factors is based upon the synthesis of the data and information mainly acquired during the author´s own research, and partly from the general knowledge obtained from the articles in the ASCE Journal of Construction Engineering and Management. The main obstacles impeding construction exports from being a more important part of the construction industry revenues are:

- **Territorial Factors** - From a general perspective, even now, while the country is a full member of the European Union, Czech construction has limited access to its nearest markets, the German and Austrian ones. The barriers are represented by measures like highly limited number of working permits, financial measures against the Czech contractors consisting of the payments of considerable charges for working permits, payments to so called holiday offices, drastic controls of many formal matters performed on the project sites, subcontracting relations possible only with a German contractor, and strong uneconomic influencing of public bidding. To provide the full picture, the problems and measures must be seen against the background of the last ten years of very serious conditions in the German construction industry. According to Eurostat, total employment in the industry lowered between 2001 and 2004 by 190 thousands employees to circa three quarters of a million. The total volume of construction production decreased by more than a third against the top year 1995. Even more dramatic are the numbers in new federal lands. Furthermore, the profitability of construction works has been hampered by their stagnant price level, 3,5 percent lower than in 1995 (11,5 percent in new lands).

  Observing the situation from the perspective of this analysis we can partly understand the logic of protectionist measures. On the other hand, there is a clear and evident conclusion about the unattractiveness of the German market for the Czech construction exports.

  There are no other more significant protectionist measures in other EU countries, except in Belgium and Austria, which required the strictest conditions for an entrance into their labor market during the EU enlargement negotiations. Bidding for international projects, acquiring or newly founding foreign country branch or subsidiary do not meet any extraordinary obstructions in other EU countries. These activities are nowadays customary, concentrated territorially in several other EU countries like Sweden, Finland, the United Kingdom, Slovakia, and Poland. Altogether, it is necessary to recall the reality in awarding the public jobs - it is always being burdened by the natural preference for the local domestic contractors and suppliers tied with the local authorities politically and personally, or maybe even some antagonism towards a stranger generally plays some role. The EU Directive on the Award of Public Works contracts (more specifically: Council Directive 93/37/EEC concerning the coordination of procedures for the award of public works contracts) mentioned earlier has ideally defined the problem and set the rules of awarding the public jobs, but it definitely takes some time to realize it fully in practice.

- **Unsufficient Awarenes of International Contracting** - another external obstacle is the unsufficient cognizance of construction export and not putting a sufficient emphasis on it from the side of state authorities or agencies providing the contractors with support of export by using both general and specific tools for the purpose. The responsible government authority is the Czech Ministry of Industry and Trade, construction section. In spite of the existence of the Overall Strategy of Czech Construction till 2015, that was declared to be created some time ago, there is **no specific strategy** for any international activities. Without strategy, there cannot be coordinated advancement.
- **Capital and Finance Problems** - rendering the necessary working capital (especially for the medium or small firms, which are usually not overcapitalized) is crucially important. For the international contracting business, as well as for the domestic construction, the most limiting factor may be the bonding capacity. The commercial state owned reinsurance bank EGAP Prague is oriented predominantly on standard industrial export of products or technology equipment and can only in some cases provide enough of the capital needed, including the bonding, in accordance with the bidding conditions. Lack of flexibly providing the reinsurance products can lead also to problems for obtaining the bank credit from the standard Czech commercial banks, especially for smaller contractors unable to guarantee the loans with some collateral.
- **Lack of Strategic Approach to Companies' International Activities as Part of Corporate Strategy** of individual firms, which is primarily due the fact that construction companies in the current phase of the national economy have been using the advantage of a growing market and have succeeded in stabilizing and strenghtening their finance and capacity to bid for more contracts inland. Simply said, as an obstacle in accelerating the exports it is still possible to consider the limited future strategic orientation of most of the contractors. At the same time, the deficit of strategic foresight can lead to company´s failure in international operation . Even though the situation is improving, the lack of strategic concept is most often characteristic for the medium-size companies, which do have neither the staff nor the resources for that.
- **Shortage of Export Oriented Engineers and Construction Businessmen** able to cope with the perilousness and specifics of the international construction business and above all, willing to go abroad into the today´s turbulent international environment (matters of personal safety, problems of a long-term stay with the family in the country of company´s acquired subsidiary). The lack of qualified, willing and at the same time a little adventurous staff can be one of the main obstacles for an export expansion. For Czech construction firms it may be even eventually connected with the lower foreign language ability. On the other hand, there are still many people capable of speaking some of the languages suitable for the Eastern markets, like Russian, since the Russian language was a compulsory one during the communist regime.

5. Conclusions and Further Research

The results of a broader analysis performed by the author leads to the following conclusions:

- The construction import to the Czech Republic plays an important role in the Czech home construction market. In most cases, it is possible to characterize it as the works on the project of foreign investors coming to the country and bringing there the construction management and/or engineering firm or as an acquisition or founding of the local company. The procurement form usually used in the first option mentioned is the construction management (CM) type of procurement (either Agency CM or CM at risk) combined with the Czech subcontractors. For the second option, it is the long-term activity of a foreign firm in the market. CM of an individual project can, in case of publicly financed projects, have a negative connotation, implied by the fact that a very small CM team can grab most of the margin and evacuate it abroad, even though the whole project is performed by the local subcontractors.

- The results of analysis of exports establish the radical improvement in 2004 and 2005, evidently as a concurring effect of the rapid growth of the volume of construction works and the financial stabilisation of the whole industry. The full utilization of the existing potential is hindered by the obstacles examined and described. The classes of the possible obstacles recognized are as follows: territorial factors, capital and financial problems, unsufficient awarenes of an international contracting, including the non-existence of a government export strategy, lack of strategic approach to companies´ international activities as the part of a wider corporate strategy, and a shortage of export oriented construction engineers and businessmen.
- The purpose of having an internationally oriented company strategy is underlined and the principles of such strategy must be in accordance with the whole Czech construction industry strategy .

Coming out of the above mentioned facts the further research potentials can be considered in two possible areas:

- Analyzing and forecasting the real capacity of Czech construction industry to go abroad and to what territories. Relating to the author´s knowledge of the recent development in 2006 and 2007 the orientation of Czech construction export has been to some extent concurrent with the main exports flows of industrial capital investment units. The degree of this interdependence can be researched in detail.
- As the degree of preparedness and facility to go abroad with the disponible staff seems to be one of the main limiting factors it should be studied to formulate the practical conclusions for improvement

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Eco-efficiency Modelling of Buildings

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Abstract:
In a global change context, as a result of new international research, it is necessary to reduce the CO_2 emissions and other industry effects on all human activities. The risk posed by global warming is significant. Buildings and the building industry generally is a sector with a high share of total energy consumption. CO_2 emission growth has a direct causality with the growing energy consumption. Eco-efficiency modelling assists in solving the problem of energy consumption and other industrial effects. At present, there exists, new instruments for energy demands, CO_2 and other effects, monitoring. This paper is occupied with the application of software in real buildings. The model works with data from the building project and evaluates them over time. The main aim is the creation of an energy demand model for the life-cycle of the building, which includes: design; use; recycling; and demolition. The outputs of the model are data relating to total energy consumption and other Eco-effects during the life-cycle, which are useful for development strategies, state politics and investment.

Keywords:
Eco-efficiency, energy consumption, energy demand, life-cycle of buildings, Sustainable development.

1. Climate Changes and Building Industry

From the aspect of climate changes, global warming is considered to be the largest risk – related to the actual value of CO_2 production and its growth. It is assumed that production of the CO_2 causes 0.5°C growth in the average yearly temperature of the Earth. In accordance with conservative estimates, global warming will lead to a 2-3°C increase in the next hundred years. The building industry has a high share in the contribution to these numbers. Building energy consumption is approximately 8% of total energy consumption, but the energy consumption of the building industry is approximately 40% of the primary energy resources (Stern, 2006).

2. Energy Efficiency

In recent years some economies have grown without effective energy management, but only by higher consumption of resources. They cause significant and non-reversible damage to the environment and uneconomic use of the noble resources. Energy efficiency is the most important index of energy and resources management. Comparison of this index is possible by the ratio of energy consumption and the real GDP. These possibilities are generally applied to national economies. It is possible to apply energy efficiency particularly to the building industry and especially for buildings. Energy efficiency is created by the amount of the product, which we can operate with determined amount of the energy (WBCSD, 2007).

2.1. Energy Efficiency Modelling in Civil Engineering

The process of inputs and outputs comparison has an analogy in Civil Engineering. The products are whole buildings, square meters and cubic meters of buildings and the numbers of inhabitants. Energy demands are created from building material consumption, transport energy, operating energy, consumption during use, demolitions and recycling. Assessment of demolition and recycling energy consumption depends on the next use of land parcels and building debris. It's difficult to combine it together with other phases of the life-cycle. Mostly for recycling it is not currently possible.

3. Eco-efficiency Modelling of the Building

Ecological assessment of buildings creates many categories, in which energy efficiency modelling is only one. Other impacts relate mainly to the broader environment. Eco-efficiency offers the comparison of the different construction variants and different types of houses. Eco-efficiency can quantify the energy demands and other impacts for the environment.

3.1. Data for Eco–efficiency Modelling

For Eco–efficiency modelling it is necessary to have plentiful data relating to the construction. These information resources create the base for the model. Typically needed are project details of the building, thermal losses computations, bill of quantities and other information. A second requirement is data about generic building materials and construction. These data are important mainly for the formulation of energy demands. In this case study two building projects are used. The first was a family house for four persons with non-traditional steel frame construction and timber walls. The second was a block of flats with standard ceramic walls in combination with a light facade and deep foundations. Both buildings had a high standard of equipment.

3.2. Basic Information about Family house

The disposition solution of the house is like a flat with one bathroom. They expect 4 inhabitants in the house (Lucida, 2005).

Area of the floor: 59.6m^2

Area of the attic: 45.5m^2

Total area: 105.1 m^2

The building is a light construction. The construction system used was a steel frame with a timber cover and insulation. The roof construction is a saddle roof from the steel frame and timber. Walls are created by timber and steel construction and inside walls are gypsum plasterboard and the steel construction. Electrical equipment includes light and power circuits, electric boiler, electric heating and electric stove. Total power consumption is 32.9 kW.

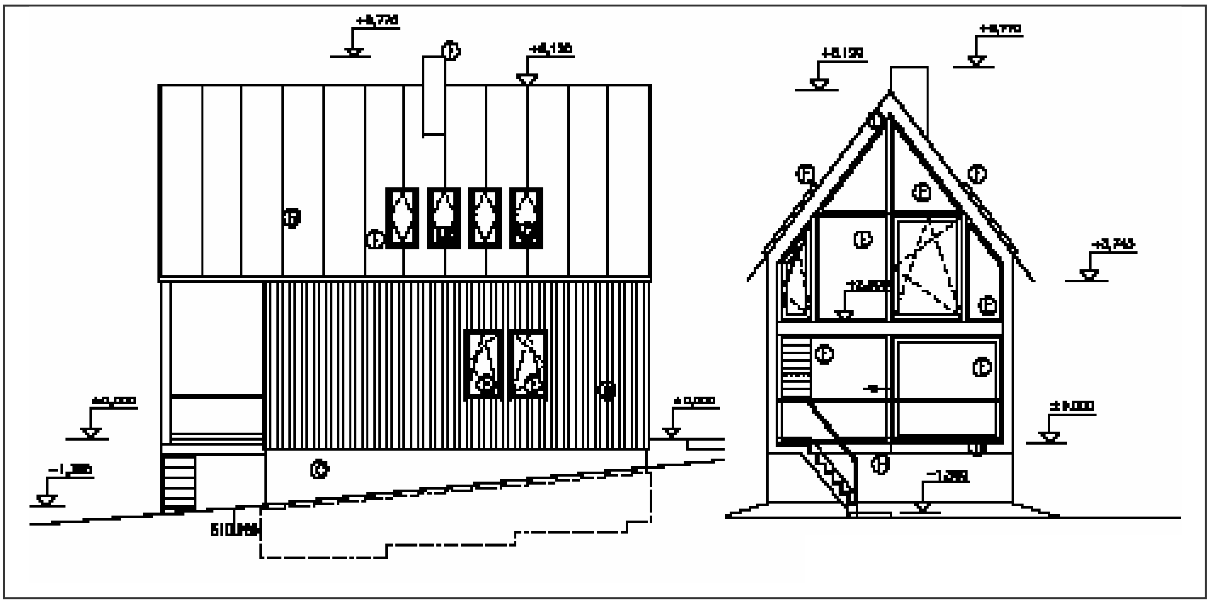

Fig. 1. Facades of the family house.

3.3. Basic Information about the Block of flats

The block is designed with 4 flats and accommodates 13 people. The building has one basement floor with cellars and garages. The next three floors contain flats. Entry to the flats is by stairs and one lift (Lucida, 2006).

Area of the basement: 259.3m^2

Total area: 903.2 m^2

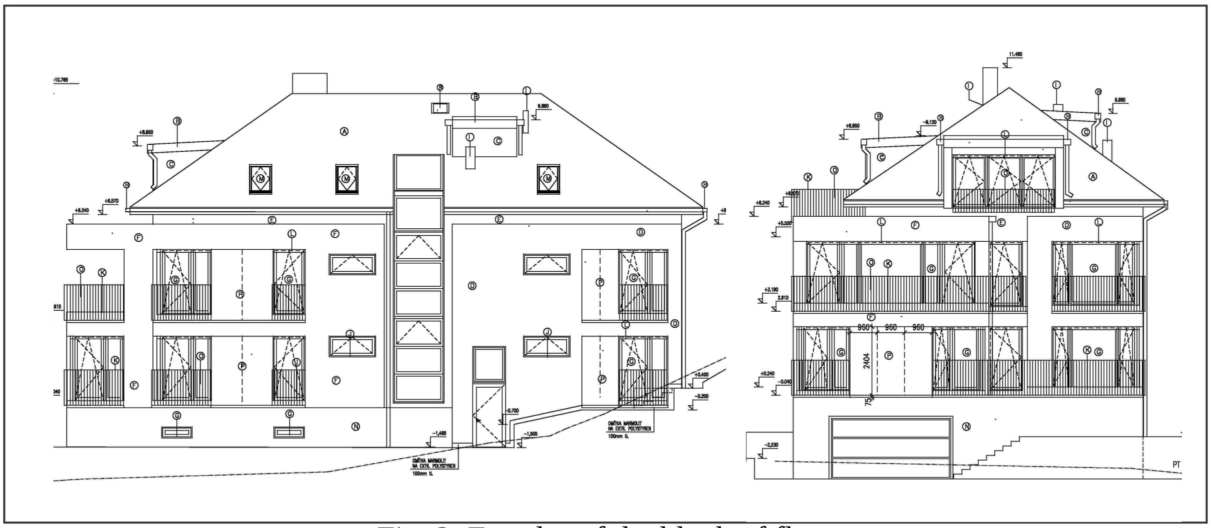

Fig. 2. Facades of the block of flats.

Construction of the building is in the form of a concrete basement and ceramic higher floors. The roof is a combination of two steel frames and timber construction. The basement has stone sheeting. Higher floors have partial chipboard sheeting. Electrical equipment includes light and power circuits, lift, electric boilers and electric stoves. Total power consumption is 70.0 kW.

3.4. Model Computing

The database of the model is created from the project details of the buildings and a database of the Eco-Quantum software. This model predicts energy demands and emissions of buildings during different periods, and also predicts total energy demands of the building. The model does not currently include the processes of transport, construction site material operations, local intrinsic building influences and the processes of demolition and recycling.

3.5. Whole-life- cycle Duration

To create a data model at a particular point of time, it is necessary to fix the first duration of the Whole-life-cycle. The age of the building is very important for the final values of the building (Beran, 2005). Building assessments of practical usage of 100 years are common, but how many buildings achieve this age? There are many differences between countries, but most countries have the biggest group between 32 and 62 years of age. These numbers are very important for the selection of time periods of the building (Statistic, 2006).

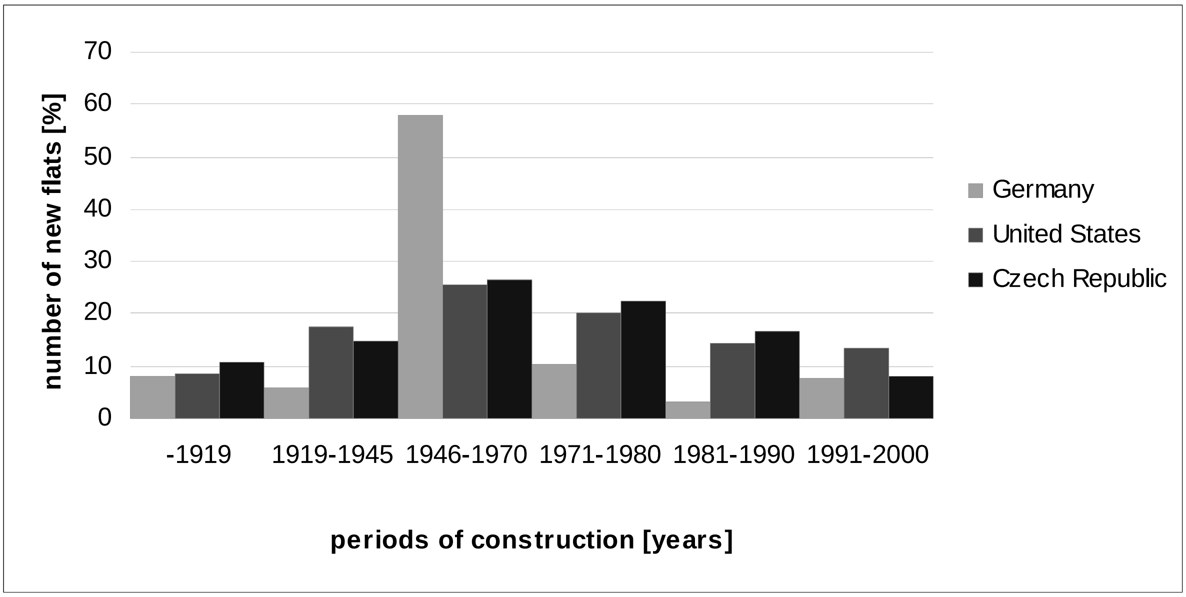

Fig. 3. Number of constructed flats in periods.

4. Emissions and Energy Outputs

The main processes of application for energy and emissions (eco-efficiency) modelling are comparable with software used in the bill of quantities and cost model of the building, but each material needs a few typical specifications. Outputs of the model are cubature of the material, emissions produced by the building, energy consumption, and the amount of waste produced by the building. In both cases the chosen durability of the building was set at 75 years. By this choice, a higher proportion of the energy consumption is use related in comparison with material consumption demands.

4.1. Emissions and Energy in the Family House

The total quantity in each category depends on the shape and measurements of the building, construction system and materials, heating systems, cooling system, and equipment of the building. The family house has a complicated frame construction, which makes for a high emission proportion from the roof and exterior walls materials. The positive influence for emissions is largely by using wood in the construction. The graph displays different categories of the ecological assessment. Material demands have the highest share in the categories: antimony substances; smog creating; sediment toxicity; phosphate emissions; and general waste. Energy demands have the highest share in the categories: global warming; ozone layer -mainly in toxicities; acid gas emissions; and energy consumption. Water demands are important only in the categories: ozone layer; and soil toxicity. Total energy demands of the building are 6213133 MJ during 75 years (Graubner, 2007).

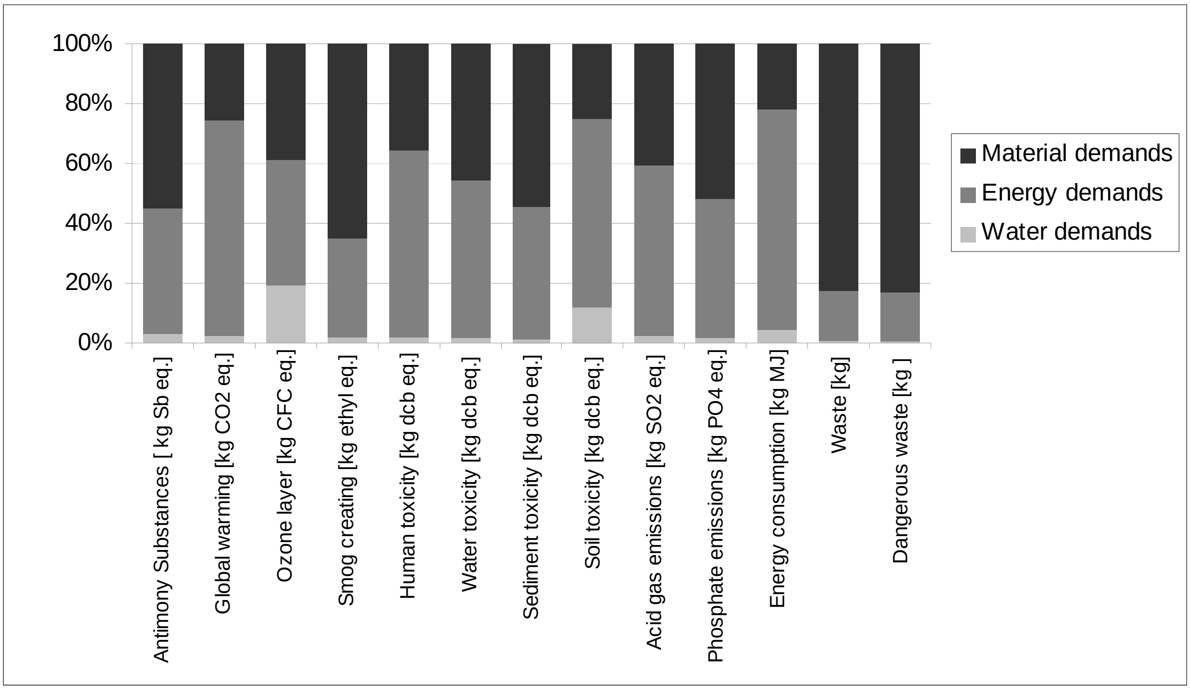

Fig. 4. Eco-efficiency of the family house.

4.2. Emissions and Energy in the Block of Flats

The block of flats has in comparison with the family house, generally higher rates of material demands caused by massive ceramic construction in the walls and a complicated roof construction. Material demands have the highest share in the categories: antimony substances; smog creating; phosphate emissions; and general waste. Energy demands have the highest share in the categories: global warming; ozone layer -mainly in toxicities; acid gas emissions; sediment toxicity; and energy consumption. Water demands are important only in the categories: ozone layer; and soil toxicity. Total energy demands of the building are 21962883 MJ during 75 years (Widera, 2007).

