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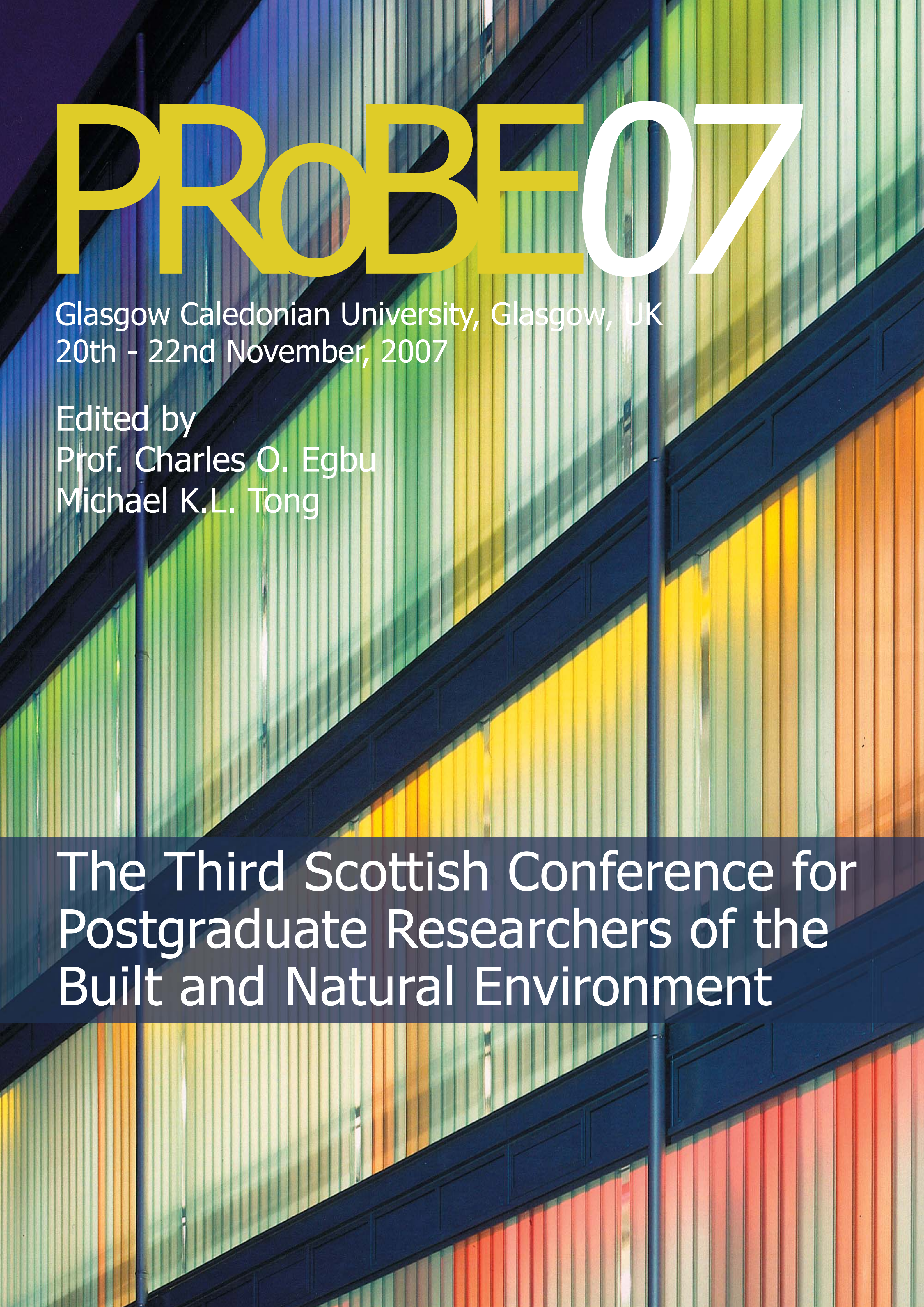

The Third Scottish Conference for Postgraduate Researchers of the Built and Natural Environment

PROCEEDINGS OF THE THIRD SCOTTISH CONFERENCE FOR POSTGRADUATE RESEARCHERS OF THE BUILT AND NATURAL ENVIRONMENT (PRoBE)

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GLASGOW CALEDONIAN UNIVERSITY

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FOREWORD

The Built and Natural Environments have a profound influence on the quality of life at home and work of everyone. The built environment is ‘the result of human intervention in the natural physical world, where places with different characteristics and identities are created, and the means to keep them functional and interdependent are established’.