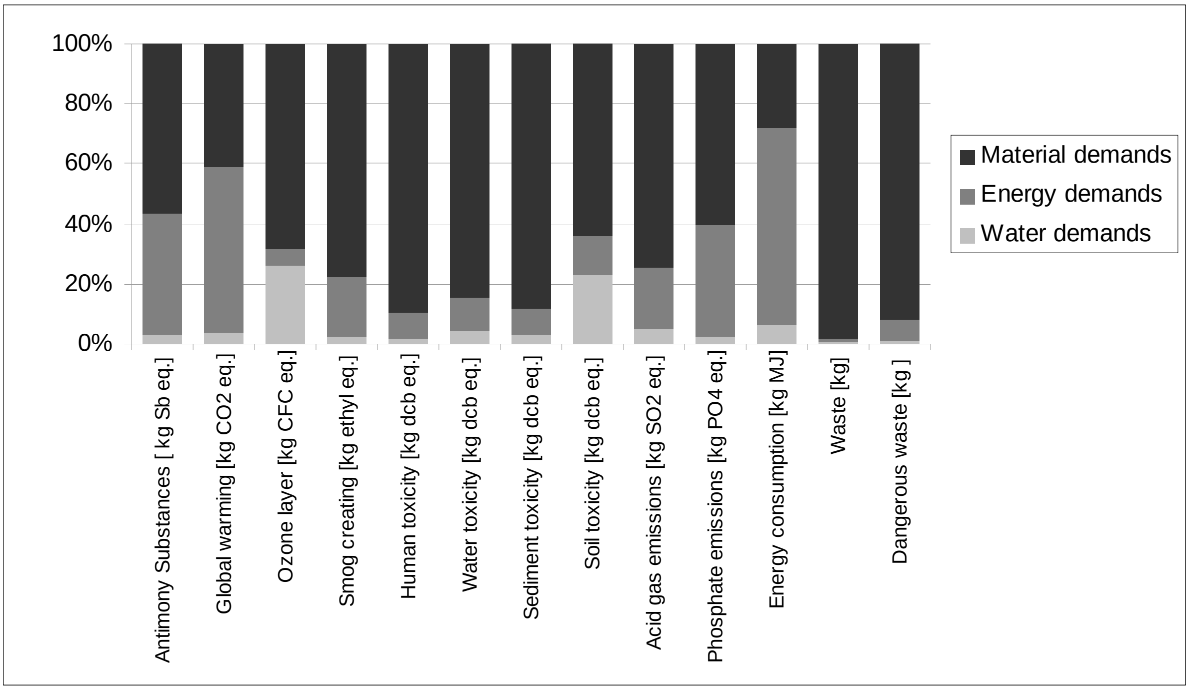

Fig. 5. Eco-efficiency of the block of flats.

5. Simulation of Energy Demands During the Whole-life-cycle

By using different time periods it is possible to determine the energy demand trends of the particular groups, in this case divided into the three groups. The first group presents energy demands during the use of the building. These are demands for heating, lighting, air-conditioning and other electrical appliances. The second group presents mainly demands during the construction phase. These are demands for construction materials and maintaining the building. This category does not include cycles of reconstruction and modernization.

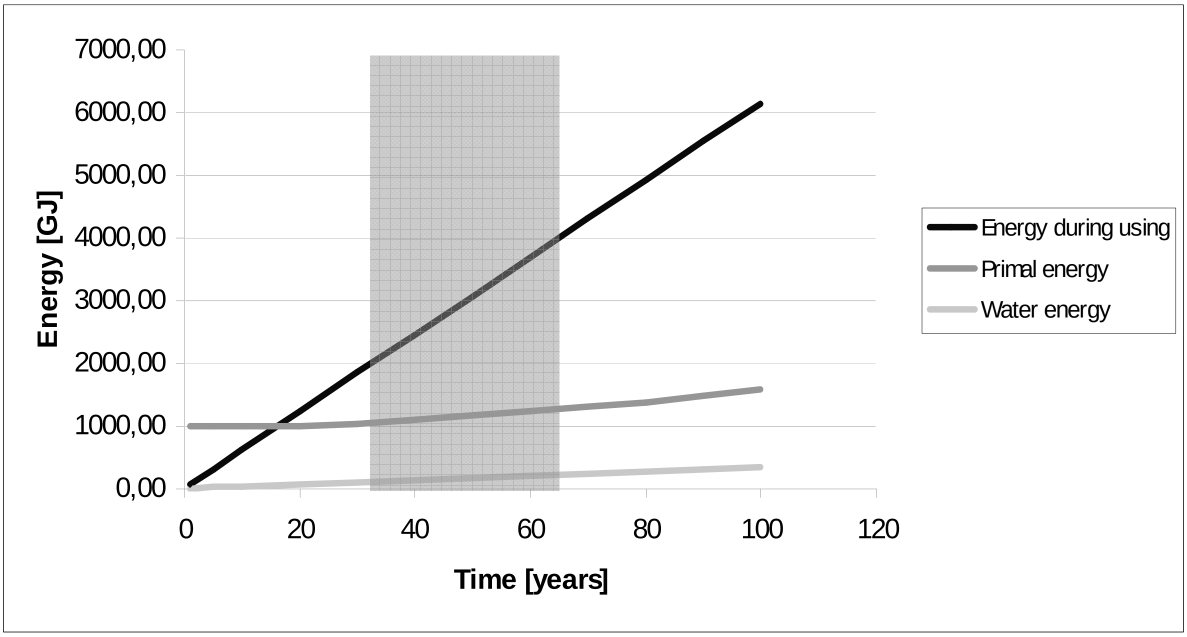

Fig. 6. Energy demands of the family house.

The third group are demands for water use. The complex assessment of individual buildings makes quantification of these energy demands possible. In the diagrams, the grey fields present the likeliest time duration of the flats. Primary energy is characterized mainly by the building process and energy during use and water energy is characterized by the consumption of the occupants. A model of these objects - including a partial representation of the process of renewal shown by the primary energy curve growing – is presented below. For both buildings it is possible to model the reconstruction and modernization processes (Beran, Dlask, 2005). These cycles depend on the life cycle of constructions and the type of owner. Both figures of buildings present quantification of energy demands for a period of 100 years.

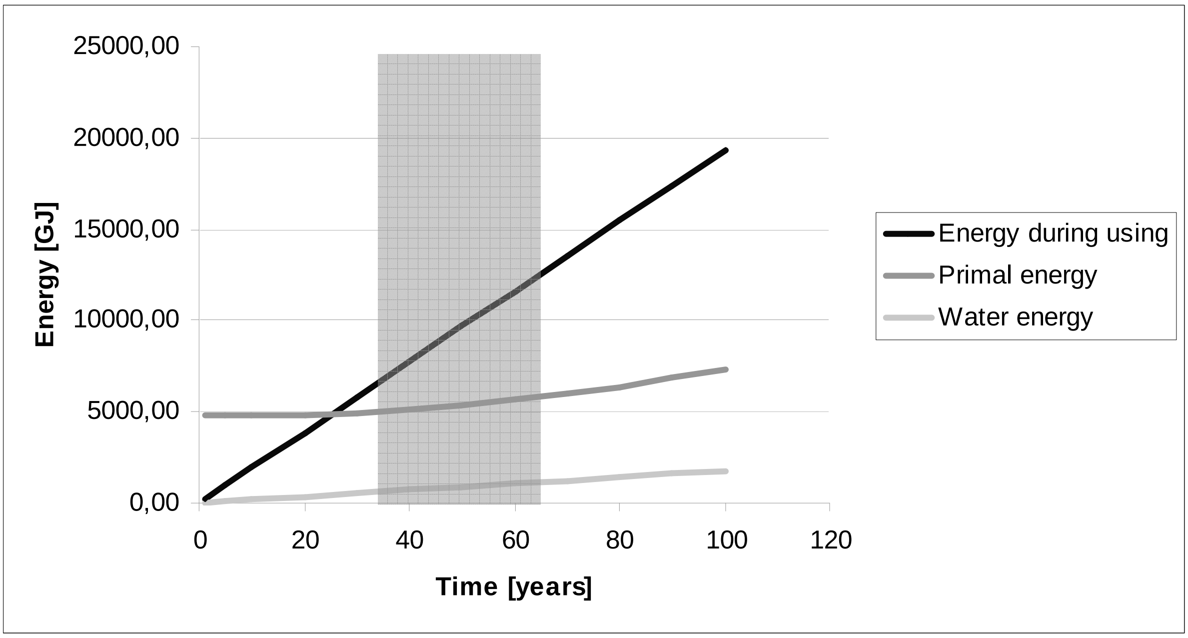

Fig. 7. Energy demands of the block of flats.

5.1. Comparison of the Family House and the Block of flats

Both buildings are constructed to a higher standard of equipment and higher standard of area per capita. In the family house the area per capita 26.27 m^2, for the block of flats it is 50.23 m^2. This is a very high figure, since flats are typically divided one floor for one flat. Energy demands for one person in the family house are 2022 GJ and in the block of flats is 2188 GJ.

5.2. Total Energy Demands

Total energy demands are one of the new indicators of building assessment. The figures present the estimated amount of energy consumed during the whole-life-cycle of the building. Presently forward investors work with building costs, not only in renewal processes, but with costs for necessary reconstructions and demolition during the whole-life-cycle (Strategy, 2007). From this cost analysis and optimization potential solutions are evaluated, however this is typically done in the future. An analogy in the field of Ecological assessment and optimizing is energy demands quantification during the whole-life-cycle.

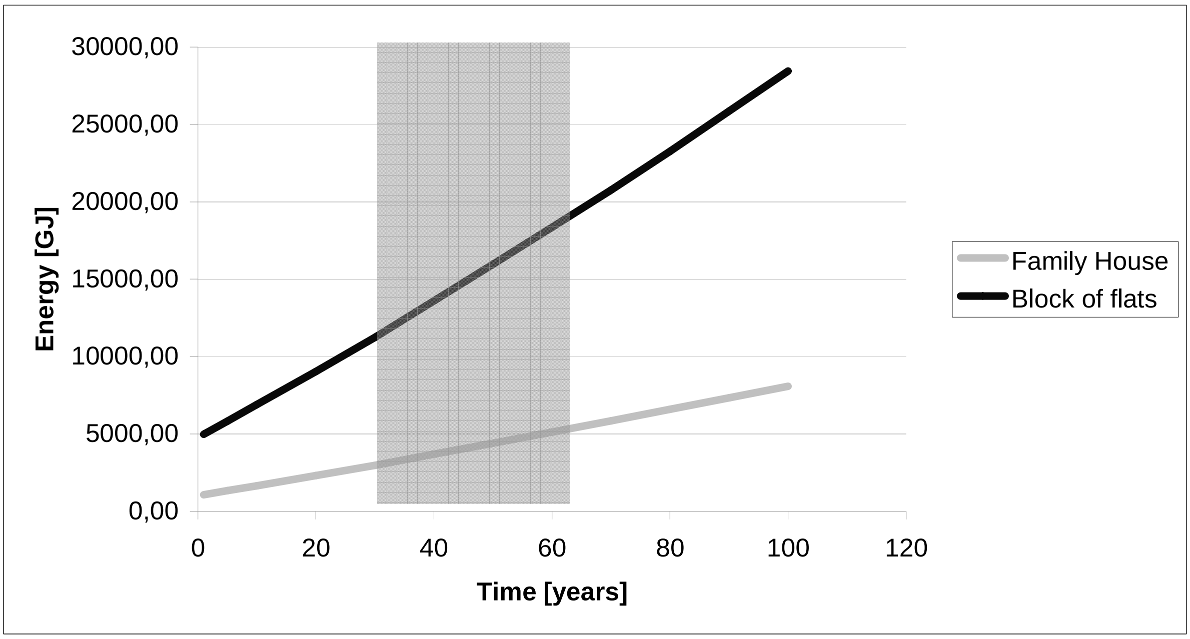

Fig. 8. Total energy demands of buildings.

5.3. Ecological Assessment of Buildings

Achieving values of new ecological limits for all buildings and all phases (construction, use, reconstruction, demolition and recycling) will become important future criteria. The figure presents an index of the primary energy demands and total energy. In this case there are significant lower energy demands of the timber structure of the building.

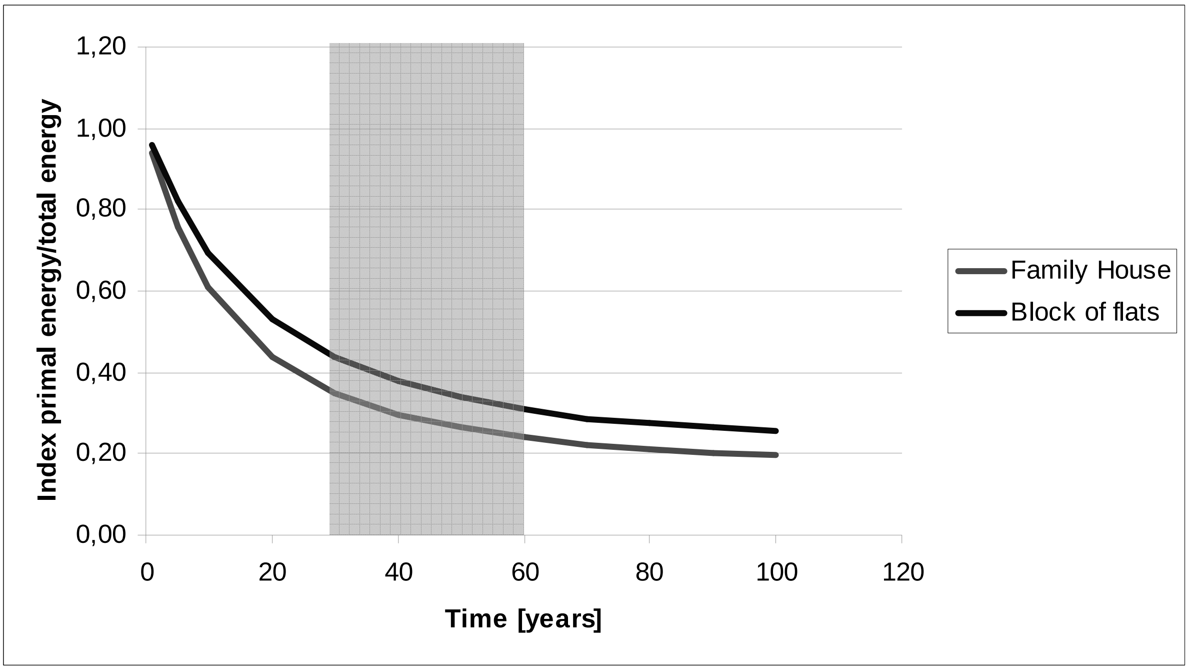

Fig. 9. Index of the primary energy demands and total energy

6. Conclusions

The main aim of this paper was to demonstrate that by using the Eco-efficiency model it is possible to make quantification of new ecological categories. Quantification of parameters offers mutual comparisons of buildings.

Eco-Quantum software works with the large database of building material parameters in many categories. It is a good choice for Civil Engineering. However aggregation of the building materials to the construction causes inaccuracies in computing.

The possibilities of building structures modeling from the sustainable development aspect offers much information for the future decision making of developers, information for planning engineers and architects and for the decision making of the state, which have to support energy efficiency and ecologically suitable buildings. Comparing the data from different construction variants, or comparing different modes of habitation from different periods can be used to estimate which ecological impacts and impacts for material recycling need to be solved in next few years. Eco-efficiency analysis shows strong points and weaknesses of structures from the perspective of sustainable development.

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Green Healthcare Facilities: Improving the Building Delivery Process of Children's Hospitals

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Abstract:
Healthcare is one of the most significant built environment markets today with over 120,000 buildings in the United States. Moreover, in the next 15 years, an estimated $300 billion will be spent on hospital construction across the United States; therefore, there is a great opportunity for research and improvements to be made in this area. Increasing research in the life sciences is showing the built environment impacts healthcare, particularly the health, safety and well-being of patients and staff. Children's hospitals are the most specialized centers for care, providing care for children with complex and rare conditions and they are therefore amongst the most complex types of facilities to design, construct and operate. This paper outlines the findings from three children's hospitals with different levels of sustainability in regards to the project delivery process, greening strategies and lean principles. This paper will provide an understanding of the building delivery process in green children's hospitals, starting from programming, through design, construction, operations and maintenance pointing out key factors that are most important in the delivery of a green children's hospital. Using the Dell Children's Hospital of Austin, the Children's Hospital of Pittsburgh and the Hershey Medical Center Children's Hospital, this paper will show how coupling lean and green principles can make healthcare facilities not only efficient, but healthful places for treatment.

Keywords:
Children's hospitals; delivery processes; healthcare design and construction; sustainability

1. Introduction

The continued growth of the healthcare industry provides an important opportunity to dramatically impact how the built environment affects human health and well-being. In the U.S., healthcare is a $1.4 trillion industry, accounting for 13.2 % of the entire U.S. gross domestic product (GDP), with projected growth to $2.8 trillion, or 17 % of GDP by 2010 (Frampton 2003), being the world's largest. Healthcare is one of the most significant built environment markets today with over 120,000 buildings in the United States. Moreover, in the next 15 years, an estimated $300 billion will be spent on hospital construction across the United States (Ulrich 2004).

The built environment has a great impact on healthcare, particularly on the health, safety and well-being of patients and staff (Ulrich 2004). Paramount, of course, is that healthcare facilities are places for treating and healing humans. Unfortunately, however, healthcare facilities are also responsible for inducing health problems: Hospital-acquired infections are one of the leading causes of death in the U.S., killing more people than AIDS, cancer or automobile accidents (Institute of Medicine 2001). A promising area of research and action to combat the stressors that affect patient and worker health and well-being has been the use of “green” or “environmental” strategies. Green healthcare also offers benefit of reducing operating costs, energy consumption and water use. Productivity in green buildings is increased due to better occupant health and decreased absenteeism. When workers are less stressed, less congested, they are more likely to be more productive. Research has found that 16-37 million cases of colds and flu could be avoided by improving indoor environmental quality, resulting in $60 $14 billion annual savings in the US, and the sick building syndrome could be reduced by 20-50 % resulting in $10-$30 billion savings in the US (Fisk 2002). Children’s hospitals are the most specialized centers for care, providing care for children with complex and rare conditions. Therefore, they are amongst the most complex types of facilities to design and construct amongst complex facilities.

2. Objective

There are significant benefits in incorporating sustainable and lean principles in the construction industry, but at the moment there are major challenges to incorporating these strategies in the healthcare building industry, more so than the commercial and residential building industry. Children’s hospitals are a type of healthcare facilities where the consequences of poor building design, construction and operations have the potential to affect the lives and health of the children and staff. In short, they are the most complex facilities to procure, design and construct. To this end, this paper seeks to provide an understanding of the building delivery process and the most important factors in green children’s hospitals, starting from programming, through design, construction, operations and maintenance. An emphasis is placed on how the delivery process, the stakeholders present in each project and also the project environment affect the final product. Understanding the delivery process is the first and most important step in facilitating the construction of more green facilities, and in reducing the challenges that come with it at the moment.

3. Background

Unlike regular hospitals, in children’s hospitals planners and designers are challenged to accommodate adults and also children of all ages. Children’s hospitals are one of the most challenging types of buildings to design and construct. Hospitals must be calming environments for the children and their families in order to aid the healing process.

Children are a unique end-user, especially in an environment such as healthcare, which supports their healing. Designers and constructors have to create children’s hospitals that are playful and provide a supportive environment for the children, while performing technically and functionally. Given the extra complexities and needs in children’s hospitals, a research focus on the design and construction of children’s hospitals is likely to have a major impact on the delivery of all healthcare facilities. The patient-friendly successes in children’s hospitals will influence all other healthcare facilities, and therefore set the standard for the next generation of hospitals and buildings in general. This paper focuses on the construction of green, LEED certified children’s hospitals, with a focus on three case studies. The Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the U.S. Green Building Council, provides a suite of standards for environmentally sustainable construction.

4. Research Methodology

To investigate this problem, this research will use detailed case study research to investigate the differences that exist in the building delivery processes for each of a LEED Platinum, the Dell Children's Hospital of Austin ant two LEED certified, Children's Hospital of Pittsburgh and Hershey Children's Hospital. The case studies provide a wide range of data, and the comparison between two moderate and a highly green project will be beneficial for the design and construction industry.

4.1 Case Studies

4.1.1 The Dell Children's Hospital of Austin

The Dell Children's Medical Center of Central Texas is located on 32 acres of the old Robert Mueller Municipal Airport. It is four-stories, containing approximately 480,000 square feet. The hospital also has a Healing Garden, totaling 3 acres, that is located on the south side. The previous Children's Hospital of Austin located downtown Austin could not be extended; therefore the new facility took into consideration the planning for future generations, creating an environment that can grow through time (Dell 2007). The project was fast-track, being on an aggressive 27 month schedule, and it opened in June 2007. The hospital is on track for being LEED Platinum, which will be the first LEED Platinum hospital in the nation.The children's hospital uses sustainable building practices as seen in Table 1 (Dell 2007):

Table 1: Sustainable Building Practices at Dell

Sustainable site planning	The site is part of the City of Austin's Smart Growth Initiative
Water Conservation	The facility contains a rainwater collection system and is xeriscaped for water efficiency
Energy Efficiency& Energy Plant on site	Heat recovery systems and high efficiency equipment Seton is building a District Energy Plant on site which provides power and chilled water and steam to the hospital and the surrounding areas.
Conservation of Materials and Resources	Use of Recycled Materials and low VOC Minimize construction waste
Indoor Environmental Quality	Optimize natural daylight, eliminate airborne pollutants

The hospital is located in a brownfield development, adding to the list of LEED points. The runway of the Muller airport was demolished and recycled. 35,000 tons of asphalt were used as a base for the parking lots. Moreover, 41,000 cubic yards of high volume fly-ash concrete were used for the foundation and walls which added to the project's LEED points. About 75% of all waste is being recycled. The roof of the facility is TPO single-membrane with standing-seam metal in a few areas. The roof reflects sunlight instead of absorbing radiant energy. Other LEED points achieved in the sustainable site section include credit for urban redevelopment and a rain and ground-water collection system for irrigation. Additional features include carbon dioxide monitoring and sealing the ends of the ductwork during construction. Water-efficiency points were earned by using low-flow toilets and fixtures and native plants in the landscaping. The construction cost for the facility is estimated to be around $110,000,000, while the 35,500 combined cooling-heating power plant is estimated to have a construction cost of approximately $18,000,000.

The decision to go green and pursue LEED Platinum has been aligned with the corporate mission from the start of the project. Austin's Green Initiative is another reason for going green. The owner also looked in depth at the life-cycle cost analysis and it was discovered that the facility would have a 5.9 year payback. Lastly, one of the factors for pursuing green was to "improve the quality of life for all".

4.1.2 Children's Hospital of Pittsburgh

The New Children's Hospital of Pittsburgh is located in Pittsburgh's Lawrenceville neighborhood on 10 acres -1.5 million square feet of usable space. Te actual hospital is 900,000 square feet with 262 beds. The cost of the hospital is approximated at $555million. The hospital is under construction on the urban campus of the former hospital, which will benefit the new hospital by using some of the assets of the previous hospital.(Pittsburgh 2007)

The hospital has been designed with input from physicians, nurses and families in order to inspire transformation to all who pass the doors. The hospital has been designed with the children in mind from the very beginning and it is committed to family centered care. The hospital is on track to be LEED certified. The hospital is grounded on five principles: patient safety and quality, family centered care, technological sophistication, environmental sustainability and quiet building:

4.1.3 Penn State Hershey Children's Hospital

Penn State Children's Hospital is part of the Penn State Medical Center, the only medical school and university hospital in Pennsylvania located outside the urban areas of Philadelphia and Pittsburgh. The present Penn State Children's Hospital is the only children's hospital in central Pennsylvania and has the region's only LEVEL III, state –of the art neonatal intensive care unit (NICU). The hospital is well-known for the following specialties: neonatal care, pediatric oncology, pediatric cardiology, pediatric surgery and pediatric trauma.

The new Children's Hospital will be approximately 323,500 square-feet. The hospital will have a total cost well in excess of approximately $270 million dollars and is seeking to raise $65 million in philanthropy.(Hershey 2007). The proposed new seven-story Children's Hospital and adjacent Cancer Institute (which is currently under construction) will make up the new face and main entrance to the entire hospital. The conceptual design of the hospital was developed through business case studies, interviews with various user groups, visits to other children's. All new construction Penn State facilities are mandated to be LEED certified and this will be one of the.

4.2 Data Collected

A comparative case study approach is used to compare certain features of the hospitals such as the LEED level achieved and the reasoning behind going after the specific points, incorporation of a "charette" system, sequence and timeline of each step in the delivery process, owner and other stakeholders involvement, costs associated with each step in the delivery process and percentage of total cost, life-cycle cost analysis if available, an evaluation of the green design feature for each hospital, integration of technical systems, satisfaction of users with green features.

Data is collected through the following methods: 1) A series of meetings, phone and email **interviews** with the stakeholders in each project. Most of the data will be collected using this method. 2) **Project materials**: design documents, meeting minutes, bidding documents obtained from the stakeholders. These materials will be primarily used to obtain an overview of the case studies and to follow their development.

After an extensive literature review and recommendations from industry representatives and academic researchers, the issues identified in Table 1 are selected to be most important in the delivery of a successful green, LEED certified building. The stakeholders for each project, owner's representative, architecture firm and construction manager, were interviewed based on the issues below in Table 2:

Table 2: Data Collection Tool

Key green factors	**Specific attributes**	**Data to be collected**
Early adoption of green	This enables a more clear understanding of project scope requirements and project needs	When was the notion of green first introduced? At what point in the delivery
	Saves project rework due to accurate project bids and costs	Who proposed the notion of green? (owner, architect, design-builder)
	Saves time for incorporating sustainable objectives later in the project	Was the team trained on these sustainable objectives?
	A sustainability filter can be applied to all decisions	Were green objectives discussed in relation to overall project goals and objectives?
Business case for green initiatives	Project budget aligned with environmental project goals	Was there a business case for going green performed
	Life-cycle cost analysis data to justify operational savings	Is life-cycle analysis data available?
	Payback period for sustainable objectives	What is the payback period for the sustainable aspects and LEED certification?
Owner commitment	Increased commitment from the owner side leads to better project planning and to better cost and schedule performance	Was the owner the green driver of the project? Did the owner introduce the concept of green? Was the owner in charge of educating the rest of the team members?
Architect and CM commitment to green and a consistent approach	Better delivery in regards to green aspects if teams are committed to sustainability.	Are these teams committed to sustainability as one of their core values regardless of owner commitment?
Early team selection/ team experience	bringing the teams together early engages critical process integration and allows system and environmental knowledge to evolve as design begins	Individual experience of team members with healthcare facilities? With green buildings? Previous team experience as a unit? Did the project have a sustainability consultant in the beginning?
LEED certification	Level of certification and break-out of points	Why did you go after the specific points? Which specific points required the most effort?
Energy Modeling	Energy modeling helps optimize the building design and allows the design team to prioritize investments in the strategies that will have the greatest effect on the building's energy use	Who was in charge of energy modeling? What were the costs associated with it? Effort and rework? At what stage in the design were energy simulations used?

4.3Process Maps

One type of analysis in this research is **process mapping** analysis. After the first wave of data collection was completed, the data was synthesized and process models were created for each case study. The critical processes and events for each children's hospital are modeled and compared. Process modeling is the critical step in analyzing and understanding the delivery process. A lot of green projects have rework, changes and overproduction as a result of not using the best delivery processes. The Lean and Green process modeling protocol will be used to model each step in the delivery process and convey it in a simple and effective way. Comparisons between the four case studies will be more effective by making everything more transparent through the process models. By using this protocol, wasteful and unnecessary processes can be identified. The timing and sequence of the different activities will be identified in each process model and also which stakeholders where involved in what phases of the projects. To prepare the maps the following protocol will be used (Klotz 2007):

- Level 1: a big picture map to understand the overall delivery process and organization. Interviews with an employee, typically a high-level executive, will be completed in two stages. First stage is to record the main events and processes and a follow-up interview is used to clarify that the draft map represents the interviewee understanding.
- Level 2: focus on each individual process, for example programming stage or design, and interview members in each project who understand best the applicable process.

Microsoft Visio has been used to create the maps. An example from the Hershey Process Map is presented below in Figure 2.

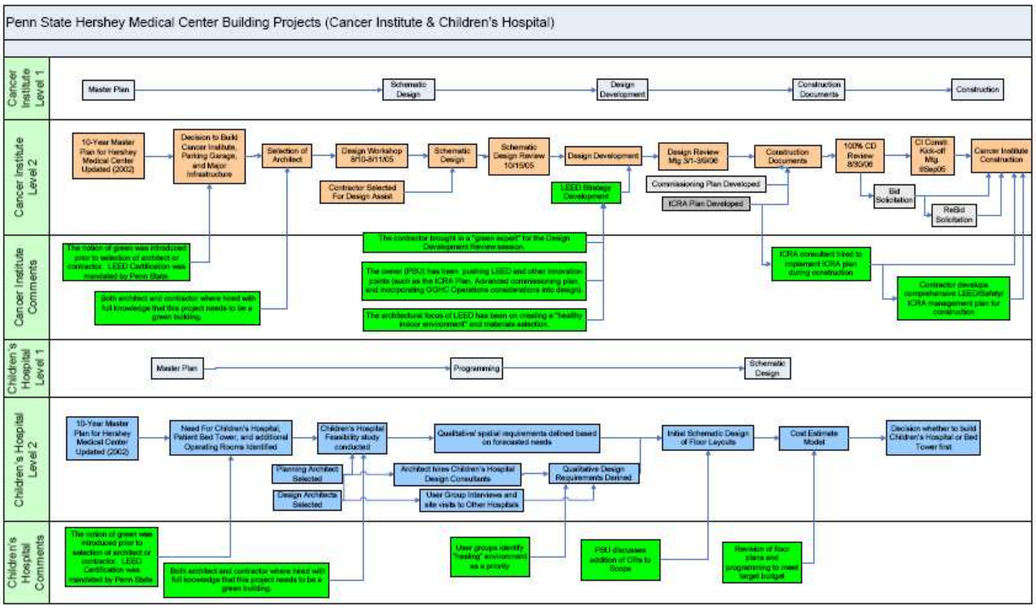

Fig. 2. The Hershey Process Map

The delivery processes for green buildings are different than those for conventional buildings. For example, green projects tend to use a stronger interdisciplinary and integrated approach, complex modeling and analysis, untraditional materials and systems that require more planning in the early stages of the project delivery process. Green buildings are often perceived as having a higher first cost due to the complexity of materials, systems and building envelopes, although their life-cycle cost is lower (Klotz 2007)

Process modeling is the crucial step in understanding green building delivery processes. A lot of green building processes have a lot of wasteful rework, delays, changes and overproduction due to inappropriate delivery processes. Process waste can undermine sustainable outcomes and limit the business case for sustainability (Lapinki 2005).The process maps for the three children's hospitals show that they all had a conventional delivery process starting with a master plan followed by programming, schematic design, design development, construction documentation, construction and occupancy and maintenance. The Dell Children's Hospital of Austin has been a design-bid-build project from the start, while the Children's Hospital of Pittsburg had a fast-track construction management at risk delivery system but now is also design-bid-build. The Hershey Children's Hospital is in the schematic design phase right now, although the master plan was developed in 2002. The delays due to financing in the case of the Hershey project and site selection for the Children's Hospital of Pittsburgh are examples of situations where specific phases in the delivery process could take longer than expected. The Dell Children's Hospital followed their strategic plan they set in the beginning and opened in July 2007, while the other hospitals are set to open in 2009 and 2010 specifically. This shows that the commitment for a LEED Platinum project to be completed on time and a commitment to green features is higher in a Platinum project than a LEED certified project.

4.4. Data Analysis

Data analysis consists of categorizing the data collected, examining, tabulating, and recombining the quantitative and qualitative data. The different parts of the delivery process and issues, such as owner commitment, LEED points achieved, will be analyzed and compared between the case studies, and they are considered individual embedded units of analysis.A criterion for analyzing the findings is to look at the patterns, a technique called **pattern-matching analysis.**

The data is analyzed by using different arrays, making a matrix of categories and placing evidence within each category, examining the frequency of certain aspects and events, charettes as an example. The issues in the data collection tool are summarized and analyzed below in Table 3with discussions for each project.

Table 3: Analysis of Results

• *Early adoption of green*
The notion of green was introduced very early in the programming phases at the Dell Children's Hospital and similarly at Hershey it is a campus-wide mandate for the Penn State campus. At the Children's Hospital of Pittsburgh the adoption of green happened in the design phases of the project. An early adoption of green enabled a more clear understanding of the project goals and needs at Dell, and it saved project rework due to accurate project bids. Although LEED certification at the Hershey Children's Hospital has been mandated from the beginning it has not been a priority for the team yet.
• *Business case for green initiatives*
A business case for infection control was made at the Hershey Children's Hospital, but not for green in general. The Penn State LEED mandate based assumption that LEED aligns with business case to reduce life-cycle costs. At the Children Hospital of Pittsburgh, sustainability was part of the hospital's overall vision. The Dell Children's Hospital of Austin focused on a business case for each initiative from the very beginning of programming. The owner has been the proponent of green on all the projects.
• *Owner Commitment*

For the Dell Children's Hospital of Austin the owner's commitment was the most important aspect in the delivery of the LEED Platinum building. The owner never wanted to sacrifice LEED Platinum. They never said it was too difficult or back down from it. Similarly to this, the owner was committed to green as part of the overall vision but not to that extent. In the case of the Hershey Medical Center, the LEED certification is a Penn State mandate.
• *Architect and contractors commitment to green*
Most of the teams are starting their involvement in LEED certified projects and are relatively new to the delivery of green building. The architect for the Dell Children's Hospital is greening their specifications and promote themselves as green experts. They hope to achieve LEED certification in every project without the owner asking for it.
• *Early team selection/ team experience*
At the Children's Hospital of Pittsburgh the architectural firm was experienced in green projects, but some individuals had limited experience. At the Hershey Children's Hospital the project teams had previous experience with LEED, but similarly individuals had limited experience. The owners were not experienced with LEED. At the Dell Children's Hospital none of the teams had previous experience with LEED, but they were strongly committed to pursuing the LEED Platinum certification and their commitment played an important role in the success of the project. The Dell Children's Hospital had an experienced sustainability consultant throughout the project.
• *LEED certification*
LEED Certification in the Children's Hospital of Pittsburgh case study was one of the several project team goals. However, LEED did not guide the design. Penn State has made an institutional commitment to decrease the lifecycle energy and maintenance cost of the facility. As a result, the University has mandated that all new construction meet LEED Certified levels of sustainability. At Dell, the LEED Platinum has guided the design from the beginning and along with patient care has been the top priority for the hospital. All the case studies have focused heavily on the indoor air quality aspect of LEED, due to the nature of the facilities.
• Energy Modeling
Both the Children's Hospital of Pittsburgh and the Hershey Children's Hospital had the energy modeling performed by the architecture teams, but the Energy and Atmosphere section was not their main focus. In contrast, the Dell Children's Hospital spent an extensive amount of time and effort on the energy modeling; the energy modeling was performed by an engineering firm. The energy modeling is probably the most important aspect in the achievement of LEED Platinum. Austin energy played an important role in the design and construction of a combined heat and power plant on site which provides all the energy for the hospitals and a few of the surrounding facilities.

5. Conclusions

Increasing the implementation of successful green design and construction processes for healthcare facilities can improve the health of the patients, in this case study the children, increase the productivity of doctors and nurses, and reduce the life cycle cost of the facilities. The analysis of the design and construction process in the three children's hospitals examined identified several key areas and issues that project teams should focus on to facilitate the implementation of green design in hospitals from both a practical and theoretical perspective. Having a committed leadership that believes from the start in the value of sustainability, adopting green issues from the very beginning, using extensive energy modeling for increased efficiency, transparency, an integrated approach to the project and most importantly an owner that is very committed to green will yield successful results in these projects. Team experience on previous LEED projects also plays a very important role, but as shown in the Dell LEED Platinum project the commitment could be in some cases more important than the experience. Energy modeling and the use of a combined heat and power plant has played a very important role in reducing energy use and achieving LEED Platinum. In the case studies examined, achieving the LEED certification was aligned with good hospital design practice, the owner's aspirations, and other project goals, such a providing an indoor environment conducive to patient recovery. Finally, the LEED green building rating system has provided substantial assistance to the project team in identifying green design features and performance goals. For the Children's Hospital of Pittsburgh and the Hershey Children's Hospital LEED was not fully integrated with the design and construction process, and therefore LEED has remained independent and somewhat secondary to hospital's design development and construction process. In contrast to that, LEED has been integrated through out the design and construction process and it has been a goal and a priority from the start. Completing a LEED Platinum healthcare facility successfully requires a well integrated design and construction approach, buy-in from every team, owner commitment from the very beginning and a sustainability consultant who can guide the teams through the process and provide expertise on the documentation process.

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Informational Policy Instruments for Environmentally Sustainable Buildings: A comparative study on HK-BEAM and LEED

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Abstract:
Policy makers in government can choose various options of policy instrument to improve energy efficiency. In order to make an appropriate choice, they need to take into consideration the characteristics of all policy instruments. As one of principal policy instruments, informational instrument plays an important role in promoting sustainable built development, and this is the major component of this paper. In this paper, comparative study of voluntary environmental labelling- Hong Kong Building Environmental Assessment Method (HK-BEAM) and Leadership in Energy & Environmental Design (LEED) in United Stated will be undertaken to analyze the characteristics of each instrument, their objectives and underlying working principles. Their major differences are highlighted and explained. The findings will provide valuable insights into implementations and effectiveness of each instrument.

Keywords:
Informational policy instruments, voluntary environmental labeling, HK-BEAM, LEED

1. Introduction:

Various types of policy instrument have been implemented to reduce the impact of the building sector on the environment. They are expected to reduce the energy used for the operation of buildings, which accounts for a significant proportion of energy use in the building sector. Although building regulations have played a central role in the improvement of energy efficiency, other non-regulatory policy instruments, like informational instruments, have received a lot attention from the government and they have been increasingly implemented during the last two decade. Informational instrument in this paper means the information tools that policy makers has been applied as another principal means, apart from regulatory instruments and incentive instruments, widely used in reducing energy consumption, promoting energy efficiency, enhancing environmental protection and arousing public concern of sustainability, etc (OECD report, 2003).

Policy makers have been paying increasing attention to information instruments as a means to reduce energy use in the building sector. Many countries have recently introduced new environmental labelling schemes for buildings, which can be classified into two categories: Mandatory energy labelling for buildings and voluntary environmental labelling for buildings. Main characteristics for each of them are listed in Table 1.

Table 1: Two types of environmental labelling schemes (ELS) for buildings

Type of ELS	Characteristics
Mandatory energy labelling	- Labelling is obligatory - Scope of assessment is limited to energy efficiency - Mainly applied for dwellings
Voluntary environmental labelling	- Labelling is voluntary - Scope of assessment coves main environmental characteristics (e.g. energy efficiency, use of recycled materials, indoor air quality) - A large number of performance items are indicated - Mainly applied for commercial buildings

The first category is mandatory energy labelling, an obligatory labelling scheme, which is backed up with statutory provisions to provide information on the energy efficiency of buildings to potential buyers. This type of labelling has been introduced in many countries. For instance, in the UK, as of the beginning of 2001, all new dwellings are required to carry an energy label to provide prospective buyers with information on each home's energy efficiency. A mandatory scheme in Germany covers existing buildings when they are under major renovation.

Voluntary environmental labelling may be the most common form of environmental labelling. This type of scheme is used on a voluntary basis, and the assessment criteria are not limited to energy efficiency and cover a wide range of environmental attributes of buildings. Many schemes in this category have been developed across countries, whose schemes are reportedly established with a commitment from government. One of the best known examples is the Leadership in Energy & Environmental Design (LEED) in United Stated, where various environmental aspects of buildings, such as energy efficiency, indoor air quality and use of recyclable materials, are assessed. The Hong Kong Building Environmental Assessment Method (HK-BEAM) is another well-recognised model of voluntary environmental labelling launched in Hong Kong since 1996. There are also some voluntary labelling schemes covering existing buildings. For instance, the German government recently has introduced a voluntary labelling scheme for existing buildings. However, there are not many cases reported as the schemes have been widely used for existing buildings.

Voluntary environmental labelling is so commonly used and it covers not only energy efficiency, but also a wide variety of environmental attributes of buildings. This paper will mainly focus on this category and investigate the main instruments by comparative study. In this paper, two examples of voluntary environmental labelling- Hong Kong Building Environmental Assessment Method (HK-BEAM) and Leadership in Energy & Environmental Design (LEED) in United Stated will be undertaken to analyze the main characteristics, objectives and working principles of each instrument. Their major differences are highlighted and explained. The findings will provide valuable insights into understanding informational policy instruments, their implementations, and the effectiveness of each instrument.

2. Background information for HK-BEAM and LEED

2.1 Introduction to Hong Kong Building Environmental Assessment Method (HK-BEAM)

HK-BEAM has been adopted since 1996, aiming at promoting voluntary initiatives to measure, improve and label the environmental performance of buildings on environmental sustainability. It is run by a non-profit and self-financing based organization. HK-BEAM is the leading initiative to assess, improve, certify and label the performance of building in Hong Kong. It provides a comprehensive standard and supporting process covering all types of new buildings and existing buildings. It is a means to benchmark and improve the whole life-cycle performance of the buildings, by which industry can assure a healthier, higher quality, more durable, efficient and environmentally sustainable working and living environment is delivered. HK-BEAM is also exerting itself to attract public awareness and to gain its image as a leading voluntary scheme in the world.

HK-BEAM is divided into “New Buildings” and “Existing Buildings”, both of which covers the areas of “site aspects”, “material aspects”, “energy use”, “water use”, “indoor environmental quality” and “innovation and additions”. The credits and weight of each category are shown in Table 2.

Table 2: HK-BEAM (Ref: Extracted from HK-BEAM Standard)

Categories	Credits	weight
Site Aspects	26 credits	13%
Material Aspects	14 credits	7%
Energy Use	103 credits	50%
Water Use	12 credits	6%
Indoor Environmental Quality	45 credits	22%
Innovation & Additions	5 credits	2%

Up to 2003, HK-BEAM has achieved the recognition for improving building performance from nearly 80 landmark properties, over 3,600,000 m2 of office space and 30,000 residential units (source: HK-BEAM Society websites). However, HK-BEAM has not been commonly diffused in construction industry, which now addresses it attraction only by providing a better image of building or company. Further study is called for to improve the design and performance of HK-BEAM as well as to enhance the public concern of sustainable built environment in Hong Kong.

2.2 Introduction to Leadership in Energy & Environmental Design (LEED)

LEED is a leading-edge system for designing, constructing, operating and certifying green building in the world, which is launched by the US Green Council. LEED covers various types of building products: LEED-NC (LEED for New Construction and Major Renovations/ Additions, 2000), LEEB-EB (LEED for Existing Buildings, 2004), LEED-CI (LEED for Commercial Interiors, 2004), LEED-CS (LEED for Core and Shell), LEED-H (LEED for Homes, 2006), LEED for schools (2007). LEED is also used to facilitate the positive results for the environment, such as occupant's health and financial return. It provides a standard, as a green design guideline, for measuring and justifying the green buildings. During the design stage of Green Buildings, seven prerequisites are required under the rating system in LEED: (1) Erosion and Sedimentation Control, (2) Fundamental Building Systems Commissioning, (3) Minimum Energy Performance, (4) CFC Reduction in HVAC&R Equipment, (5)Minimum IAQ (Indoor air quality) Performance, (6) Non-smoking Building, (7) Storage and Collection of Recyclables. LEED-NC is cited as an example of rating systems to show how the credits are distributed and weighed among different categories shown in Table 3.

Table 3: LEED-NC (Ref: Extracted from LEED Standard)

Categories	**Credits**	**weight**
Sustainable Sites	8 credits	23%
Water Efficiency	3 credits	9%
Energy &Atmosphere	6 credits	18%
Material & Resources	7 credits	21%
Indoor Environmental Quality	8 credits	23%
Innovation & Design Process	2 credits	6%

LEED has been commonly been diffused and accepted for its certification benefits by the property owners and developers in the US. The US Green Building Council, as the third party, provides official certificate as well as validation support for green buildings, which arouse the awareness of the public widely. Besides, due to its merit of easy implementation of LEED measures, LEED attracts a great arrange of property owners and developers to join this green benchmark system (US Green Building Council website).

3. Comparative study on HK-BEAM and LEED

For providing a complete picture of these two schemes and better understanding the rationale of the different aspects to be examined in the following, a comparison study is adopted. In this section, a detailed comparison will be conducted between HK-BEAM and LEED, followed with insightful observations and discussions. The comparative study demonstrates the difference between HK-BEAM and LEED in terms of credits for both new buildings and existing ones. The study is mainly divided into examining five aspects: the site aspect, energy saving, water sources, materials and indoor air quality.

3.1 Comparison between HK-BEAM and LEED - Site Aspect

For the site aspect, there is a significant difference between HK-BEAM and LEED in terms of credit provision items. The reason might be due to the difference of environment conditions as well as culture between Hong Kong and the US.

Table 4: Comparison between HK-BEAM and LEED - Site Aspect

<table>
<tr><th colspan="2">Criteria for new buildings</th><th colspan="2">Criteria for existing buildings</th></tr>
<tr><th>HK-BEAM</th><th>LEED</th><th>HK-BEAM</th><th>LEED</th></tr>
<tr><td>- Land use
- Site design appraisal
- Cultural heritage
- Noise during construction
- Emission from wet cooling tower</td><td>- Storm water design</td><td>- Contaminated land
- Neighbourhood amenities</td><td>- High development density building and area
- Alternative transportation: bicycle storage; alternative fuel vehicles
- Heat island reduction
- Light pollution reduction
- Reduced site disturbance</td></tr>
<tr><td colspan="4">Remarks on difference from Hong Kong’s perspectives:
- Limited land use, better to encourage more use of contaminated land
- High-density buildings with serious noise pollution.
- Strong awareness of protecting heritage
- Bicycle is only popular for leisure entertainment
- Alternative fuel vehicles are not widely used.
- Night lighting from buildings is an attraction to tourists
- Neighbourhood amenities in Hong Kong more focus on artificial features due to different culture.</td></tr>
</table>

Unlike the US, in Hong Kong, limited land area is available for constructing new buildings, and most of which are normally built on reclaimed land or redeveloped site. In order to alleviate this problem, HK-BEAM encourages developers to construct new buildings as well as to retrofit existing buildings on the previously developed land by granting 2 credits. It is also important to have better integration on site planning in Hong Kong, which includes minimizing the construction wastage, reducing the released pollution during the construction process. Besides, the high cost of labour, machine and delay of projects requires careful site design appraisal before construction.

In the past, impacts on heritage were normally ignored by profit-oriented developers in Hong Kong. Nowadays, however, more concerns have been raised by public to protect the cultural heritage. Thus, HK-BEAM put high emphasis on demonstrating minimising negative impacts on cultural heritage. While in the US, LEED has not mention about it. On the hand, bicycles and alternative transportations are promoted in LEED, but it doesn’t exist in HK-BEAM. This might due to the geographic constraints, existing polluted environment and lack of promotion for such alternatives from government. Light pollution reduction is listed in LEED, while it is not suitable under the HK-BEAM, as Hong Kong is famous for its beautiful night lighting image and it is a major attraction to tourists.