The built environment plays an important role in the social fabric of the nation, through the provision of appropriate and affordable housing stocks. Construction processes and their functions, desirability, cost, sustainability and utility of finished products and services therefore affect the quality of life of everyone. Through the provision of infrastructure projects for other industrial sectors, the built environment also impacts upon major transport infrastructure such as road networks, rail networks and airports. From a sustainability perspective, the built environment addresses the notion of environmental impact of air, water and land on human life and on different ecosystems. From a planning and regulations standpoint, the built environment considers the importance of permissions for proposals likely to have a deleterious impact on existing or planned adjacent uses because of visual intrusion, noise, vibration, atmospheric pollution, unusually high traffic generation, unusual operating times, or any other characteristic which in the opinion of the relevant local Planning Authority would constitute bad neighbourliness.

The natural environment covers a host of areas and our management of the natural resources. This includes such issues as pollution, waste management, land and water management.

This conference is the third Scottish Conference for Postgraduate Researchers of the Built and Natural Environment (PRoBE). The main aim of the conference is to provide an avenue for postgraduate researchers in academic institutions in Scotland, UK and beyond, to share and exchange research information and knowledge in the areas of the built and natural environment. It is also intended that the conference would help to enhance research and presentation skills for up and coming researchers. In addition, it provides a forum for postgraduate researchers to debate and exchange ideas and experiences on a broad range of issues related to the built and natural environments.

This book contains papers which have undergone a two-stage paper review process. The first involved the review of each paper abstract by two members of the International Scientific Committee. The second stage involved the review of each full paper by three members of the International Scientific Committee. Of the ninety eight (98) papers initially submitted, forty-seven (48) papers have been selected on the basis of the strict review of the International Scientific Committee members to ensure a good quality standard. The papers in this book have come from many parts of the world, including China, Nigeria, Ghana, Australia, Canada, Denmark, Netherlands, Luxembourg, South Africa, Pakistan, Wales, England and Scotland.

Professor Charles Egbu

(Chair: International Scientific Committee and Local Organising Committee)

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The reader should verify the applicability of the information to particular situations and check the references prior to any reliance thereupon. Since the information contained in the book is multidisciplinary, international, research and professional in nature, the reader is urged to consult with an appropriate licensed professional prior to taking any action or making any interpretation that is within the realm of a licensed professional practice.

ACKNOWLEDGEMENTS

We are very grateful to the many people and organisations who have contributed to the success of the conference: authors, delegates, local organising committee and the international scientific committee. We are particularly thankful to the sponsors of the conference who have provided us with the funds and Prize Awards for Best Papers and Presentations:

Scottish Enterprise, Glasgow, Scotland, UK
Association for Project Management (APM)
Emerald Property Journals
Glasgow Caledonian University (GCU), UK
International Council for Research and Innovation in Building and Construction (CIB)
Journal of Engineering Design and Technology

We would like to thank our Keynote Speaker: Prof. Andrew Dainty (Loughborough University, UK).

We are also grateful to Mrs. Janet Anderson (Conference Administrator, GCU) who worked tirelessly with the administration and smooth running of the conference. Our thanks also go to Ms. Olivia Gill (GCU) for the design of the cover of the proceedings.

Finally, this conference is supported by Glasgow Caledonian University CIB Student Chapter. We are grateful to all the committee members of the Student Chapter for all their efforts in making the conference a success.

Editors:

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A CALL FOR METHODOLOGICAL PLURALISM IN BUILT ENVIRONMENT RESEARCH

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Abstract: As management-oriented research in the built environment has grown and matured over last thirty years, it would be reasonable to expect that the methodologies employed by researchers will have diversified to reflect the multiple traditions and perspectives from which researchers now draw. However, an analysis of the methods used reveals that the ongoing maturation of the discipline has seemingly done little to promote either methodological pluralism or a diversity in the methods employed by management researchers. This paper examines the impact that methodological uniformity and a lack of adventure in interpretative research design is likely to have. It is argued that those engaged in social science research IN the built environment could usefully embrace the emerging principles of multi-strategy or 'multimethodology' research design in order to better understand the complex network of relationships which shape industry practice. This radical perspective eschews traditional dualisms by positing the view that no single methodology can ever provide a complete picture of the complexities of projects and organisations. However, researchers must show courage and adventure if they are to challenge the paradigmatic intransigence which is seemingly so pervasive within the built environment research community.