In addition, Hong Kong is a dense city surrounded with high-rise buildings. It is significant to control the noise pollution during construction process to minimize the negative impacts from surrounding neighbourhood. Besides, credits regarding to the emission from wet cooling tower, which may cause the Legionnaire Disease, also call for consideration. However in the US, the noise problem is cut down by its availability of larger open space and between neighbourhood and little disease would spread in good ventilation systems. Thus, these credits do not exist in LEED. On the contrary, LEED has a credit in terms of storm water design, while it does not exist in HK-BEAM, due to its comprehensive drainage systems available throughout Hong Kong city.

3.2 Comparison between HK-BEAM and LEED – Energy saving

Table 5: Comparison between HK-BEAM and LEED – Energy saving

Criteria for new buildings		**Criteria for existing buildings**	
HK-BEAM	**LEED**	**HK-BEAM**	**LEED**
- Clothes drying facilities - Embodied energy in building structural elements - Annual energy use	- Measurement & verification - Minimum energy performance - Energy cost saving percentage	- Air-conditioning unit	- Building operations and maintenance & staff education program
Remarks on difference from Hong Kong's perspectives: - Drying machines are widely used in Hong Kong due to its poor ventilation. - Estimations for HK residential buildings embodied energy amounts to 20-40% used over 40-60 years - Owners and developers are more profit-oriented thus pay less attention on efficiency of input resource. - Hot and humid weather lead to more energy consumption of Air-conditioner.			

As shown in Table 5, there are many differences between HK-BEAM and LEED in terms of energy saving. High-rise residential building with density space and poor ventilation has mainly resulted from widely in use of drying machine, while it is not mentioned in LEED. Besides, HK-BEAM encourages new building to minimize the embodied energy in the building structural elements by demonstrating life-long assessment, while there is no such requirement in LEED. It was estimated that Hong Kong residential buildings normally have 20-40% embodied energy used for over 40-60 years (Lee and Yik, 2004); however, it seems no special emphasis placed by LEED.

Both HK-BEAM and LEED account for the energy consumption but with a different approach. The former one mainly illustrates the annual energy consumption and electricity demand, with credit ranging from 1 to 10; while the latter one estimates on-going consumption over time by allocating only 1 credit. The high-range credit in HK-BEAM indicates the different emphasis and various stage of achieving energy saving.

In Hong Kong, air-conditioners consume a large amount of energy and are used whole year round in commercial and other public buildings. Therefore, HK-BEAM encourages the stakeholders to install ACs in a proper way to reduce energy consumption. LEED supports the maintenance and building operations and staff members are encouraged to get training or education. However, it calls for more motivation for building owners to spend money on training or education for energy consumption.

3.3 Comparison between HK-BEAM and LEED – Water source

Table 6: Comparison between HK-BEAM and LEED – Water source

Criteria for new buildings		**Criteria for existing buildings**	
HK-BEAM	**LEED**	**HK-BEAM**	**LEED**
- Effluent discharge to foul sewers	______________	- Water quality - Annual water use, monitoring and control	- Water use reduction
Remarks on difference from Hong Kong's perspectives: - Flushing and portable water is over-consumed. - Effectively reduce the discharge by using suitable facilities. - Significant amount of discharged water due to the dense population. - Low public awareness of water saving which needs more control, such as auto shut-off device.			

Compared with LEED, HK-BEAM provides a special credit for effluent discharge to foil sewers. This may be due to the flushing and portable water is over-consumed in Hong Kong, which calls for measures to reduce the discharge effectively. The high population in Hong Kong accounting for a significant amount of water consumption may be another cause of concern. HK-BEAM requires credit assessment on the water quality as well as monitoring and control of annual water consumption, while LEED only emphasizes on water use reduction.

3.4 Comparison between HK-BEAM and LEED – Materials

Table 7: Comparison between HK-BEAM and LEED – Materials

Criteria for new buildings		**Criteria for existing buildings**	
HK-BEAM	**LEED**	**HK-BEAM**	**LEED**
- Envelope durability - Building reuse - Sustainable forest products	- Building reuse (Existing walls, floors & roof) - Materials reuse (Building materials & products) - Certified wood	- Modular and standardised design - Adaptability and deconstruction	- Sustainable cleaning products and materials - Optimize use of alternative materials
Remarks on difference from Hong Kong's perspectives: - Minimize poor quality of building. - Many old and depilated buildings, which are not suitable to reuse. - Low demand on adaptive reuse cause by people's preference to new stuff. - Plot ration was not fully utilized previously due to the low incentives to developers. - Wood/bamboo is commonly used in worksite for temporary usage. - More use of prefabricated materials.			

HK-BEAM gives credit to the integration of building systems to encourage better quality of building products. Regarding building reuse, HK-BEAM focuses on the sub-structure or the façade of the building, while LEED concerns more about the existing structures and the building materials. The reason may lie in the poor and dilapidated condition of old buildings in Hong Kong, which are not suitable for reuse. In addition, preference to occupying new buildings leads to low demand of adaptive reuse, which lessening the initiative of developers to reuse materials. Besides, the plot ratio of old building sites were not fully utilized in the past, so the developers are more motivated to rebuild the buildings with more floor area rather than reuse the existing buildings and preserving the façade.

In addition, HK-BEAM restricts the original forest products used for temporary works but promotes its use in buildings, which is similar to LEED. However, the criteria is difficult to be achieved in Hong Kong, because it is common to use bamboo/wood only for the temporary works, while it is difficult to permanently install them into buildings due to the humid weather.

The use of prefabrication was included in HK-BEAM soon after it was introduced in Hong Kong. It is recognised that the more use of prefabrication, the less waste is produced. Flexible design for the adaptability and deconstruction are also found only in HK-BEAM. If the adaptability of existing buildings is low, it may cause more waste during the demolition and construction.

Meanwhile, LEED provides some special criteria to be justified. First, LEED promotes to use sustainable cleaning products and materials, while this concept is fresh for many people in Hong Kong. LEED also encourages the use of alternative materials, such as office paper and equipments. In conclusion, sustainable concepts in the US seem to be wider than that in Hong Kong.

3.5 Comparison between HK-BEAM and LEED – Indoor Environmental Quality

Table 8: Comparison between HK-BEAM and LEED – Indoor Environmental Quality

Criteria for new buildings		Criteria for existing buildings	
HK-BEAM	**LEED**	**HK-BEAM**	**LEED**
- Fire safety - Electromagnetic compatibility - Security - Plumbing and drainage - Ventilation - Outdoor sources of air pollution	- Environmental tobacco smoking control - Increased ventilation - Indoor chemical & pollutant source control	- IAQ in car parks and public transport interchanges - Room acoustics - Noise isolation - Fire safety -	- Documenting productivity impacts: absenteeism and health care cost impact
Remarks on difference from Hong Kong's perspectives: - Strong concern in fire safety. - High density & high-rise buildings. - Common use of EM appliance. - More attention on improvement of building hygiene and local residence's safety. - Smoking inside commercial buildings is illegal. - More large cark-park building and public transport interchanges			

HK-BEAM has a high concern on the fire safety and environmental protection on products of combustion and contamination by stipulating requirements on design integration between fire service systems and other building service provisions. Besides, electromagnetic appliances are mentioned in HK-BEAM due to densely populated environment in high-rise buildings. Security is another major concern, which calls for improving the building hygiene since the outbreak of SARS virus in Hong Kong. Therefore, HK-BEAM includes credits for reducing the potential spread of virus through the plumbing and drainage system. As smoking has been prohibited indoors in Hong Kong, it leaves no credit on this issue, while LEED has a credit on Environmental Tobacco Smoking (ETS) Control.

Both HK-BEAM and LEED include credits for ventilation. HK-BEAM places a higher concern in terms of outdoor air ventilation rate and effectiveness of air exchanges, while LEED more focus on the ventilation space. This difference indicates that it is necessary to improve air ventilation in Hong Kong because of limited space and densely constructed buildings. Regarding air pollution, HK-BEAM intends to minimize the airborne contaminants from external sources, while LEED aims for minimizing and controlling the pollutant from entering and contaminating in the buildings. Apart from the above reason, air pollutant emitted from vehicles are explicitly serious in Hong Kong, so external control of pollutants is placed with higher priority compared with US, where wider space is available with better ventilation. For existing buildings, the higher living density in Hong Kong is a possible reason that fire safety, room acoustics and noise isolation are included in HK-BEAM, but not in LEED.

4. Key Observations and Recommendations

Based on the findings of the above comparative study, some measures to improve the effect of HK-BEAM are suggested:

First, it will be more precise to design more benchmark tools to suit different building types and needs, e.g. HK-BEAM for schools might be possible;

Second, provide awards to buildings with consideration of all-round building performance, rather other focusing only on several aspects.

Third, some more credits could be added into different aspects in order to assess the building more comprehensively

Lastly, low public awareness as well as lack of training and education to participants involved in the building sector need to be ameliorated for better implementation of HK-BEAM.

4. Conclusions

After the comparison between HK-BEAM in Hong Kong and LEED in the US, the characteristics of each instrument, their objectives and underlying working principles has been analyzed and discussed. The findings provide insights into implementations and effectiveness of each instrument and they provide a valuable foundation for future study. Some key observations with recommendations are highlighted for the imprevment of the assessment instrument used in Hong Kong.

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Roof Top Rainwater Harvesting for Ground Water Recharge – A Case Study

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Abstract:
The existence of life on planet earth is contingent on the water resource availability.
Civilization needs water for various reasons which include urbane progress. Distinctiveness of water is that it has no substitute unlike other resources like petroleum and coal which have alternatives like wind and solar energy. Hence all forms of life, to survive in the future require a secure source of water.

The present study being conducted at our college campus is an attempt to analyse the effects of artificial recharge of groundwater. There are seven bore-wells and one open well in the campus. Rainwater harvested from two buildings of the college has been used to recharge through Gravity head recharge settling tank (GHRST) with filter bed at the bottom. Arrangements are made for the water from settling tank to enter the nearby bore-well, thus inducing the recharge of the unconfined aquifer.

The campus receives 880mm rainfall annually. Soil of the area is hard and gravely with an excellent vertical drainage property. Water table fluctuations in a well are continuously monitored for assessing the yield of water. Pumping test has been carried out for determining the aquifer parameters T and S. Water and soil tests were also conducted.

Keywords:
Harvesting, rain water, pumping

1. Introduction

Water resources occupy prime place among all natural resources of any region. We should realise the importance of water to our survival and its limited supply. Efficient planning and management of water sources for various uses is an important aspect for the development of any system. Rainwater is the prime source for supplying water. The growing scarcity of water worldwide has made rainwater harvesting a buzzword. Rainwater harvesting is simple and a traditional practice of tapping and conserving rainwater. It makes ecological and financial sense not to waste the natural resource available in large quantity on one's roof. Collecting rain that falls on a building to be used nearby is a simple concept.

2. Purpose

The purpose of harvesting rain is to improve the well-being of the urban and rural community through improved water supply. The development and assessment of low cost domestic roof water harvesting technologies will meet the water needs of the households:

In areas where there is inadequate groundwater supply or surface resources are either lacking or insufficient, rainwater harvesting is an ideal solution.

Helps in utilizing the primary source of water and prevents runoff from going into sewers or storm drains, thereby reducing the load on treatment plants.

Recharging water into the aquifers help in improving the quality of existing groundwater through dilution.

The wastage of surface water and depletion of groundwater to an alarming level has led to reduction in well yield, drying up of shallow wells, deterioration of water quality, sea water intrusion into coastal aquifers and increase in energy consumption to lift water from greater depth. The depletion in groundwater has necessitated for artificial recharge of groundwater. The need of the hour, therefore, is for artificial recharge system that conveys fresh water to the aquifer. Artificial recharge to groundwater is a process by which the groundwater reservoir is augmented at a rate exceeding that obtained under natural conditions or replenishments. Any manmade scheme or facility that adds water to an aquifer may be considered as “Artificial Recharge System”. (Agarwal, 2000)

The main source of water for RVCE campus is underground water, which is drawn from the aquifer through bore wells. There is need to assess the quality and quantity of groundwater.

Due to the proximity of VRISHABHAVATHI River carrying a portion of Bangalore city sewage, the aquifers beneath the college campus are prone to contamination with the harmful bacteria creating health hazards. The contaminated water is likely to enter the aquifers of the campus and pollute the groundwater resulting in quality deterioration. The situation has prompted conservation of rainwater for artificial recharging of groundwater. (Agarwal, 2000)

Study Site:

The field study has been conducted in the campus area of R.V.College of Engineering, Bangalore .The college campus area spreads over 21.3 ha (52.5 acres) and is on Bangalore – Mysore Road (in between Jnanabharathi and Kengeri). The population of the campus is about 3500 of which 250 are faculty members and the day scholars are about 2000. The campus residents including hostellers depend on bore well water. The study area receives 880 mm of rainfall annually. Soil of the campus area is hard gravelly with extremely good drainage property. (Karanth, 1987)

Out of 21.3 ha (213030 sqm) of the campus area, the buildings cover 67,778 sqm, and roads cover 2000 sqm, totaling 69778 sqm. Thus the permeable area works out to 1,43,973 sqm. The impermeable area will contribute for a maximum yield of rainfall falling over it which is available for harvesting, i.e. 47.56 million litres.

The water table fluctuation in a well has been monitored continuously for assessing yield of water. In addition, pumping test has been carried out for determining aquifer parameters T and S. Water and soil quality tests have also been carried out.

There are seven borewells and one open well in the campus area with water level ranging from 20m to 25m below ground level. Recently, a borewell was drilled in the campus and water was struck at 161 m below the ground level. There is acute pressure on the aquifer system in the campus because of continuous pumping. This condition has resulted in lowering of water table and may result in entry of sewage water into the aquifer system. The pumping of bore wells is continuous (sometimes exceeding 12 hours). It can be inferred that the soil has good vertical transmission capacity. Hence, induced recharge is adopted for one bore well in Phase I of the project. Since the College Campus is situated near the fringe of Bangalore south, the hydrological and hydro-geological characteristics of Bangalore city are assumed to prevail in the campus area too. (Agarwal, 2000)

3. Methodology

The rainwater-harvesting program is divided into three main stages, and they are:

- Stage A- Initial analysis
- Stage B- Design
- Stage C- Assessment.

The methodology of investigation involves –

1. Harvesting of rainwater from rooftops of Administrative and R&D blocks of RVCE campus in Phase I (Fig 1).
2. The harvested water is collected in Gravity Head Recharge Settling Tank.
3. The water infiltration into the subsoil in the first compartment (inlet) where silt and heavy particles are settled.
4. Then the water rises up and is made to fall into the second compartment (outlet) where again the silt and other particles are made to settle.
5. The water level rises up and injected into the bore well directly.

Thus the method involves subsoil recharge as well as direct injection of water into the bore well.

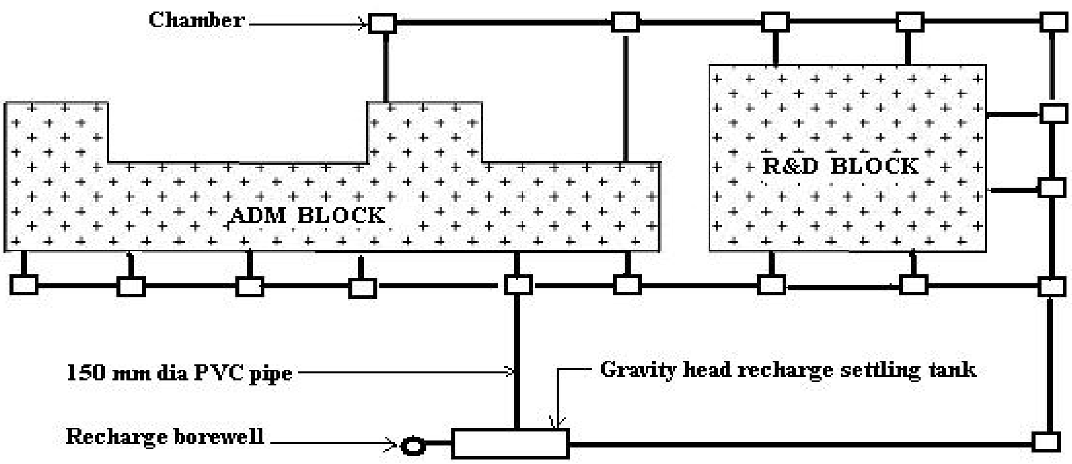

Fig. 1. Layout plan of the artificial recharge system

Data Collection and analysis

Table 1: DATA

Areas	Details
Area of the campus	52.6 acres i.e., 21.303 hectares or 213,030 sq m
Impermeable area: i) Building area ii) Road Total	 67,778.00 sq m 2,000 sq m 69,778 sq m
Permeable area	143,252 sq m

In the present study, rain water harvesting from the roof top of administrative and R&D blocks are considered for recharging bore wells located in front of the administrative block (North West) of the college campus.

Table 2: Assessment of harvestable water for recharging of Borewell

(a)	Roof top area of the administrative block	1123.75 sqm
	Roof top area of R&D block	490.00 sqm
	Total	1613.75 sqm
(b)	Normal annual rainfall	880 mm
(c)	Quantity of water harvested	1207 cubic meter or 1.20 million litres
(d)	Effective quantity of rainwater for recharge through bore well	1002 cubic meter or 1.02 million litres

Table 3: Computation of water demand for administrative, R&D block phase-I

Sl no	Block	No. of users	Water demand		Total water demand (lpcd)
			Drinking (At 3 lpcd)	Toilet (At 4 lpcd for flushing)	
1	Administrative block	Students: 540 Staff: 45	3X585=1755	2340	4095
2	R & D Block	35	3X35=105	4X35=140	245
3	Gardening				1000
4	Cleaning				1000
Grand total					6340 litres/day

Table 4: Summary

i)	Roof top area	1613.75 sq m.
ii)	Average point rainfall	880 mm.
iii)	Harvestable quantity of water	1.20 million Litres.
iv)	Effective quantity of water for recharging Bore well	1.02 million Litres.
v)	Annual water demand	2.02 million Litres.

Design computations

Data involved -

- Point rainfall.
- Catchment details-area of rooftops of buildings, permeable and impermeable area.
- Soil characteristics- moisture content, permeability and chemical composition.
- Groundwater quality- pH, hardness, etc.

4. Artificial recharge through gravity head recharge settling tank

Gravity head recharge settling tank is constructed near the existing borewell in front of the administrative block (Fig 2). It is a brick masonry structure 3.7m x 3.2m x 2.44m embedded below the ground level. A baffle wall of size 3.7m x 0.23m x 1.25m is provided in the middle of the settling tank dividing it into two compartments. At the bottom of the tank for the entire area, sand bed for a depth of 150mm and coarse aggregate for a depth of 200mm is filled in, to act as a filter bed.

The water from the roof top is led into the settling tank through the inlet, and made to fall over the filter bed in the inlet compartment for recharge through infiltration into the soil. When the rate of inflow of rainwater through the inlet is greater than the rate of infiltration, then water rises upwards in the inlet compartment and then the water flows over the baffle wall and fills the outlet compartment through which water is directly injected into the bore well. (Karanth, 1987)

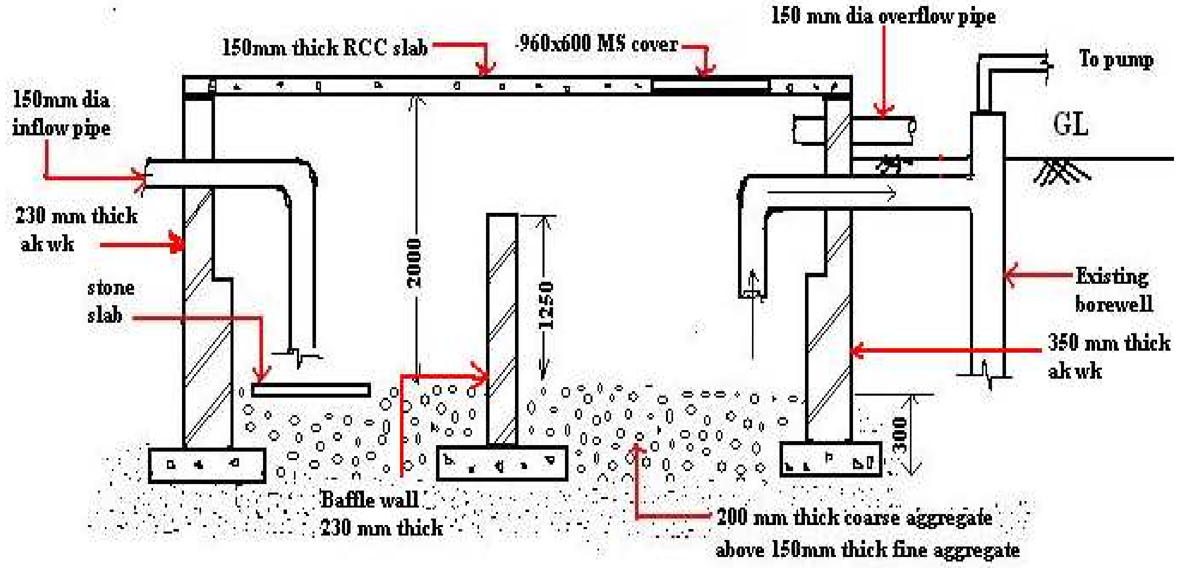

Fig. 2. Details of gravity head recharge settling tank and recharge borewell.

5. Assessment

Water Level in the recharge borewell:

Water level fluctuations in the recharge borewell are recorded daily since Sep- 2004 using a water level recorder. The graph in Fig 3a & 3b shows water level fluctuations in the recharge borewell.

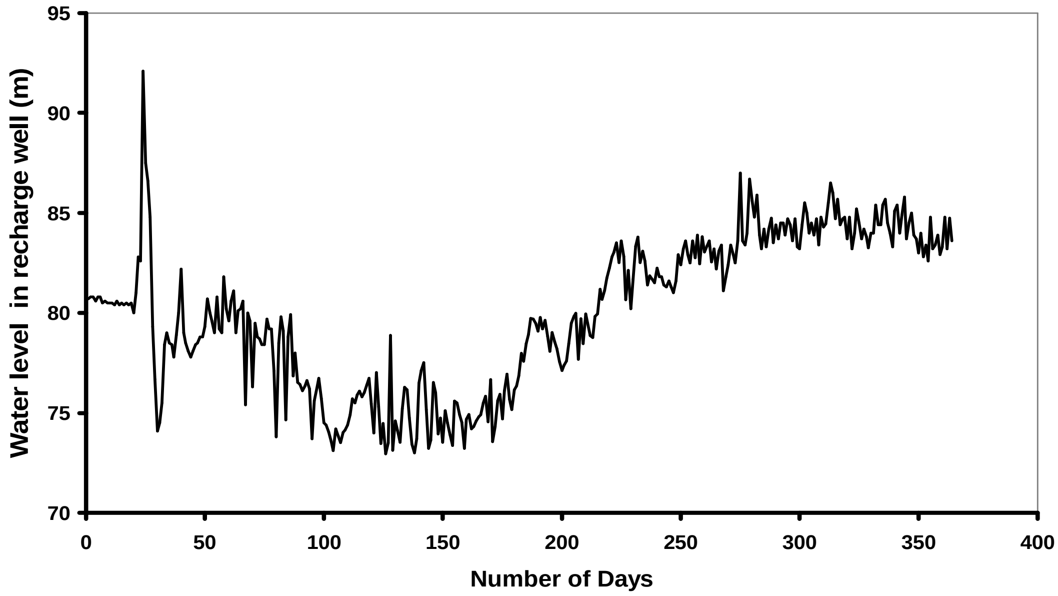

Fig. 3a. Water level fluctuation in recharge bore well

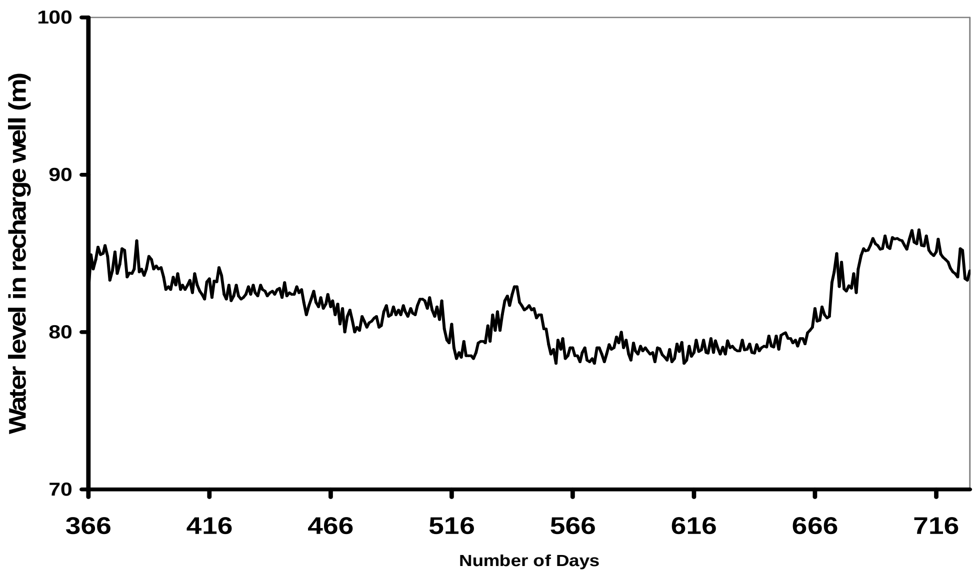

Fig. 3b. Water level fluctuation in recharge bore well

6. Cumulative water harvested

The Fig.4 shows the plot of cumulative water harvested during the monsoon period from the water level data of the Gravity Head Recharge Settling Tank. During this period 2.39 million liters have been harvested.

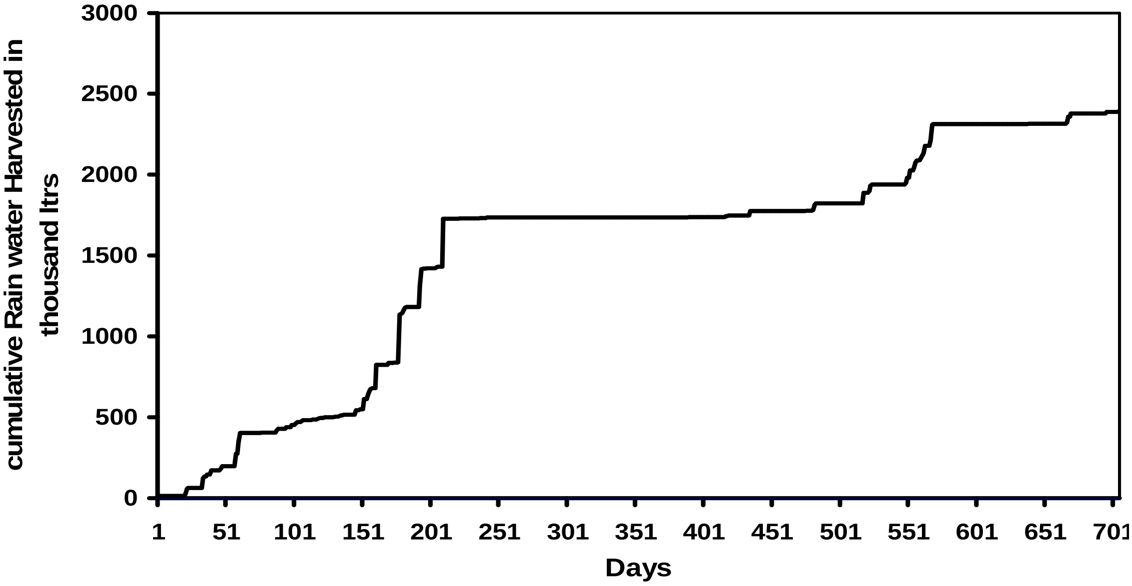

Fig 4. Cumulative water harvested

7. Water level in the Gravity head recharge-settling tank

The Fig 5 shows the plot of water level in the Gravity head recharge-settling tank versus time. It is observed that whenever there is rainfall, there is rise in the curve indicating recharge into the ground, which fulfils the function of providing the gravity head recharge-settling tank.

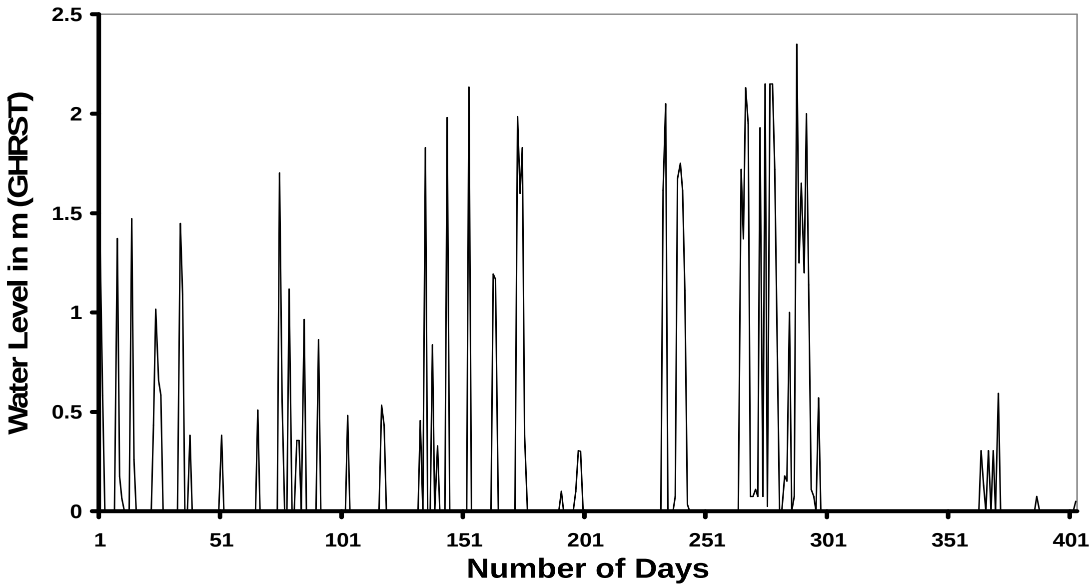

Fig. 5. Water level in the recharge-settling tank during recharge

Benefits of the scheme are:

- Proper utilization of rainwater.
- Restore supplies from aquifers depleted due to excessive draft or improve supplies from aquifers lacking adequate recharge.
- Improves physical and chemical quality of groundwater and creates fresh water layers.
- Prevents brackish water intrusion into fresh water aquifer near the watercourses carrying sewage.

8. Results

Water levels observed in the recharge well and water level fluctuations are plotted. It is observed that during the injection of water into the recharge borewell there is appreciable rise in water level (Fig.3a & 3b).

It is observed that about 2.39 million liters of water have been harvested (Fig.4).

It is observed from the gravity head recharge settling the rate of infiltration is 58.69mm/hour. The Coefficient of Harvesting of Rainwater using GHRST works out to 0.82.

The Benefit - Cost ratio is found to be 1.55. So the Artificial Recharge project is feasible. (Table.5)

Since the consumption of potable water per person is considerably less when compared to the consumption for non-potable purposes, the recharged water will be more economical for use. The aquifer characteristics of recharge borewell are presented in Table 5.

Table 5: - Aquifer characteristics

Aquifer Parameters	Before Recharge	During Recharge	
		Dec 2006	June 2007
Transmissibility (T)	1.2 X 10^4 lpd/m	6.8 X 10^4 lpd/m	9 X 10^4 lpd/m
Storage Co-efficient (S)	0.95 X 10^{-5}	2.15 X 10^{-5}	2.36 X 10^{-5}
Yield	122 litres/min	134 litres/min	146 litres/min

As the recharging of the borewell is under initial stages, there is moderate improvement in water quality. (Refer Table 6).

Table 6: Results of water quality analysis

	CONSTITUENTS	Open-well	Recharge Borewell					
			Before recharge	During recharge				
			Sept-2005	Dec-2005	Oct-2006	Feb-2007	Sept-2007	Nov-2007
A	TYPE- Cat ions							
1	Calcium (Ca) mg /l	101	110	86	83	83	83	21.2
2	Magnesium (Mg) mg /l	41	52	33	26	35	40	38
3	Sodium (Na) mg / l	167	132	120	99	100	99	45
4	Potassium (K) mg / l	7	5	3	2	2	2	1
5	Total iron (Fe) mg /l	0.2	0.01	0.1	0.08	0.05	0.25	0.6
B	TYPE- An ions							
1	Bicarbonate mg / l	554	573	431	399	391	208	200
2	Carbonate mg / l	Nil	Nil	Nil	Nil	Nil	Nil	Nil
3	Chloride mg / l	165	140	109	92	106	124	86
4	Fluoride mg / l	0.35	0.35	0.4	0.6	0.62	0.2	0.4
5	Nitrate mg / l	60	23	24	18	30	32	9.4
6	Sulphates mg / l	99	94	88	60	77	75	22
C	Total dissolved salts (TDS) mg/l	900	880	710	610	660	620	100
D	Specific conductance µmhos/cm	1580	1560	1230	1060	1140	1100	1053
E	Total hardness mg / l	416	485	348	312	348	372	308
F	pH	7.27	7.29	7.2	7.10	7.03	7.00	7.00

9. Conclusions

Roof top rainwater is channelised to the well and recharges under gravity flow condition through gravity head recharge settling tank. Recharge water should be silt free as far as possible. Most suitable for the areas where groundwater levels are deep. The runoff of first rain should not be allowed to percolate into the rain harvesting structures. Thus it should be drained off through a bye-pass arrangement provided near the harvesting structures. This can be applied to extremely big projects provided rainfall is satisfactory. In the current scenario LEED receives a lot of importance, hence Rain water harvesting an extremely efficient way to score required points. It also takes care of the water which would be wasted otherwise.

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Simulation and Analysis of Future Low-energy Materials Utilization

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Abstract:
The EU spring summit 2007 adopted the target of a 20% share for renewable energy in overall energy consumption by 2020. The EU renewable energy share, however, continually remains about 6% of overall energy consumption. It is obvious that for this target to be achieved effective measures for change in the structure of energy consumption should be undertaken. In the sphere of construction the decision can be for an increase in the utilization of more effective, low-energy materials. This paper deals with the simulation of such a utilization using the example of wood. The simulation is made by means of a Modified Dynamic Model (Beran, Dlask, 2004). The objective of the study is to choose the most appropriate scenario of development with respect to different terms of time. The expected outcome would be the proposal of certain changes in the model of materials utilization development on the basis of their efficiency. The achieved results will be the basis for a management action proposal which can be further used by state authorities and building enterprises.

Keywords:
Future development, low-energy materials, simulation, strategy analysis.

1. Introduction

At present the challenges of climate change and security of energy supply are multifaceted and require a coordinated response. Gross energy consumption in the EU represented 3.79 tons of oil equivalent per person in 2005. In this situation any assessment of future development begins to play a great role.

Sustainable construction can be regarded in the following way : that it is not just building concepts but also the components and materials which are used, which have to meet the present needs of users without burdening future generations with waste disposal problems or prolonged use of an out-dated building design.

As regards to using wood for construction for example, this saves the amount of energy in two phases, one in raw material formation by solar energy absorption (photosynthesis) and the other with energy consumption during the wood processing. It presents moreover an advantage in relation to the consumption of energy for construction processing and assembling and especially concerning the utilization of its waste as thermal energy (Winter, 1998).

The objective of the paper is to simulate the future development of the mutual interaction of economy and ecology regarding low-energy materials use in construction. After initial simulation the efficiency of certain changes in these interactions is evaluated.

2. Materials and Methods

At the initial stage of the research there were elaborated the input data for further simulation. Basic data necessary for the commencement of modeling are presented in the form of a matrix which expresses the interrelations between the chosen basic elements of the developed example of the model. The following elements were chosen for the modeling: *ecology, economy, woodworking industry* and *construction*.

The selection of basic elements is based upon the expert opinion of the research team working on the scientific project called Management of Sustainable Development in the Life Cycle of Buildings, Building Enterprises and Territories. The aim of the selection was to express basic relations which have the greatest influence on the analyzed problem in the fullest possible measure. In the future, further elements can be introduced to the model for the purpose of a more comprehensive description and evaluation of initial data and receiving more detailed results, but at the initial stage their introduction would create difficulties for the clear reflection of those analyzed relations. Further elements could be investment in low-energy buildings, a policy of low-energy construction, the volume of new buildings erection, energy prices, energy consumption and others. The most important elements can be chosen by means of the methods of multi-criteria evaluation.

Basic matrix $\boldsymbol{A}$ is represented in Table 1. Each element a_{ij} shows the influence (positive or negative) of one element to the other. These interactions were evaluated by means of an interval [-1; 1] after transposing the elements into common units of measurement. The evaluation of these interactions is described in detail in previous publications of the author.[1]

Table 1: Matrix of simulation of element interactions

	1. Economy	*2. Ecology*	*3. Woodworking industry*	*4. Construction industry*	***Initial value X(2004)***
1. Economy	*0*	*-0.2*	*0.25*	*0.3*	***0.28***
2. Ecology	*-0.28*	*0.2*	*-0.1*	*-0.12*	***0.4***
3. Woodworking industry	*0.11*	*-0.2*	*0*	*0.1*	***0.25***
4. Construction industry	*0.299*	*-0.1*	*0.1*	*0*	***0.3***

After the definition of element interactions it is possible to perform the initial simulation which was carried out by means of the Modified Dynamic Model (Beran, Dlask, 2004) elaborated in the environment of Microsoft Excel and developed at the Department of Economics and Management of Construction of CTU in Prague.

The key element in the simulation results is *rational expectation r* with can be expressed as follows:

$$r_i(t) = \sum_{1}^{4} s_i(t) v_i \qquad \text{for } t = 1,\dots, \text{n.} \qquad (1)$$

where s_i(t) is the standard value of element *i* at a certain moment of time *t*,

v_i – weight of element, which was defined by the Saaty Method. Alternatively, the introduction of v_i(t) can be considered.

Rational expectation expresses the cumulative tendency of future development and shows the total value of all the elements on the basis of their significance. Further evaluation of proposed changes in the model will be based on the changes in rational expectation.

The initial results of the simulation are expressed in the form of a graph of standards of the elements (Fig.1). After receiving these results, it became obvious that the initial example cannot function in a sustainable manner over the long term. It was necessary to determine which interactions should be modified to achieve positive changes for future development and how to evaluate the efficiency (benefits and costs) of any changes to be proposed.

To fulfill the first task the matrix ***B*,** which expresses the management of element interactions, was used. For the fulfillment of this task each parameter b_{ij} of the matrix ***B*** was changed in the interval from -0,2 to 0,2 and the influence of these changes in the values of four basic elements was followed. It turned out that a significant impact on standards parameters (which express the development in the values of basic elements over time) have the components b_{12}, b_{13}, b_{21} and b_{31}, which are indicated in bold type in Table 2.

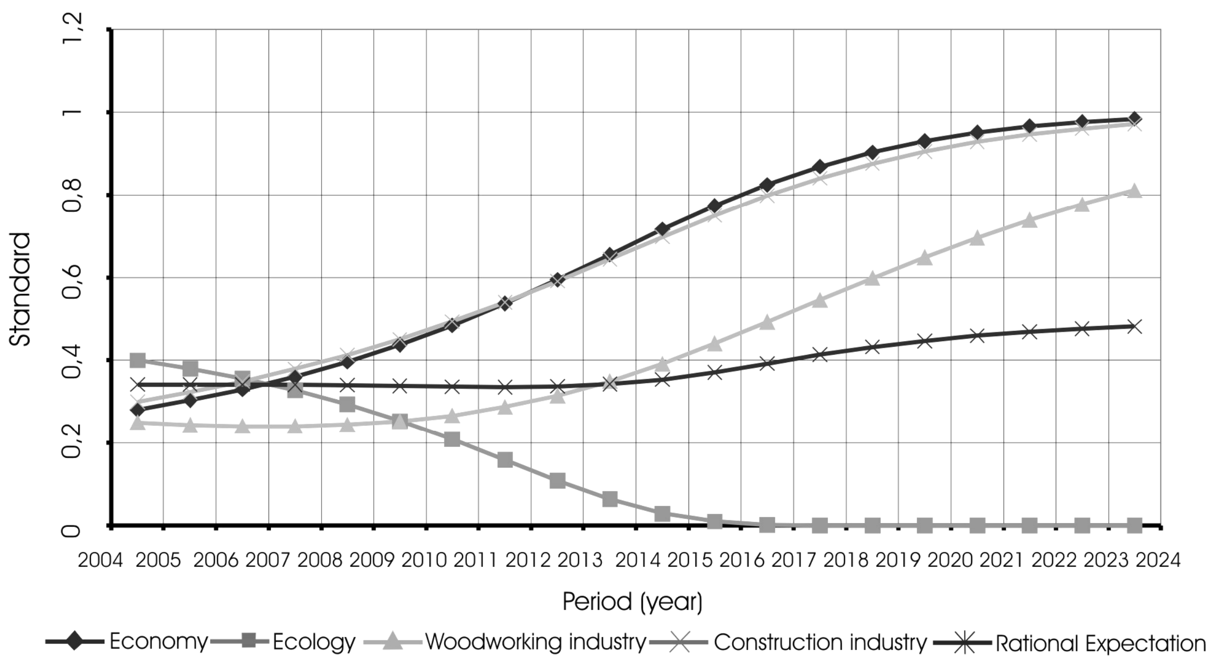

Fig. 1. Development of basic element interactions

Table 2: Matrix of element management

	1. Economy	*2. Ecology*	*3. Woodworking industry*	*4. Construction industry*
1. Economy	b_{11}	$\boldsymbol{b_{12}}$	$\boldsymbol{b_{13}}$	b_{14}
2. Ecology	$\boldsymbol{b_{21}}$	b_{22}	b_{23}	b_{24}
3. Woodworking industry	$\boldsymbol{b_{31}}$	b_{32}	b_{33}	b_{34}
4. Construction industry	b_{41}	b_{42}	b_{43}	b_{44}

It shows that in our example of the Modified Dynamic Model the two-way interactions between *economy and ecology* and between *economy and woodworking industry* are the most significant. Management of these interactions in the form of certain values of components b_{ij} will present certain strategies for an increase in low-energy materials utilization.

3. Results

At the next stage the costs and benefits of each change in the model's interactions were evaluated. This will give a basis for any proposal's efficiency and for the right choice between any measures (interaction changes) that are proposed.

Table 3 presents an evaluation of costs for each increase by 0,1 in the value of b_{ij}. For this evaluation it was necessary to express each model's interaction by means of certain financial indicators, which are cited below. Only significant components of ***B*** matrix were used.

The parameters on the basis of which the costs and benefits were defined are cited according to Eurostat and the Czech Statistical Yearbook 2007. All data cited are for the Czech Republic.

Table 3: Cost evaluation of proposed changes.

No.	*Increase of component of **B** matrix by 0,1*	*Financial indicator, F, €million*	*Expenses, E=0,1 x F, €million*
1.	***b_{12} strategy***	*[1]1,249.28*	*124.93*
2.	***b_{13} strategy***	*[2]2,366.9*	*236.69*
3.	***b_{21} strategy***	*[3]744.43*	*74.44*
4.	***b_{31} strategy***	*[4]80.8*	*8.08*

The **component b_{12}** presents the influence of *ecology on economy*. For the cost estimation the value of b_{12} was multiplied by the economic benefit derived from environmental protection activities[1].

The value of **component b_{13}** expressing the influence of *woodworking industry on economy* can be multiplied by turnover in the woodworking industry and the manufacture of articles of straw and plaiting materials[2] in the Czech Republic (acc. Eurostat).

The **component b_{21}** expresses the influence of *economy on ecology* and can be evaluated by means of the value of total environmental expenditures.[3]

The last influence on the basic interactions expressed by **component b_{31}** (influence of *economy on woodworking industry*) was evaluated by means of the value of gross investment in the manufacture of wood and of products of natural origin[4] (acc. Eurostat).

After that it was necessary to evaluate the benefits of each change in matrix B components, as far as this change expresses in certain measure any external influence which can be made to change the behavior of the model in the desired way. Table 4 contains the results of a benefits evaluation for managing influences.

The value of benefit was calculated as a multiplication of difference Δ_i between the initial values of rational expectation and the changed model's rational expectation by a corresponding financial indicator. Benefits were calculated for the 5-th, 10-th, 15-th and 20-th year of simulated development.

Table 4: Evaluation of the benefits of proposed changes.

No.	*Strategy*	Δ_5	Δ_{10}	Δ_{15}	Δ_{20}	*Corresponding branch production, €million*	*Benefit, B_5, €million*	*Benefit, B_{10}, €million*	*Benefit, B_{15}, €million*	*Benefit, B_{20}, €million*
1.	***b_{12} strategy***	*0,03*	*0,04*	*0,03*	*0,01*	*[1] 1,249.28*	*41,95*	*47,53*	*32,56*	*8,38*
2.	***b_{13} strategy***	*0,02*	*0,03*	*0,02*	*0,01*	*[2] 2,366.9*	***51,48***	*74,80*	*57,07*	***14,99***
3.	***b_{21} strategy***	*0,05*	*0,12*	*0,10*	*0,01*	*[3] 744.43*	*38,91*	***91,49***	***77,05***	*4,72*
4.	***b_{31} strategy***	*0,01*	*0,03*	*0,03*	*0,01*	*[4] 80.8*	*0,76*	*2,57*	*2,71*	*1,00*

The highest benefits in the short term is given by the b_{13} strategy, which means that at the initial stage the interaction of *woodworking industry and economy* should be improved by means of measures directed to an increase in turnover in the woodworking industry, for example. But in the medium term the strategy b_{21} (expressing the influence of *economy to ecology*) is the most favourable. That means that after an increase in renewable materials production special attention has to be paid to a decrease in the negative influence of economic activities on the environment, for example in the form of environmental expenditures.

For a definition of the efficiency of proposed measures, expenditures and benefits in different terms were compared. The results are illustrated in Table 5.

Table 5: The efficiency of proposed measures.

No.	*Strategy*	*Expenses €million*	*Efficiency E=expenses/benefit*			
			E5	*E10*	*E15*	*E20*
1.	***b_{12} strategy***	*124.93*	*0,34*	*0,38*	*0,26*	*0,07*
2.	***b_{13} strategy***	*236.69*	*0,22*	*0,32*	*0,24*	*0,06*
3.	***b_{21} strategy***	*74.44*	***0,52***	***1,23***	***1,04***	*0,06*
4.	***b_{31} strategy***	*8.08*	*0,09*	*0,32*	*0,34*	*0,12*

The only strategy with a favourable efficiency is b_{21}. This means that the influence of *economy on ecology* should be changed as a matter of priority. This corresponds to recent investigation of the economics of climate change (Stern, 2006). Moreover, this change (strategy) should be realized within 15 years according to the simulation. After that, the level of efficiency reduces sharply.

The same result is demonstrated by comparison with the proposed interferences to the basic model by way of accumulated welfare *W* (Stern, 2006), which is characterized by the following expression:

$$W = \sum_{1}^{n} r_i(t)e^{-\alpha t} \qquad \text{for } t = 1,\ldots,\text{n} \tag{2}$$

where r_i(t) – rational expectation in time t,
$e^{-\alpha t}$- coefficient of utility devaluation in time.