Keywords: epistemology, management, methodology, methods, paradigm.

1. INTRODUCTION

The past thirty years have witnessed an exponential growth in what can be broadly termed management research for the built environment, a trend which has inevitably led to a growth in the number of researchers engaging in social research. A fundamental question confronting anyone doing social research is for them to construct a philosophical position and orientation towards their enquiry. Unlike many domains which have established practices stemming from a deeply rooted domain knowledge base, construction management is a relatively new field which lies somewhere between the natural and social sciences. As such, many different theories of knowledge or paradigms compete for methodological primacy. Researchers draw from both traditions when designing their research projects in a way which remains sensitive to the theoretical and philosophical foundations upon which their enquiry is based. However, the extent to which this has resulted in a plurality of methodological perspectives is questionable. For many years construction management has been subject to the ascendancy of positivism and quantitative method (Fellows and Liu 2003). This has promoted an orthodoxy of the application of natural science methods to the study social phenomena and an attendant focus on *explaining* human behaviour. In contrast, proponents of interpretivism, as an alternative paradigm, espouse the importance of *understanding* human behaviour. This has an emphasis on the empathetic comprehension of human action rather than the forces which shape it (Bryman and Bell, 2003: 15-16). This perspective arguably has the potential to provide complementary insights enriching understanding of the perspectives of those who work in the sector.

Around 12 years ago some of the leading researchers within the construction management research community debated the merits and demerits of different theoretical and philosophical perspectives on methodologies from different research paradigms. This debate was initiated by two papers in particular (Seymour and Rooke 1995; and Seymour *et al* 1997), which questioned the dominance of the rationalist position which seemingly underpinned most research within the community, suggesting that this tacitly endorsed the very attitudes in need of change in the industry. They suggested that the culture of research must change if researchers were to have an influence on the industry. Seymour *et al* (1997) further questioned the dominance of the scientific theorising associated with realist ontological and epistemological positions given that the 'object' of most construction management research is people. These papers invoked a vigorous and somewhat polarised response around the relative merits of different research approaches. Seymour and his colleagues were accused of being 'anti-scientific' and of propagating an approach which has yet to yield productive output, theories or progress (Runeson 1997). Further, they were accused of promoting an approach more akin to consultancy than research, and of advocating methods which themselves have been widely criticised within the sociological literature (Harriss 1998). Seymour and Rooke (1995) were also accused of setting out battle lines in the way that they dichotomised rationalist and interpretative paradigms to the detriment of research standards (Raftery *et al* 1997). Seymour and colleagues defended their position by counter claiming that Raftery *et al* themselves undermined standards by failing to recognise that different methods suit different purposes and that their position was symptomatic of the widespread confusion over terms such as 'method', 'methodology' and 'paradigm' (Rooke *et al* 1997). They also questioned Runeson's definition of 'science', defending the rigour of methods associated with the interpretive paradigm and their value in establishing the meaning ascribed by the actors studied (Seymour *et al* 1998).

More than decade on, a number of questions emerge in terms of the legacy of this debate in terms of the impact it has had on management research in the built environment. Firstly, have alternative research paradigms been embraced, or did the construction management community merely revert to its traditional adherence to positivism and quantitative methods? Secondly, do those within the construction management community draw upon a greater diversity of methods to enrich their understanding of the actuality of practice from the perspectives of those who work in the sector? And thirdly, has their been a move towards mixing paradigms and methods, or have the rival camps within the construction management research community remained entrenched and dichotomised within their own ontological and epistemological communities? This paper aims to attempt to provide some answers to these questions in order to establish whether the debate has had a lasting legacy on the way in which management researchers in the built environment now 'do' research.