The graph of accumulated welfare also shows a preference for the strategy of environmental support, in other words of fulfilment of principles of sustainability in construction including the development of low-energy materials utilization. Besides it demonstrates the loss of efficiency in 19 years. This means that strategy realization should begin at least within this period.

The other three strategies have approximately equal efficiency in all periods of simulated development.

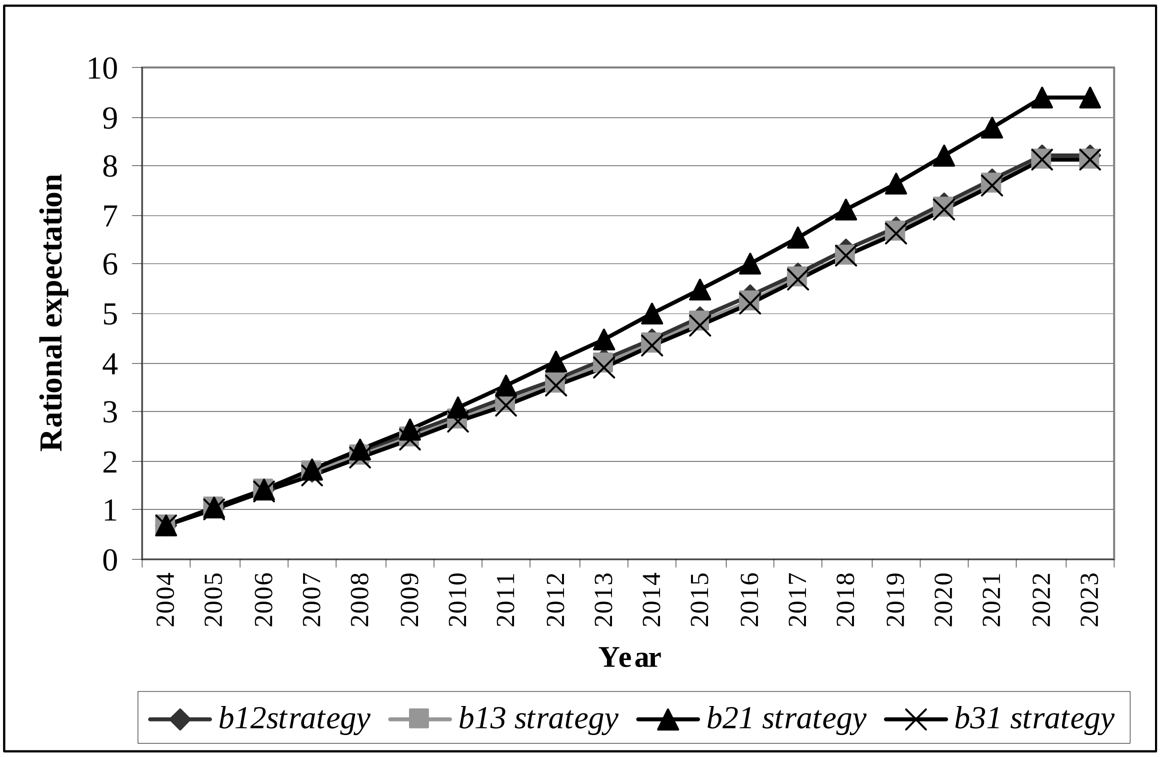

Fig. 2. Accumulated welfare *W* of proposed strategies of development

4. Conclusion

The tool of simulation used, the Modified Dynamic Model offers a device to formalize a view of the future situation, as well as a possibility to compare different measures of future development management. Using this device it is possible to define what actions in construction management should be undertaken in what period of time and evaluate what will be the costs of these measures. In the current example of this dynamic model, construction development was simulated with regard to wood and low-energy materials utilization.

At further stages of the research the model can be extended to other basic elements, which will give a more comprehensive description of the problem and more detailed investigatory results.

The given model is a managerial instrument which allows the simulation of further strategies and gives the opportunity to change the current situation which is unsatisfactory from the view of long term sustainability.

The received results will be the basis for the development of any proposal for the amount of necessary investment and certain measures of support given to the development of building with low-energy materials.

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Sustainable Construction in Costa Rica Towards a strategic approach to construction material management for waste reduction

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Abstract:
In developing countries, construction waste is becoming a serious environmental problem due to the continuing growing population and urbanization, which demand material resources, water and energy.

Information and data about the sector in those countries are scarce, therefore, this study aimed to provide a baseline analysis related to construction waste in a developing economy.

An investigation in Costa Rica identified the need to do an assessment in order to understand the present situation related to the production of construction waste, its causes and barriers for the activity to become more sustainable.

This paper summarises the most important findings of the survey undertaken showing high amounts of waste produced, the diversity of causes and the major barriers for the activity to be more sustainable.

This research is part of a more comprehensive study, which is trying to model the procurement of buildings to determine waste generation in a newly starting industrialized setting.

Keywords:
Barriers, causes, construction sector, sustainability, waste composition.

1. Introduction

The construction sector plays a key role in shaping and developing the built environment. In the developing world the construction sector represents 2-3% of GDP, and 74% of the 111 million of workers in all sectors. Developing countries account for 23% of global construction activity, which represent that the activity is more labour intensive. The sector consists overwhelmingly of micro, small and medium-sized enterprises (MSMEs), or more accurately 'micro firms' with ten or fewer employees (UNEP, 2003).

Construction waste is becoming a serious environmental problem in many large cities in the developing world, due to the fact that the activity generates lots of pollution, which causes significant impacts on the environment and arise growing public concern in the local community. Based on the impacts, the industry has for some time been seriously challenged to become more environmentally friendly and promote sustainability (Shen et.al., 2000; Smallwood, 2000; Poon et al., 2001; Tam et al., 2004; Begum et al., 2006)

The construction industry and its related materials, service, and supply feeder industries are jointly considered to be both the world's largest industrial employer and the largest natural resources consumer. As much as 50% of all materials extracted from the earth's crust are transformed into construction materials and products. Building activities based on these materials account for as much as 40% of all energy use. When these materials enter the waste stream, they account for some 50% of all waste generated prior to recycling, recovery or final disposal (Environmental Protection Agency U.S, 1995; Arpad, 2004). Moreover Mocozoma (2002) indicates that the sector is responsible for 12-16% of fresh water consumption, 25% of the wood harvested and 20-30% of greenhouse emissions.

This paper is based on a study performed in Costa Rica, where data related to construction waste is scarce. The aim of the study was to investigate the quantities and composition of the waste in the construction sector. It also analysed the main causes for its generation and the barriers and motivators for the activity to become more sustainable.

2. Construction Industry in Costa Rica

Costa Rica is situated in Central America. It has 4.5 million inhabitants, with a developing economy and a construction activity growing very rapidly. The construction industry contributes a significant amount to the country's economy (The Economist Intelligence Unit, 2006) and the rate of growth has been one of the most dynamic in the past five years, surpassing the rate of GDP growth (Costa Rican Construction Chamber, 2007).

In developing countries there are very few data available in relation to the construction sector and waste generation. The literature review indicated that the availability of data on the Costa Rican construction sector related to waste production (quantity and composition) is very scarce and variable, e.g. Villalobos (1995) reported as an indicator of construction waste generation between 11-25 kg/m^2 while Ramirez (1995) presented a value between 300-700 kg/m^2. A study done by Leandro (2006) showed that the projects investigated generated a roughly average of 115 kg/m^2.

These data suggest that the access to more precise information could reveal opportunities for waste reduction strategies at its source, being the most economical way to "treat" construction waste (Gavilan, 1994).

3. Research objective and methodology

This study aimed to provide a baseline understanding related to the construction waste in Costa Rica, its quantities, composition, causes, as well as, motivators and barriers for achieving a more sustainable activity. It is part of a more comprehensive research, which attempts to model the procurement of buildings to predict waste generation in a newly starting industrialized setting.

The study is explorative and descriptive and the theoretic bases for the study were found in a combination of the theories of communities of practice (Lave and Wenger, 1991) and production management. The community of practice theory suggests that in any industry agents – forming together a community of practice- operate based on a common and/or complementary field of interest, motivation, and knowledge. They are in one way or the other related to each other and they influence the outcome of the activities in the community. The production management theories provide a frame of analyses for the output of production processes, indicating the generic characteristics of the output in terms of quantity and quality. This output highly depends on the production input and the process, as well as on the involvement and influence of the various agents in the process. In this study the produced waste is seen as one of the outputs of the construction processes.

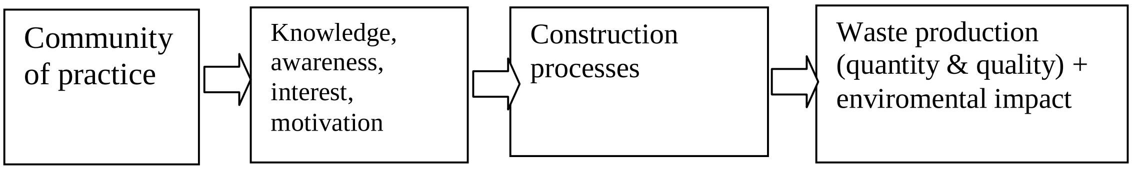


Fig. 1. Analytical framework

The research was conducted with the participation of small, medium and big construction companies. It took place from November 2006 to May 2007, in collaboration with the Costa Rica Institute of Technology; the collection of the information was done by means of questionnaires, site visits, interviews and a group discussion.

A questionnaire was prepared based on Kuijsters (2004) and Bossink and Brouwers (1996) and adapted to the local conditions. Prior to data collection, it was pre-tested for content validity. First, seven experienced construction engineers from the Research Centre for Housing and Construction of the Costa Rica Institute of Technology were asked to critique the questionnaire for ambiguity, clarity and appropriateness of the items used, and the feedback received helped to modify the instrument. In the second stage the questionnaire was emailed to 419 companies that were listed in the Engineer and Architect’s Federation. It was also placed on a website using the programming ASP.Net. The information received was stored on a SQL Server 2005 database.

The questionnaire was directed to the engineers responsible for the projects from the construction companies. Choosing the engineer had the advantages that s/he knows what is happening on the construction site with regard to material flows, s/he is involved in more administrative and legislative matters and has more than one project to manage. The respondents were 40, but useful questionnaires for the analysis were only 29.

The on site visits were performed to 5 projects in order to have a general idea about the building practices. A checklist using the Costa Rican waste hierarchy, known as “4R’s (reject, reduce, re-use and recycle) was used as a guide for the observations.

The personal interviews were mainly done to the Costa Rican Construction Chamber, environmental consultancy entities, research centres from universities, environmental governmental agencies and Board of Engineers. The objective was to get a better understanding on how the sector interacts with the different actors, and how the construction practices are influenced by traditions, legislation, economy and other concepts. The interviews were semi structured and the questions were related to the organization of the sector and topics related to construction waste.

The group discussion organised took place half a year after the completion of the data analysis. The findings of the survey were presented, discussed and validated with 43 participants from the construction sector.

4. Delimitations

The construction activity is involved in different stages of the building process and there is a large number of actors in the sector (Bueren and Priemus, 2002; Mocozoma, 2002). However, this research focused primarily on the phase related to construction of edifices in the Great Metropolitan Area, where most of the construction activities take place, and is mainly focussed on contractors.

5. Survey results and analysis

The size of the company was defined, for this study, by the number of employees working for it during the survey. Those numbers may fluctuate in time since the companies can hire and fire personnel relatively easy due to the fact that most of the employees working at the construction sites have temporary contracts.

Table 1: Company size

No. Employees	Label	No. Firms
< 25	Small	11
25 - 100	Medium	9
> 100	Large	9
TOTAL		29

In the responding firms, an average of two thirds of the employees have primary or up to third year of secondary education while the other third has workers with higher degrees.

5.1. Quantity of construction waste

From the literature review, the following waste generation figures were found.

Leandro (2005): 115 kg/m^2
Villalobos (1995): 11-25 kg/m^2
Cartín (1995): 0,97 m^3/m^2 (300-700 kg/m^2)

This baseline analysis didn’t consider an on site material flow analysis but the questionnaire had questions related to the knowledge the interviewee had of their construction waste generation. The survey revealed values ranging from 7 to 170 kg/m^2.

Most of the waste generation values found in the literature for different countries provided a total value per year. In Costa Rica it was not possible to find such a value but what was found was the amount of construction that took place in the private sector in the last 5 years, which can give an idea of the potential amount of waste generated during that period (CCC, 2007).

Table 2: Amount of construction floor in Costa Rica 2002-2006

YEAR	CONSTRUCTION (Million m^2)
2002	1,3
2003	1,8
2004	3,3
2005	3,7
2006	5,95

The answers to these waste generating questions showed that companies are not aware and do not keep track of the total amount of waste they produce. Four of the five on-site visits illustrated that fact. The interviews with the supervisors clearly showed unawareness in topics related to environmental matters related to the sector and lack of information. This lack of awareness in itself is already a cause of waste generation since unaware companies are not likely to take action against polluting activities that they do not even know exist.

5.2. Composition of construction waste

The type of waste produced is wood, steel, concrete, soil, piping materials, corrugated roof sheets, wires, packaging materials (paper, plastic and cardboard), cement, blocks, paints and debris. The amounts (either by volume or by weight) of these streams are unknown since the majority of the companies don't keep track of these data.

Analysing the waste streams showed that a considerable part of it consisted of recyclable materials. Therefore recycling can contribute to diminish the need for landfills or disposal sites, diminishing environmental pressure and increasing revenues. One construction company in Costa Rica that participated in the survey had performed a material flow analysis and proved that a recycling rate of 80% is feasible (Chinchilla, 2007). Some of the respondents also mentioned that some of the waste produced in their projects is already reused, mostly on-site, and some via recycling companies.

To try to make a correlation between the waste streams and the company's environmental behaviour, an indicator was prepared, and here defined as "environmental performance". It is based on questions related to some good environmental practices used by the organizations. They were: if the company monitors the amount of waste produced and which indicators are used, if it has a waste management plan or someone in charge of environmental topics for the construction sites, if the company had any environmental friendly technologies to decrease the environmental impact of construction in the last two years and questions related to separation and reuse of waste.

That is an indication that the waste streams, as such, cannot be prevented given the current technological and organisational characteristics of the Costa Rican construction sector. Maybe attention to environmental measures can decrease the magnitude of the waste streams.

Table 3: Environmental performance, statistical analysis

Environmental score	No. Companies	% Companies
Low	11	36,7
Medium	15	50,0
High	3	10,0
Total	29	96,7
Missing	1	3,3

5.3. Environmental impact

The pollution of the site and its surroundings is the principal manifestation of environmental effects created during the construction works. The impacts can be to the air, water and soil. Pollution to the air is mainly due to the dust produced and the common practice of burning the combustible waste to reduce its volume. The surface and ground waters are affected by surface runoff and infiltration during heavy rains (2000-4000 mm/year) that may transport fuels, oils and paints that are improperly stored. Besides construction waste is sometimes dumped in the ocean or onto the riverbeds. The soils are affected as well, by the practice of leaving waste in the ground that often is covered with vegetation at the end of the projects.

Another impact on the environment is the abundant use of wood as a casing material, which results in an extra pressure on forests that are already under stress.

5.4 Causes of waste generation

The empirical findings revealed that the causes of waste generation are mainly related to legislation and law enforcement, awareness, and technical aspects as: material sizes, material handling and revenues.

Legislation and law enforcement

The country has plenty of laws and regulations to protect the natural resources but the enforcement is weak, the fines to be paid in case of non-compliances are very low and there are no policies that can help the sector towards sustainability.

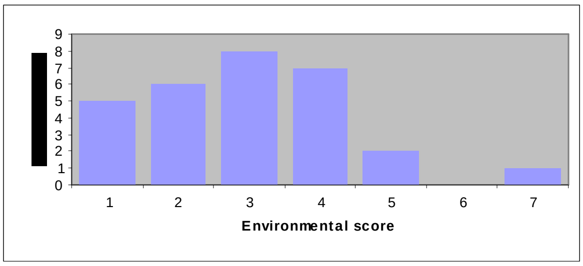
Awareness

The awareness concept meant as the importance that the company gives to the protection of the natural resources or the environment in general, was assessed during the survey. Awareness of environmental problems is one of the most important precursors for environmental benign developments.

Questions used to analyse this concept were related to the incorporation of environmental practices in terms of: including the environment into their accounting, personnel promoting environmental practices within the company, environmental criteria when choosing the suppliers or sub-contractors, knowledge of where the waste is disposed of, recycling activities, information required and technical assistance related to sustainable construction, environmental certifications, measures to save input materials and waste management plans. The outcomes showed a low level of awareness related to environmental matters and particularly of construction waste (Table 4). Based on the "responding firms"' scores on individual questions an overall score depicting the environmental performance is devised.

Table 4: Environmental performance distribution

Score	No. companies	% of companies
Low < 2,5	13	45
Average 2,5 - 5	15	52
High > 5	1	3
Total	29	100



The need for information and technological assistance is also an indicator for awareness. The survey demonstrated that most of the information required is related to legislation and few of the companies look for information or technology related to sustainable construction which shows that they are looking for a way to reduce their environmental pressure, whether motivated by economical or ecological reasons.

<u>Technical aspects</u>

Knowledge of the causes of waste generation from the technical point of view is essential. Incompatible standard sizes of construction materials are causing a major problem related to waste generation. More than 50% of the companies experience this problem in more than half of their projects. Incompatible standard sizes also have the highest number of companies experiencing this problem "on all projects".

Table 5 shows the problems encountered that are either related to material management or causes that are related to the material suppliers. The score is based on the importance assigned by the respondents. A score was calculated ranging from 0 (for never occurs) to 4 (occurs on all projects).

Table 5: Waste generating technical aspects

Waste generation influencing aspects	Score
Incompatible standard sizes available on the market	2,30
Errors by tradespersons or labourers	1,93
Designers unfamiliarity with alternative products	1,77
Environmental unfriendly attitude of project team and labourers	1,73
Changes made to the design while construction is in progress	1,72
Complexity of detailing on the drawings	1,52
Use of incorrect material, thus requiring replacement	1,37
Damage to work done caused by subsequent subcontractors	1,29
Bad weather	1,23
Required quantity unclear due to improper planning	1,17
Ordering errors (too much, too little)	1,13
Incomplete contract documents at the beginning of the project	1,10
Selection of low quality products	1,10
Delays in passing of information to the contractor on types and sizes of products to be used	1,10
Materials supplied in loose form	1,10
Damages during transportation	1,07
Inappropriate storage leading to damage or deterioration	1,07
Equipment malfunctioning	1,00
Lack of possibilities to order smaller quantities	1,00
Purchased products that do not comply with specifications	0,93
Errors in contract document	0,77
Accidents on the construction site	0,72

One of the major material suppliers for buildings are companies from United States of America that use the Imperial System of measurement (British), which is not compatible with the SI-measures used by Costa Rica. Besides the sector has to deal with a colonial heritage, which is the unit ‘vara’ used to measure wood during its colonial Spanish period, therefore extra waste is generated to fit all the pieces together. This standardization topic is already analysed by the Camara Costarricense de la Construccion and efforts have been made in order to look for solutions for this situation.

Another common practice within the builders is to request future owners to buy more materials than actual needed. This is profitable for the contractor who can benefit from increased turnover and convenient for the construction workers. They do not have to work meticulously in order to get the most useful sections out of a piece of wood or a steel bar. Obviously, this practice generates waste. Sometimes, leftovers are used to construct ladders, sieves and scaffoldings. However, when the construction is completed, these materials turn into waste. A useful practice is an unknown amount of informal recycling by construction workers.

5.5 Motivators and barriers

The survey included questions about the most important motivators and barriers to environmental building practices. The responding firms identified environmental awareness and cost reduction as important motivators to use more benign construction practices. Many measures to reduce the environmental pressure are linked with increased material efficiency and hence with economic benefits. However, in the construction sector the profits are very high as a result, the companies are not so eager to invest time, effort and money in ways to increase their profits a few percent by means of good material management.

Barriers were analysed from different perspectives: knowledge, technology, economical and governmental. The results are presented in Table 6.

Table 6: Barriers to environmental building practices

Type of barrier	Variable
Knowledge	– Lack of money to implement environmental programmes within the companies – Lack of programmes and studies on sustainable construction at the formal education entities
Technology	– Lack of knowledge on appropriate technologies and their implementation – The assumption that a cleaner construction process has higher costs – The fact that designers work isolated without having an integral approach in the design process
Economical	– Lack of financial instruments like taxes and subsidies – The fact that the prices of the construction works do not reflect the environmental cost. This implies that companies are willing to use more expensive technologies if only they could price their houses higher
Governmental	– Inconsistencies between different governmental agencies – Bureaucracy – Lack of governmental support to use sustainable technologies This result is in line with the previous result that companies would behave different if there would be taxes, subsidies or incentives

One last aspect important to analyse as a barrier is the low education level of the majority of the workers participating in the construction process. The construction sector in the country is labour intensive, with workers sharply divided between a small group with high level of education, mainly composed by skilled engineers and managers that are organised on a permanent basis, and a bigger group consisting of employees with very low motivation, working on site, which are hired with temporary contracts and low salaries. The training of these workers takes place on site in an informal way. It is common to hire unskilled migrants from Nicaragua, which in many cases are illegal.

6. Conclusions

The literature related to the quantity and composition of the construction waste in Costa Rica is very limited and the existing one has discrepancies. The most important waste categories are wood, concrete, piping materials and roof sheets. Often, the waste is mixed and only 50% of the companies indicated that they separate the waste to some extent. The most used fractions for waste separation are wood, metals and mixed waste.

The survey helped to find the causes of waste generation, which are not only related to technical aspects but also to the lack of governmental motivation and enforcement of the existing legislation. There are no policies aimed at the reduction of the environmental pressure of the construction sector. Besides, the lack of financial measures to influence the behaviour of the sector is a cause mentioned by the respondents.

There is a general lack of awareness on environmental issues among the construction sector. Additionally a lack of information, technologies and governmental or market incentives to use those technologies frustrate the efforts of those trying to improve their environmental response.

At a company level, the most significant cause for waste generation is unawareness. This results in low interest in sustainable ways of construction and is thus a barrier to decrease the environmental pressure. The respondents also indicated that even though the profit margins are very high, the companies don't dedicate part of the revenues to environmentally sound technologies and this shows also the unawareness of the potential profitability by applying those technologies. But since the profits in the sector are very high this will not be a very important motivator.

The need for information and technological assistance is also an indicator for environmental awareness. The fact that companies search for information or technology related to sustainable construction shows that they are looking for a way to reduce their environmental pressure, whether motivated by economical or ecological reasons.

Builders can improve their operations through a better understanding of their activity in an integral way, taking into account not only the cost, quality and schedule of the projects but also the environment.

Further research should be done in order to assess the performance of the production system by means of physical flows analysis, which can help to point out the main causes of inefficiency allowing areas of potential improvement.

Probably no sector has more potential to contribute to the achievement of sustainable development than construction and most attention has to be devoted to analyse the proper management of the materials that enter in the production process, and future research should continue in this line.

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The Effects of Passive Design and Renewable Energy in Producing Low Energy Efficiency Architecture and Special Identity – (Case Study Libyan Desert Zone – Ghadames)

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Abstract:
The use of passive design is not a new innovation. It is as old as the technique of building and art of architecture. Prior to the modern era, architects and builders had little else other than local materials and natural resources. They designed their buildings carefully so as to maximize the thermal properties of materials and the availability of local resources.

Contemporary architecture reveals its similarity in almost every part of the world without any consideration to regional characteristics, in comparison to vernacular architecture which is almost always climatically appropriate, where architects and builders traditionally had to design with respect to nature and local climate.

This paper attempts to evaluate the housing settlements in Ghadames where the vernacular, urban and architectural patterns provide useful hints for designing more sustainable environments. In this context, the compact city, covered streets and covered courtyard, provide the elements most important to climatic comfort efficacy in a hot arid climatic region. The importance of using renewable energy and local materials are also explored as design tools towards more sustainable development solutions.

Keywords:
Architecture, Climate, Ghadames, Passive design, Vernacular architecture, Renewable energy

1. Introduction

At this present time there is universal concern about our environment. We are living during a unique time in human history, when man has achieved the ability to almost completely control his environment. However, at this impatient point in his development, the relationship between man and environment has become difficult and contentious.

Passive design, in essence taking maximum advantage of nature and the climate in particular to design the built environment, may seem to be the latest trend in building design, but it is an idea that has been with us for a long time. Our early ancestors lived in sympathy with nature and lived in the moment. Nowadays people try to live in the next coming centuries before they even know what will happen in the coming second. Hassan Fathy (1986) confirmed that man has for along time reacted to his environment, using his materials to develop techniques and technologies, in the past he lived attuned to the environment.

EREC (2000) confirmed that ancient civilizations used passive solar design. The new aspects are building materials, construction methods, and software that can improve building design and incorporate passive solar principles into modern residential structures.

As a consequence of our greediness and ignorance of the environment and material resources, and our extensive use of mechanical systems to create comfortable indoor environment which caused a wide range of health, the environmental problems will increase. To limit and reverse these adverse effects, passive design became one of the most needs in saving our built environment, therefore the environmental impact of the buildings should be considered including effects on the global and local environment.

Contemporary Libyan architecture has rarely recognized the local climate or renewable energy. Issues related to these subjects are neglected or rarely studied where as Libyan local architecture, such as that at Ghadames, includes traditional solutions that have been tested over centuries, providing passive design that leads to reducing building's energy consumption as well as creating an architecture related to the local environment. Yet, as this architecture provides a motivating and valid lesson; it also illustrates and present riches of knowledge about how humans remain in touch with nature and how they adjust to the local natural environment and climate.

This paper is a part of the PhD project titled "Climatic design as a tool to create comfortable, energy- efficient and environmentally wise built environment - (Tripoli-Libya)".

2. Sustainable architectural design

Sustainability in general deals with the relationships between human and natural systems and considers the long term. Sustainable architecture can be defined as a planned effort at designing a built environment that is energy and ecologically considerate both internally and externally. According to Brundtland (1987:8) Sustainable development is the "*development that meets the needs of the present without compromising the needs of future generations to meet their own needs*". Sherlock shares Brundtland's definition: "*Sustainability means living now in such a way that we do not threaten future life*" (Sherlock, 1991: 293).

Roaf *et al.*, (2005) defined the eco-house as a house that is closely connected to the site, society, climate, region and planet. Roaf asks the question of why we do not make all building more ecologically connected in this way, and recognises that appropriate more sustainable alternatives are still not acceptable to society as a whole, even when modern buildings are contributing to the trends undermining the planetary systems. Oliver (2003:130) defined the relation between building and climate as "*Buildings do not control climate, which, apart from the wind or sun shadow that they cast, remains largely unaffected. But from within the dwelling can modify the internal climate, even though it is affected by the external conditions. The materials that are used, the forms they take, the volumes they enclose, and the services that are installed may all contribute to the 'micro-climate' that the house generates. This is not always precisely what the occupants require in temperature, ventilation or relative humidity."*

2.1. The principles of the sustainable architecture

There were many studies conducted on sustainable architecture such as (Sherlock, 1991, McDonough, 2000, Cofaigh et al., 1996, John et al., 2005, Roaf et al., 2005).The main principles of the sustainable architecture as following;

- **Respect of the user's socio-cultural values**. Rapaport (1969) clarified that the variety in architectural form can be seen as a result of a host of social, cultural, economic, physical, and technological variables

- **Adapting the climatic conditions.** Sustainable buildings should have the ability to benefit from local climatic conditions and adapt to the daily and seasonal climatic changes
- **Energy conservation.** Buildings consume energy not only in their operation, for heating, lighting and cooling, but also in their construction. Construction often requires large amounts of energy for processes ranging from moving earth to welding. Also the materials used in architecture must be produced, processed, and transported to the building site.
- **The use of local material**. Using the provided local material will significantly contribute in respecting and enhancing the environmental issues.
- **Respect the location (site conditions).** It is essential to consider that the building design and construction will not have a major effect on the site topography and the surrounding architectural style.
- **Water Efficiency.** As water consumption is a serious ecological concern nowadays, it is imperative to consider regulating its use and reuse inside and outside buildings.
- **The use of natural light and ventilation**. Building and window design that utilizes natural light and ventilation will lead to conserving electrical lighting energy, shaving peak electric loads, and reducing cooling and heating energy consumption.
- **The studied use of colors.** Colors have physiological and psychological impacts on the human body and in addition to its esthetic values, it plays a significant role in reducing and reflecting the solar radiation on the external walls.

- **Treatments for ecological problems such as noise pollution**. Noise is like light in its effect on psychological human health, accordingly buildings should be protected from noise sources.

3. Passive design

Passive design in essence is taking the maximum advantage of nature, and the climate in particular, to design the built environment, without using mechanical heating or cooling.

Passive design is a process to develop ideas and strategies “for the design of whole buildings that have minimal reliance on mechanical plant”, it works with the building envelope which filters the climate and tempers the internal environment (Dowdle, 2003:3).

Reardon (2005) confirmed that Passive design is design that does not require mechanical heating or cooling, dwellings that are passively designed take advantage of natural energy flows to sustain thermal comfort.

According to the U.S. Department of Energy (2004) passive solar design or climatic design is designing the components of the building, windows, walls, and floors to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. Gedik (2004) stated that climatic design can be learned and inspired by observation of the old traditional buildings. Architects should pay maximum attention to design buildings adapted to local climatic conditions in order to provide residence comfort while using minimum artificial energy.

For most, passive climate control is a design principle where it is important for the engineer to be aware of how the building is used. At the same time it is important for the user to be aware of any activities that could possibly have an unintended and inappropriate effect on the indoor climate (René *et al.* 2001).

3.1. Principles of passive design:

The principles of passive design in homes:

- Provide acceptable levels of comfort.
- To be as low energy as possible to (Reduces heating and cooling bills).
- As self sufficient in renewable energy as possible
- To have as little impact on the environment as possible by reducing greenhouse gas emissions

3.2. Basic Passive Solar Design Techniques:

NREL (2001) explained 'the difference between a passive solar home and a conventional home is design'. And the key is to take the advantage of the local climate when designing a passive solar home.

According to U.S. Department of Energy (2004) there are three basic types of passive solar design; direct gain, indirect gain, and isolated gain, and every passive solar building includes five different elements as shown in figure (1):
The Collector: collect the sunrise throw windows which should face the south .
Absorber: It is the storage element which could be wall, floor, or partition. Sunlight hits the surface and is absorbed as heat.
Thermal mass: It is the materials that store the heat produced by sunlight. It is the material below or behind the absorber (exposed surface).
Distribution: It is the method by which solar heat circulates from the collection and storage points to different areas of the house.
Control: it is the elements which could control under or over heating during summer time such as using roof overhangs to provide shaded areas during summer months.

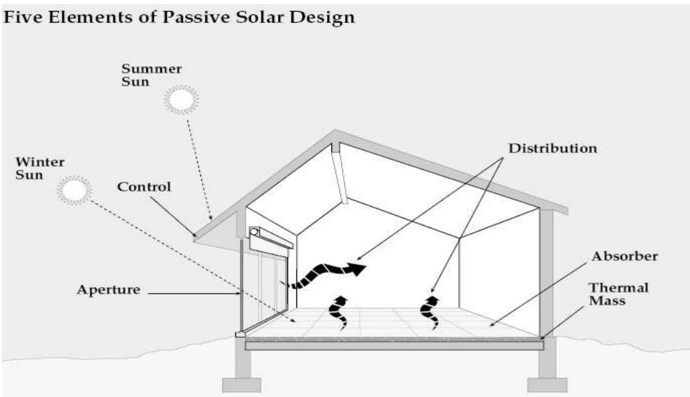


Fig. 1. Five passive solar design elements
Source:http://www.eere.energy.gov/consumer/your_home/designing_remodeling/index.cfm/mytopic

These elements are very important in places which need heating more than cooling, but in the desert regions, which need cooling more than heating, the fifth principle (control) should be the main principle to avoid the overheating.

4. Renewable energy

Renewable energy is introduced as clean, environmentally safe resource when compared with conventional energy resources. While being one of the most oil exporting countries, Libya recognizes the existence and potential for renewable energy resources.

Nasr (2006) illustrates the clean energy resources; Fuel Cells; Geothermal Energy; Micro- and Small Hydro Energy; Large Hydro; Photovoltaic Energy; Solar Energy; Tidal Energy; Wave Energy and Wind Energy. He expects Renewable energy technologies to grow and have the possibility to provide future energy supplies in buildings such as: passive and active heating and cooling systems, photovoltaic and wind power. Khiat and Stambouli (2006) defined renewable energy projects as tools for the management of reserves and sustainable development of desert communities. They classified the motivations to be taken into account into four points as following: Environment protection, Energy dependence, Rural and agricultural development and Renewable energies availability.

Nowadays most countries are used a combination of fossil fuels, nuclear fuels and renewable energy, whereas, before the industrial revolution, human societies were largely dependent on renewable energy sources such as solar energy which was used to heat, cool and light homes and also wind, water and wood were another source of energy (QSEIDG, 2004). Suharta (2006) clarified that energy can contribute to the three sustainable development pillars: economic, social and environment. However, since one solution does not fit all, the local context (political, social, technical and economic) should be taken into account for all energy involvements.

5. Ghadames- Introduction and Location

As shown in map (1), Ghadames is a town located in a Saharan oasis at the point where the borders of three Arab countries meet: Algeria, Tunisia and Libya. It is located about 620 km southwest of Tripoli in the desert region, its geographical co-ordinates are: 30°08' latitude north and 9°30' longitude east. (Chojnacki, 2003).

Ghadames is recognized for its beautiful and creative architecture, designed to fight the harsh desert climate. The present old town is probably 800 years old; it is often called "the jewel of Sahara", and was in 1999 added to the UNESCO World Heritage List, as one of five places in Libya (Kjeilen, 1996).

Map. 1 the location of Ghadames
Source :
www.worldsurface.com/images/maps/libya

5.1. The Climate

The climate in the Libyan Desert and semi-desert region generally, is dry and hot in summer. In winter, it is mostly very arid since there is rarely rain. By reviewing the literature, the authors notice that there is no accurate data, the average humidity is 20% to 59%. The minimum average temperature in January is 2.1C° and the maximum average in August is 40.2C°. The winds in this region are southerly and in summer and spring, they are hot and dusty while in winter and autumn, the area experiences northerly winds.

Ahmed (1985) confirmed that and illustrated the most monthly and hourly periods of climate as shown in Fig. (2). Also Chojnacki (2003) has noted that temperatures of over 50.0°C have been recorded. Ghadames rises about 340 to 370 m above sea level. Relative humidity of the air ranges from 72% in winter to 17% in summer. The average monthly climate indicators in Ghadames based on 8 years of historical weather readings cited by climate-zone.com are shown in table (1). As can be seen in the (Figure 2 and Table 1), the maximum average temperature during (1985 to 2007) has been increased from two to three degree in most months.

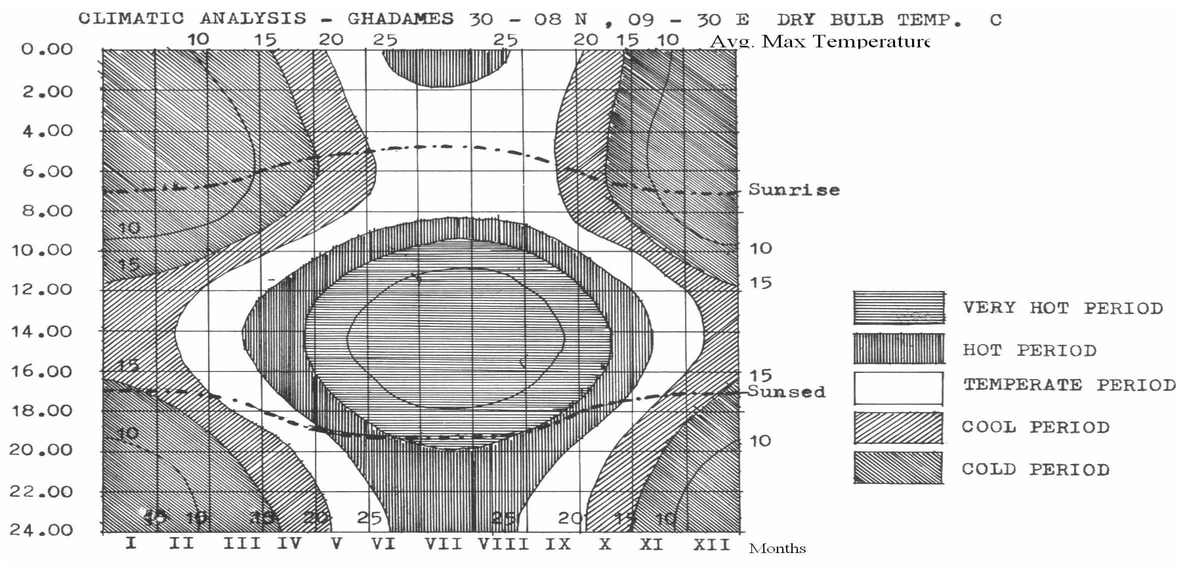


Fig. 2. Shows the hourly climatic analysis during a year (Source author cited from Ahmed 2003)

Table 1: displays the average monthly climate indicators in Ghadames
http://www.climate-zone.com/climate/libya/fahrenheit/ghadames.htm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
± *Avg. Temperature*	*11*	*13*	*18*	*22*	*28*	*32*	*33*	*33*	*31*	*23*	*17*	12
+ *Avg. Max Temperature*	*17*	*20*	*25*	*28*	*35*	*39*	*41*	*40*	*37*	*30*	*24*	18
− *Avg. Min Temperature*	5	*7*	*11*	*15*	*21*	*23*	*25*	*26*	*24*	*17*	*11*	6
Avg. Rain Days	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	0
Avg. Snow Days	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	0

5.2. The Characteristics of the City Form

The architecture of the old city in Ghadames (map, 2) is well adapted to desert life. It includes an almost unique system of covered streets with formally arranged squares, to bring together the compact form and reduced exposure to the sun and the proved complete privacy of family life and suitable conditions for social (Chojnacki, 2003, Azzouz, 2000).

In order to create a comfortable internal microclimate, traditional architecture in Ghadames, responds to the harsh desert climate through: protection, modification & adaptation. Protection from extreme solar radiation, high temperatures and dusty wind, then modifying and adapting to these harsh conditions, through sensitive and conscious solutions, construction technologies and well-studied planning and design by using suitable building materials of certain thermal properties that corresponded to the ambient environment (Al-Zubaidi, 2002).

El-Fortea (1989) described the building composition as firmly grouped together and constructed vertically rather than spreading out horizontally. He explained that a tight cluster of houses creates its own cooling system by keeping the streets free from direct sunlight and maintaining the temperature at relatively modest levels, even on the hottest summer days. The small windows located in the narrow gaps between houses help to draw in cool air from the openings and the house entrance which, in turn, cause a movement of cool air in the streets, providing in this way, an almost ideal ventilation system.

The main principles of shaping the old part of the town and the nature of the traditional housing construction are;

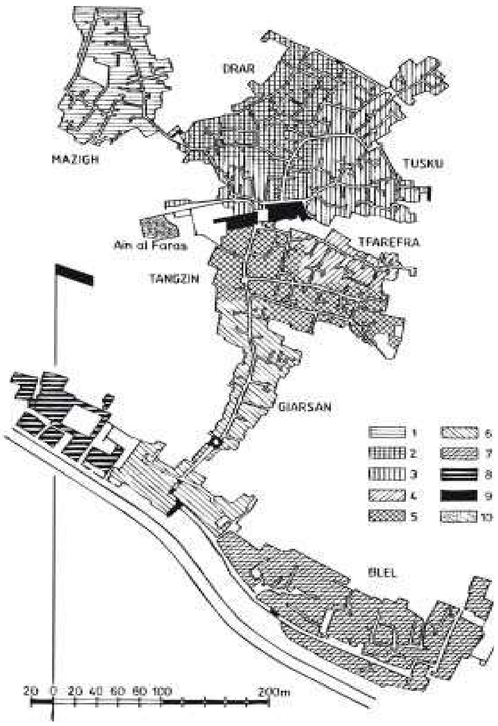
- Compact urban fabric fig(3):
- Covered streets fig (4):
- Narrow passageways :
- Exclusively design houses:
- Building materials and construction.

These principles help to minimize the thermal load on the building envelope and provide comfortable conditions even in the summer time. The streets are also built in a way which makes it possible to maintain a favorable microclimate, functioning together with the buildings as a single, compact structure to keep the temperature and the humidity of air at a satisfactory level fig (5). In addition to reduced exposure to the sun, it provides full privacy of family life and suitable conditions for social life.

The normal streets are used by men fig (6), whereas the roofs are used by women for general circulation. According to that the height of roofs to the entire city remains the same and reaches 10m. According to Al-Zubaidi, (2002) the design of the streets was adapted as one of the most important planning solutions in desert cities because the streets, ventilated and lighted from frequently small openings each 15 m which makes different pressure zones, the air movement from high-pressure zones to low pressure zones, where the hot air is replaced with cooler and humid air in the shaded passageways.

Fig. 3. An over view of Ghadames old city

Fig. 5. Top view perspective for the city of Ghadame



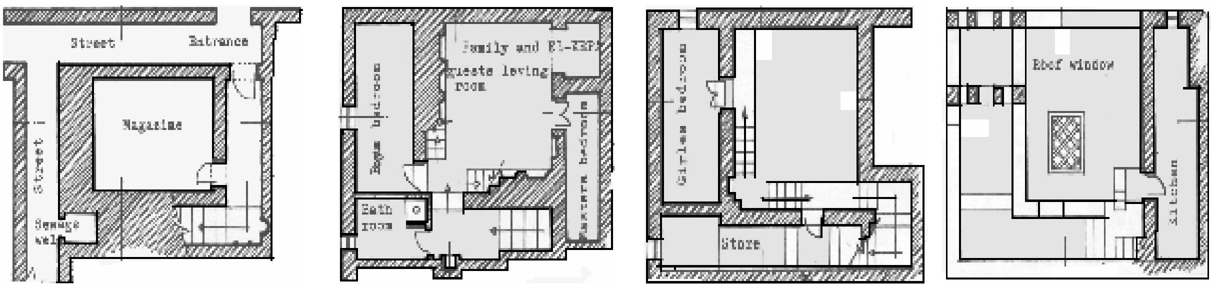
Map .2. Ghadames - plan of the old town
Source (Chojnacki, 2003)


Fig. 4. covered streets   Fig. 6. meeting spaces
Figures (3,4,5,6) source (Almansuri, 2000)

5.3. Type of traditional housing

Houses are attached by two or three sides. They comprise of a number of spaces extending on three levels. Men used the first floor and women lived on the top where they could meet each other or call across the roofs in complete privacy from the men, also they could use the roads located at ground level when they needed to. Figure (7) illustrates the design concept of one of the old city houses which includes four levels. The ground level consists of the man entrance, lobby, storage area (which receives ventilation from the entrance door), a small space for sewerage located under the toilet (open only from outside towards the green areas) and stairs leading to the toilet which is located between the first and second floor. The first floor includes the main central hall known as the '*Sadr el-beit*' used as a living and guest area and leads to other bed rooms and storage areas in different levels. This hall is often characterised by an artistic masterwork with brass pots, plaited fabrics, and mirrors to reflect the light Fig.(8). The hall is more than 4m high Fig. (10) and includes a sky-opening centered in the ceiling with a maximum area of 1m square for supplying light and ventilation Fig. (9). The open roof/terrace is used to prepare meals and also to sleep during summer nights.

The upper level of the house mostly forms an open terrace; it includes high walls to provide privacy and help in circulating the air, this area is kept for women's use for two reasons. Firstly, because all dwellings' roofs are connected, women can move freely from one house to another through these connections Fig (5), and secondly, the kitchen is located on the upper floor (Daza, 1982).



Ground floor First floor Second floor Roof floor
Fig. 7. Plans of a typical house in Ghadames- Libya (Source author cited from Ahmed 2003)

Fig. 8. Shows the interior space

Fig. 9. Shows the roof opening

Figures (8,9,10), source (Almansuri, 2000)

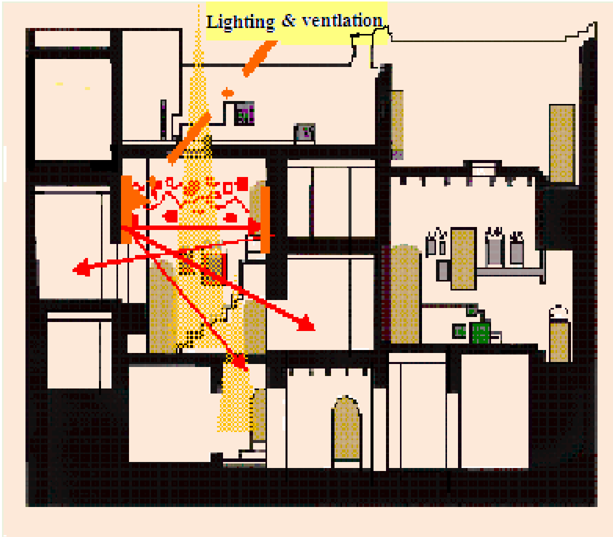


Fig. 10. Longitudinal section in Ghadames's houses shows the different levels and the concept of lighting and ventilation.

5.4. Building materials and Construction system

The primary elements in the construction of the dwellings are the local available materials.

Building elements of walls and roofs had sufficient thermal resistance. They consist of heavy, thick walls of mud, stone and hay that were composited, shaped in blocks and seasoned for over a period of a year (Azzouz, 2000). According to Daza (1982) the main material for walls was 'sun dried brick' which was made out of earthy clay mixed with water, formed in a rectangular wooden frame and then dried in the sun. Corresponding to wall thickness, the size of the bricks is measuring (0,60x 0,40) m in the ground floor, (0.50x 0,40) m at first floor and (0,40x 0,40) m at top floor (Al-Zubaidi, 2002).

Walls, arches and vaults were built using the clay as a mortar to connect the courses of bricks together. Stone was used as a foundation and some times used in the parapet wall fig. (11). They used the palm trees as the beams for roofing fig. (12). and to make doors and shelves fig. (13). Branches of the palm tree were used as a flooring surface which was then covered with palm tree leaves; they also were used as a base for roofing substances, such as clay mixed with sand and small pieces of stone, a surface was then plastered and finished with limestone white wash fig. (14).