2. RESEARCH STRATEGY AND DESIGN

Research methodology in social enquiry refers to far more than the methods adopted and encompasses the rationale and the philosophical assumptions that underlie a particular study. These, in turn, influence the actual research methods that are used to investigate a problem and to collect, analyse and interpret data. In other words, research methods cannot be viewed in isolation from the ontological and epistemological position adopted by the researcher. In philosophy, ontology refers to conceptions of reality; objectivist ontology sees social phenomena and their meanings as existing independently of social actions, whereas contructivist ontology infers that social phenomena are produced through social interaction and are therefore in a constant state of revision (Bryman and Bell, 2003: 19-20). Epistemology refers to what should be regarded as acceptable knowledge in a discipline (ibid: 13). Epistemological perspectives are bounded by the positivist view that the methods of the natural sciences should be applied to the study of social phenomena, and the alternative orthodoxy of interpretivism which sees a difference between the objects of natural science and people in that phenomena have different subjective meaning for the actors studied. Understanding the influence that competing paradigms have on the way in which research is carried out is fundamental to understanding the contribution that it makes to knowledge. Taking Kuhn's (1970) definition of a paradigm as a cluster of beliefs and dictates of how research should be done, different research paradigms will inevitably result in the generation of different kinds of knowledge about the industry and its organisations. This perspective sees different paradigms as incommensurable, and so the choice of which paradigm to adopt fundamentally affects the ways in which data is collected and analysed and the nature of the knowledge produced.

In broad terms, the term 'research design' refers to the process of situating the researcher in the empirical world and connecting research questions to data (Denzin and Lincoln 2000). In other words, it describes the ways which the data will be collected and analysed in order to answer the research questions posed and so provides a framework for undertaking the research (Bryman and Bell 2003: 32). Making decisions about research design is fundamental to both the philosophy underpinning the research and the contributions that the research is likely to make. For example, qualitative research stresses ecological validity, the applicability of social research findings to those that exist within the social situation studied. Choosing a reductionist approach to examining social phenomena (such as questionnaire survey) is likely to distance the enquiry from the social realities of the informant, thereby undermining its ecological validity. Thus, methods are inevitably intertwined with research strategy.

Without wishing to dichotomise or pigeonhole management researchers within the built environment research community, it is important to distinguish between the different types of research conducted as a backdrop to discussing the diversity of the methods employed. In broad terms researchers adopt either an objective 'engineering orientation' where the emphasis is on discovering something factual about the world it focuses on, or a subjectivist approach where the aim is to understand how different realities are constituted. Whilst the former emphasises causality and generalisability, the latter focuses on localised subjective meaning. In this paper a distinction is also drawn between 'quantitative' and 'qualitative' research. Whilst this distinction is considered by some as unhelpful (Layder 1993), it nevertheless provides a useful framework for categorising the methods used by researchers. Indeed, it can be argued that quantitative and qualitative research methods are themselves rooted in particular ontological and epistemological foundations (i.e. objectivism and constructivism, and positivism and interpretivism respectively). Accepting this association between research methods and research paradigms enables philosophical differences in the role that theory plays in research to be viewed through the lens of the methods employed by researchers. In other words, the methods employed can be used as a proxy for the paradigm adopted.

3. THE DOMINANT RESEARCH PARADIGM WITHIN CONSTRUCTION MANAGEMENT

In order to examine the methodological positions and research methods adopted by management researchers, an analysis was carried out of every paper published in *Construction Management and Economics* in Volume 24, 2006 (see Dainty 1997). Each paper was scrutinised for statements as to the methodological position of the author(s) and the methods employed. Where this was not unambiguously stated within a defined section of the paper, efforts were made to identify the methods adopted from the narrative description of the research. In some cases no discernable empirical research methods were adopted as the paper was a review-type contribution. In other cases papers drew upon a multi-paradigm research design. These papers were defined as 'review' and/or 'mixed methods' respectively. Thus, four broad classifications were used for summarising the methodologies adopted, namely: *Quantitative* – unambiguously adopting quantitative methods rooted in a positivist research paradigm; *Qualitative* - unambiguously adopting qualitative methods rooted in an interpretative research paradigm; *Mixed methods* – comprising a combination of both inductive and deductive research methods; and *Review* – not utilising empirical research methods. For those papers which reported research which adopted a qualitative (2) or mixed method (3) approach, a further sub-classification step was undertaken to categorise the methods used. These categories were established inductively and were not based on an *a priori* classification of research methods. In this respect, the interpretation of the methods adopted by the papers studies is itself interpretative. This was necessary as some authors did not unambiguously state their adopted methods. The qualitative methods adopted by the authors comprised interviews (semi-structured and unstructured), focus groups and group interviews, observation (non participatory and/or participatory including ethnography), document or other textual analysis and visual data analysis.