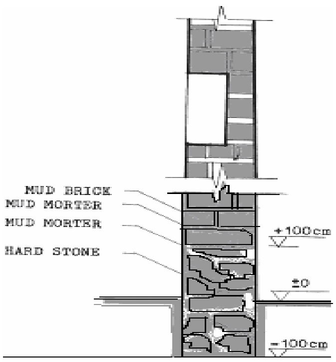


Fig. 11. The wall and foundation
Source (Ahmed, 1985)

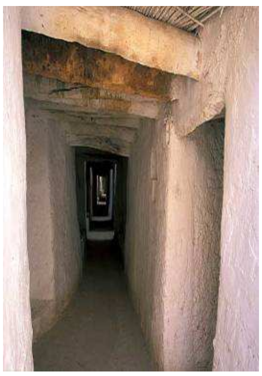


Fig. 12. The roof materials

Fig. 13. Door materials

Figures (12, 13) source (Almansuri, 2000)

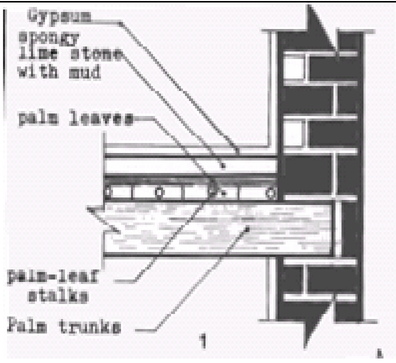
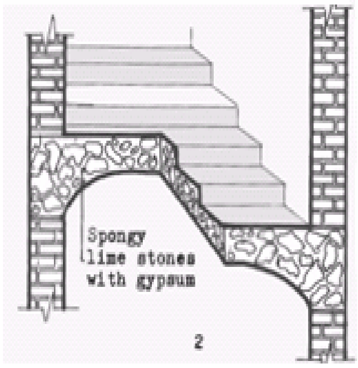
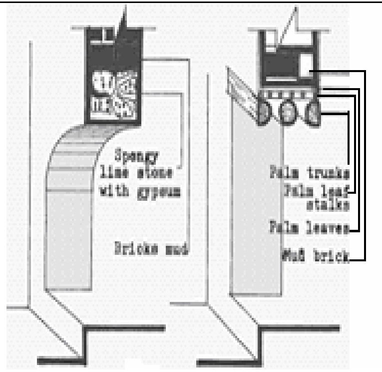
 Section showing the construction building and how it was constructed	 Isomtrical section showing the Staircases construction	 Isometrical section showing the two methods of the lintels construction.

Fig. 14. Shows the building materials and method of construction source author based on (Ahmed, 1985)

5.5. Thermal Performance of traditional Building

To achieve optimum comfort and energy savings, the building envelope should integrate design of building form and materials as a total system and the way they will operate towards the heat transference through it and modify the internal climate of the building in reaction to the external climate. In Ghadames, the effects of the variation in outside temperatures and extreme solar radiation are the most clear climate conditions that affect on the interior of a building (Al-Zubaidi, 2002). Ahmed (1985) found that the thermal comforts inside the old houses in summer and winter times as shown in fig (15) were always temperate.

An article about an investigation into thermal comfort in the summer season of Ghadames, Libya by Ealiwa et al. found the results of the survey that the occupants have an overall impression of higher standards of thermal comfort in old buildings than in new buildings (Ealiwa, 2001).

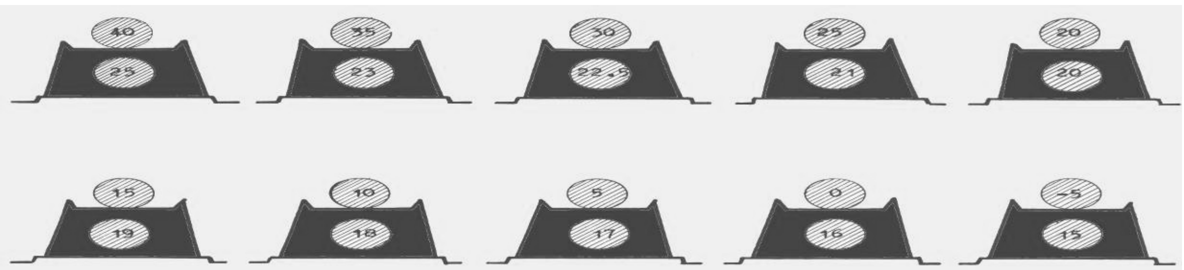


Fig. 15. The difference in temperature inside and outside Gadames old houses (Source:Ahmed, 1985)

6. Results

This paper concludes that the architecture of the old city of Ghadames is well adapted to desert life as shown in fig. (16). and succeeding to provide a sustainable environment according to its characteristics which will illustrate as follows;

- Achieving comfortable living space in a cruel climatic region.
- Producing strong social bonds and representing a clear expression of the socio-cultural requirements.

- Providing protection from the heat and sun for those out in the street and improving the circulation of air in houses by covered and winding some streets which led the wind moving fast.
- Using Local materials.
- The design of the house reflects the expected modesty between males and females through their complete separation.
- The layout provides visual privacy from outside and allowing members of the household to be in contact with outside through the roofs.

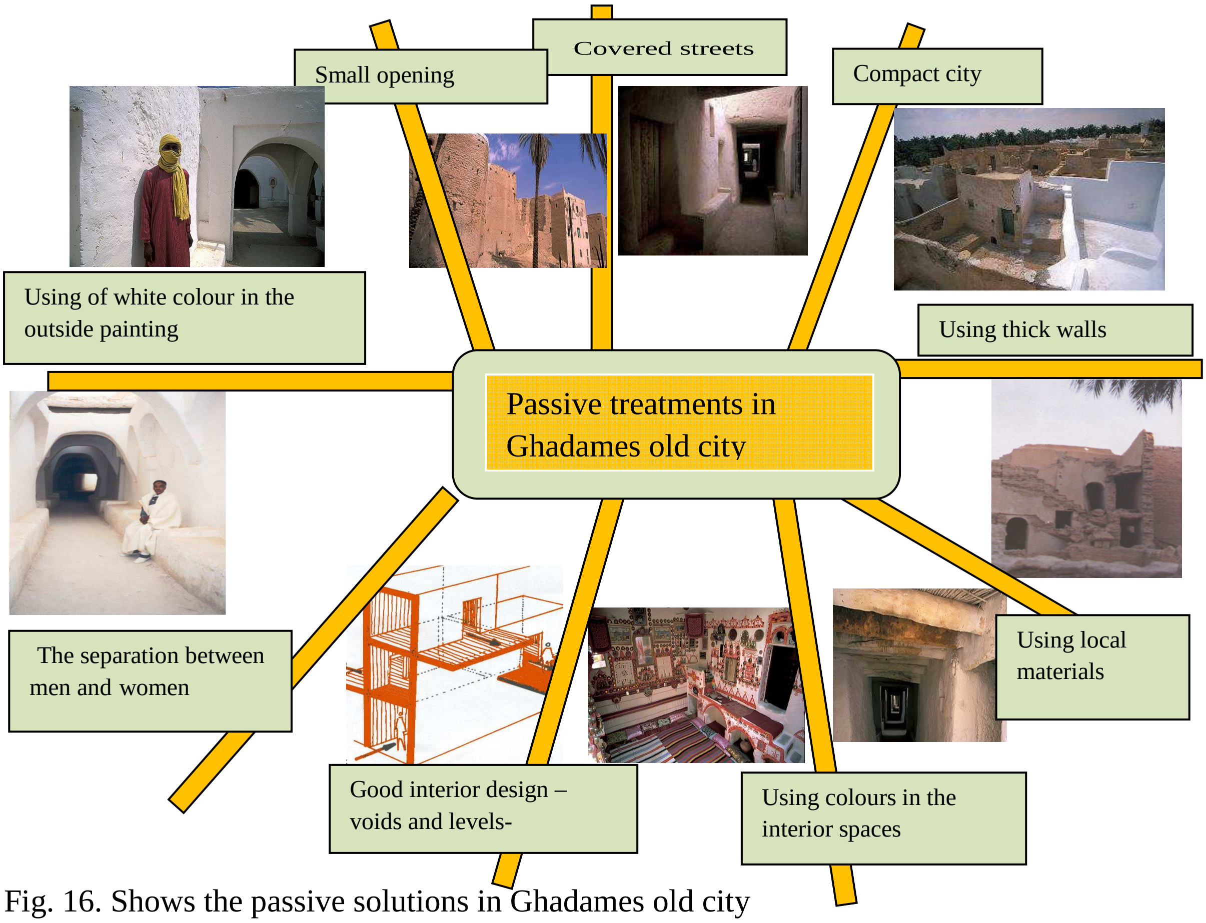
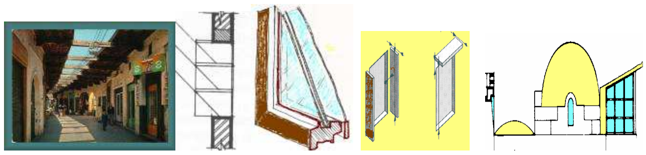
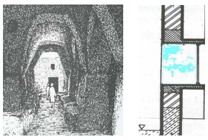
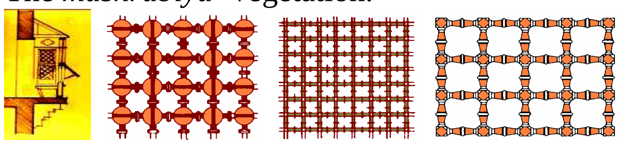
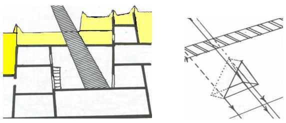
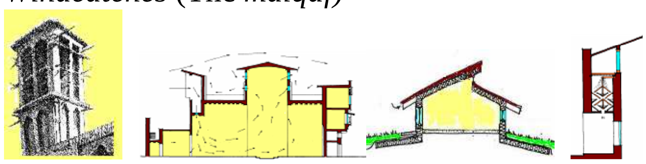
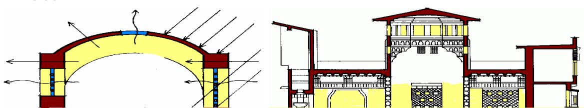
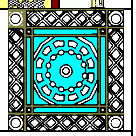


Fig. 16. Shows the passive solutions in Ghadames old city

7. Discussion

As it has been stated in section (6) the results shows that how people before many centuries could adapt their buildings to a harsh climate, However, according to the changes in life style, improvement in building materials and development of building technology, these solutions (as it is) can not meet the nowadays human needs, but lessons still can be learned from vernacular architecture and these solutions can be improved to meet today's needs as shown in Table 2.

Table 2: Design strategies in hot arid regions

The problems	Traditional solutions	Proposed solutions
protection from the heat and sun-	Compact city – covered streets- small openings- bright colours- Thick walls- Local materials 	Shading devices and vegetation to shade streets- The proportion between buildings heights and streets width- bright colours double glazing small openings- Sun-breaker- Arching the roofs - Shading the roofs- Improving the local materials and using thermal insulation-  
protection from dust	Compact city – wood shutter . 	wood shutter on small openings -ventilation blind The *mashrabiya*- vegetation. 
ventilation	Roof opening- the staircase-small opening in the covered streets 	Improve the roof opening -The position of the small openings- The staircase – *Windcatches* (The *malqaf)* 
Lighting	Roof opening- small opening – the staircase – using mirrors and metal – bright colours	Improve the roof opening -The position of the small openings – bright colours- using mirrors and metal 
Humidity		Use the fountain inside the buildings and in the open spaces. 

8. Conclusion

Because sustainable development and approaches intended at reducing environmental impacts and increasing environmental performance are become a very important issue, organizations should look forward to them.

Since the early times, while designing or constructing the buildings from the very different areas of the world, man has used the ideas from nature and has interpreted the objects and structures in nature through their cultures. The signs of the nature can be seen from Ghadames old city. One of the main conclusions of this study is that some concepts and methods that have been used for conception planning and environmental control can be learned and re uses it in future environmental planning.

The paper explains that Ghadames traditional houses can provide a desirable microclimate the whole year round without special air conditioning devices. It has confirmed to be most successful and appropriate in these conditions, by providing its own ventilation and insulation system through the structure of the buildings which is compact and integrated into the hole context in which it is hardly to make a distinction the individual houses.

This paper shows to what expand the local architecture in Ghadames respected the nature, and gives the best examples of the most environmental architecture related to time and place. It has managed to adapt to the climate with considerable success and lessons should be drawn from it in forming recommendations for future.

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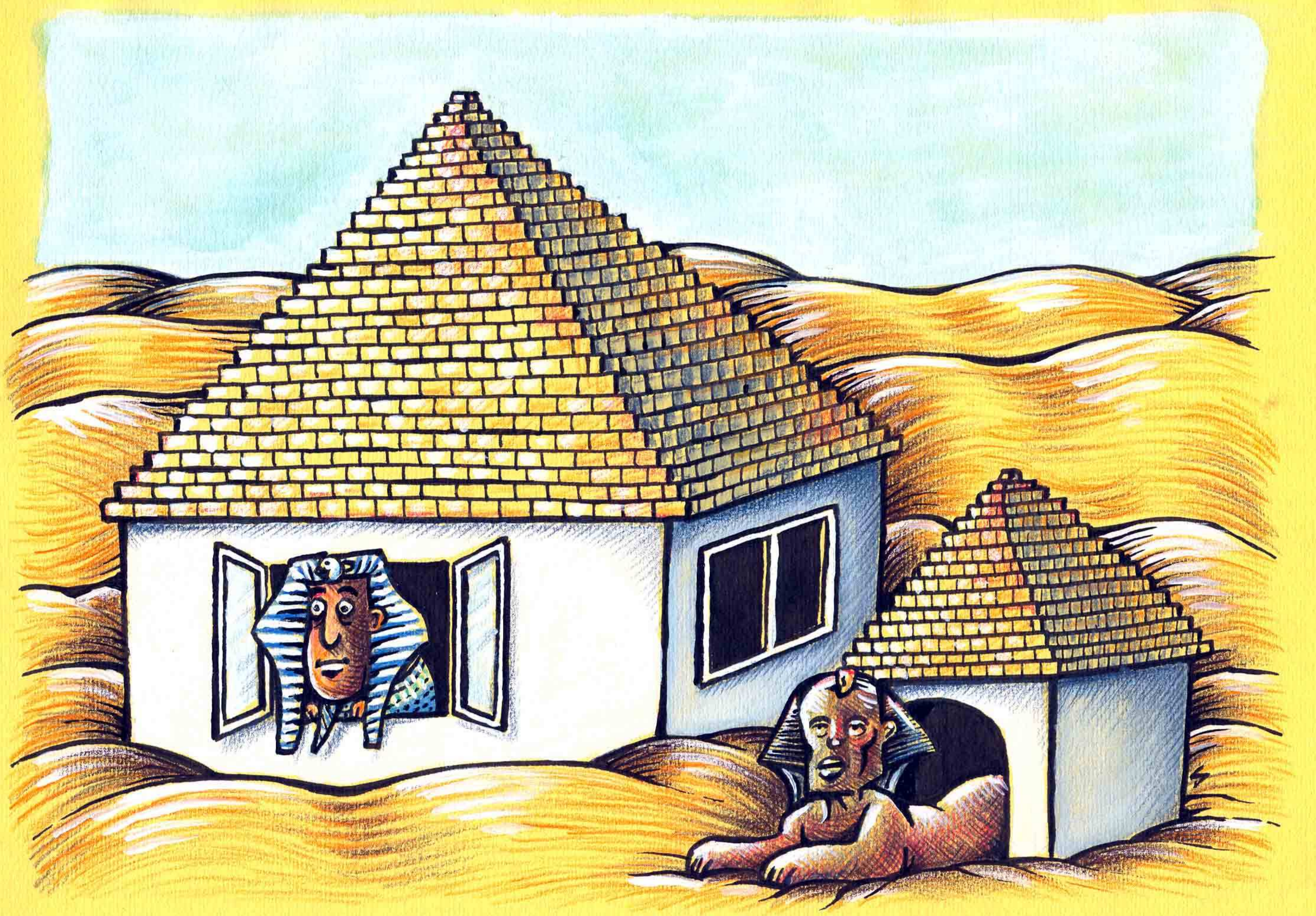

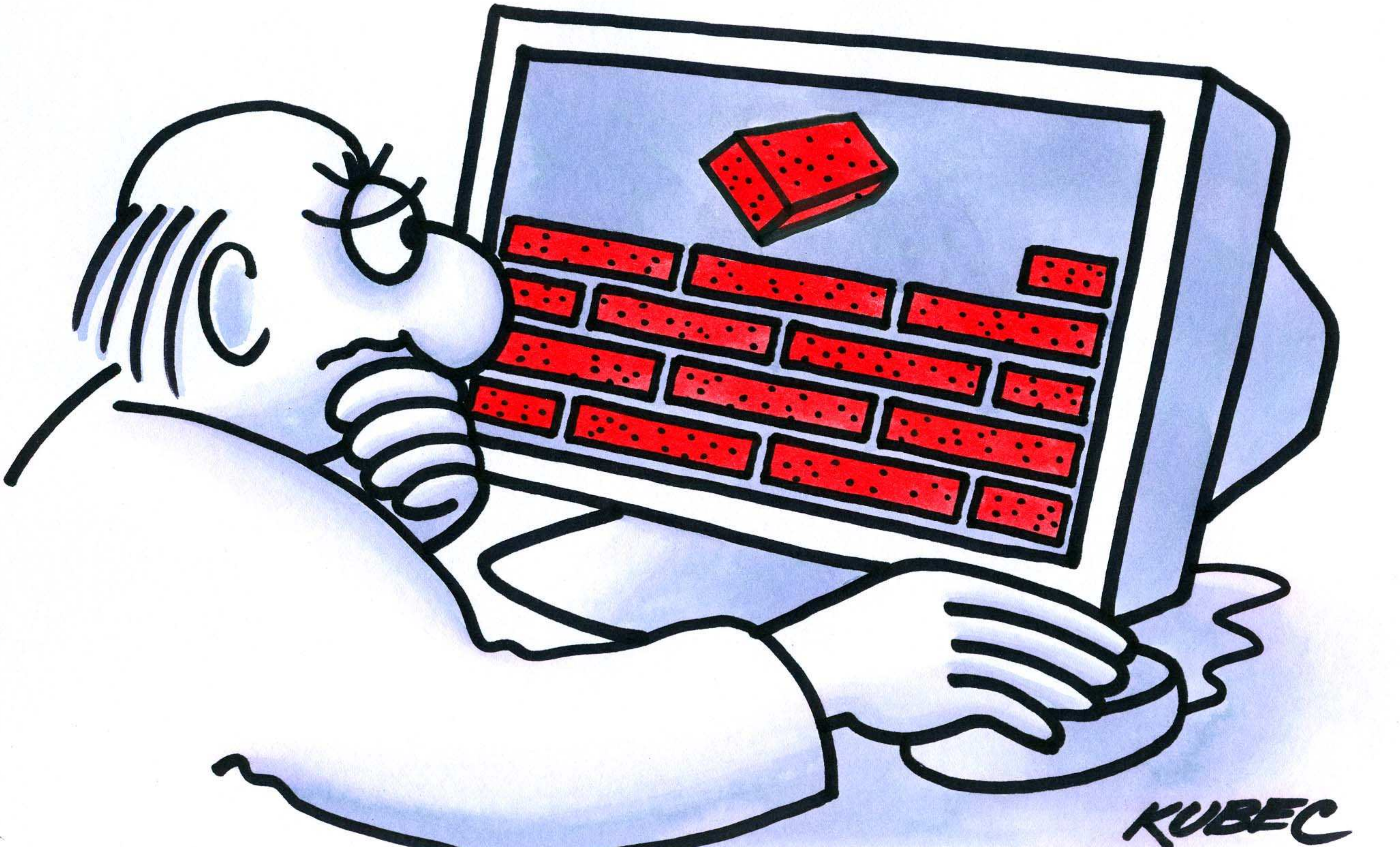
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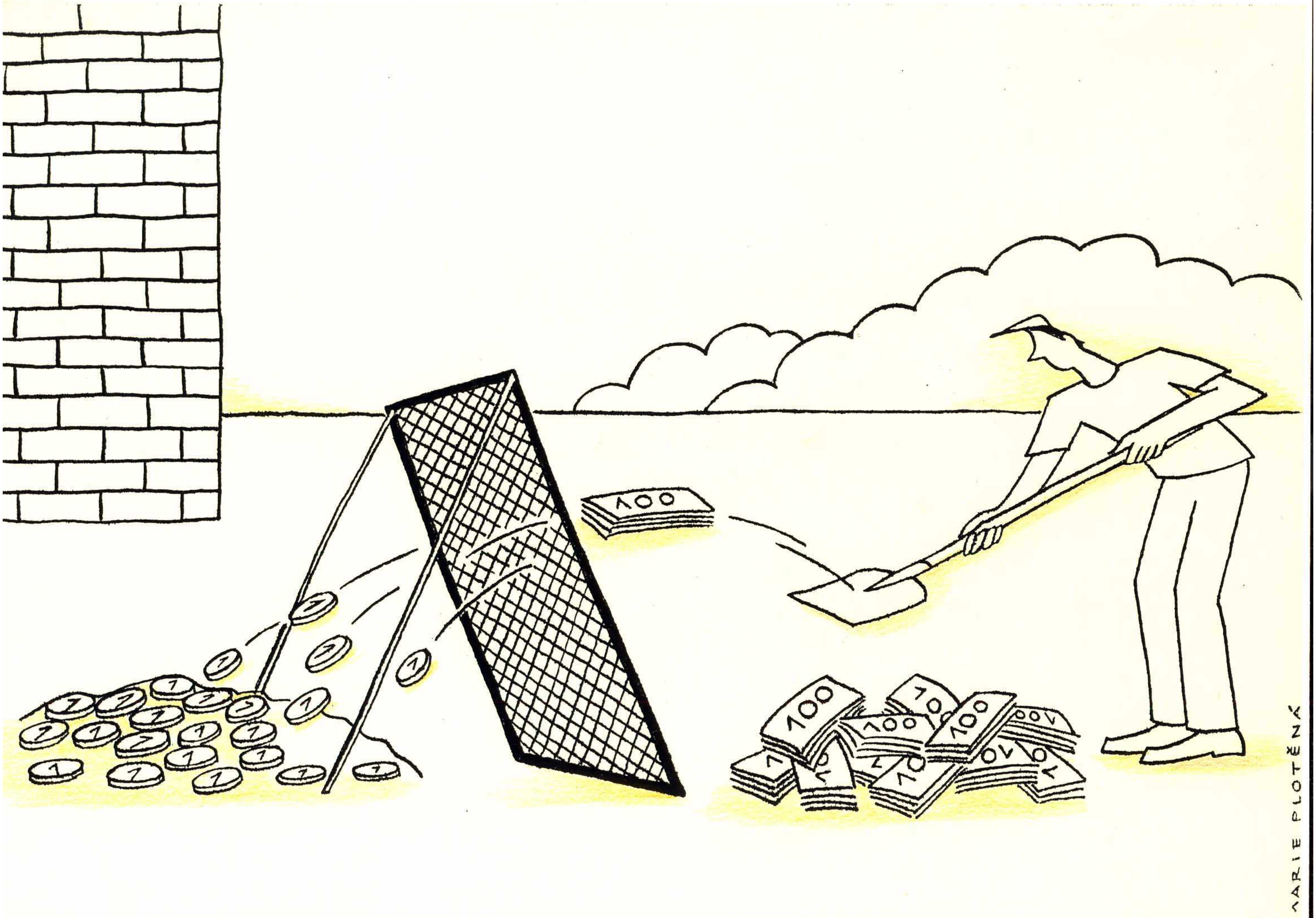
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