Table 1 presents an overview of the methods used within the research reported in the papers reviewed. These data represent the number of papers utilising the methods embodied by the broad classifications listed above. This shows that of 107 papers and notes published in Volume 24 of the Journal, 76 used quantitative methods. Only 9 used qualitative methods exclusively. In addition, a further 12 papers used a mixed methods approach combining qualitative and quantitative methods. It should be noted that in a few of the studies which have been classified as utilising exclusively quantitative approaches, a brief mention of exploratory interviews was made, although none of this data was reported in the data. The fact that they didn't warrant reporting in the papers provides justification for excluding them from the 'mixed methods' classification. Table 2 presents a breakdown of the types of qualitative methods employed by those employing only qualitative methods and those adopting a mixed methods approach. In this table, papers have been classified under each category if the particular method has been utilised and the results reported in the paper. Thus, this reflects the number of times that a method was applied across the sample of papers. Given that several studies employed a number of methods and datasets, this number is greater than the number of papers identified in Table 1. This table reveals that 16 of the 105 papers published in Volume 24 of the Journal used individual open-ended interviews. This represents more than three quarters of the studies employing qualitative methods.

Table 1: Broad Classification of Research Methods Reported in All Papers (excluding letters and book reviews) in Vol.24 of *Construction Management and Economics* (*n*=107)

	Qualitative methods	**Quantitative methods**	**Mixed methods**	**Review/other papers**
No. of papers (% in parenthesis)	9 (8.4)	76 (71.0)	12 (11.2)	10 (9.4)

Table 2: Classification of Research Methods Reported in Papers Using Qualitative Research Methods in Vol.24 of *Construction Management and Economics.*

	Interviews	**Focus groups, workshops and group interviews**	**Observation**	**Document or textual analysis**	**Visual data**
No. of papers	16	3	2	3	1

4. DISCUSSION: THE IMPLICATIONS OF METHODOLOGICAL UNIFORMITY

The construction management research community has clearly grown and developed since the methodological debates of the mid 1990s. This is reflected in the growth of the number of peer reviewed journals and the numbers of papers published relating to the practice of construction management. Much of this work could be considered social science or sociological research aimed at understanding the social structure and patterns of interaction between those working within, and affected by, the built environment and the agencies and institutions which structure it. Much of this work is also founded on the co-production of knowledge. In other words, researchers use the real-world context of the industry as sites for developing research questions, and for conducting empirical work to examine them (Harty and Leiringer 2007). It could be reasonably expected that their methodological positions and the methods adopted may have broadened and diversified to reflect the multiple traditions from which the community now draws. However, if the contents of this volume of *Construction Management and Economics* are reflective of the community at large then is manifestly not the case. The findings raise fundamental questions, both in relation to the narrow ontological and epistemological standpoints of the research community, and in relation to the uniformity of methods that interpretive researchers employ.

Questions of social ontology are concerned with whether social entities are objective realities or social constructions built up from the actions and perspectives of social actors (Bryman and Bell 2003: 19). It would seem on the basis of this analysis that the majority construction management researchers have retained an objectified view of reality. Whilst it is by no means certain that the predominance of quantitative methods revealed in this paper is inexorably linked to positivist research philosophies (surprisingly few of the papers actually stated a methodological position within the volume reviewed), it is highly likely that this reflects on on-going adherence to natural science methodologies and reductionist approaches to social enquiry within the community. Whether this should be seen as a concern will depend upon the individual standpoint of the reader, but the construction management community's apparent reluctance to embrace methodological pluralism has undoubted implications for the contribution it makes to both research scholarship *and* practice. It would seem that the research community has continued to adopt a rationalist paradigm in seeking to theorise on construction management as a discipline, with a resultant emphasis on causality over meaning (c.f. Seymour and Rooke 1995; Seymour *et al* 1997). Whilst it could be argued that the research community reflects, in microcosm, the industry's wider adherence to instrumentalist and rational solutions to complex managerial problems and situations (see Dainty *et al*, 2007), it raises questions as to the ability of the construction management research community to be able to provide a rich and nuanced understanding of industry practice.

A second issue emerging from this analysis concerns the apparent reliance of qualitative construction management researchers on open-ended interviewing. As was discussed above, in contrast with quantitative research design, which remains relatively methodologically unidimensional, contemporary qualitative research is characterised by its diversity (Punch 2005: 134). However, in the volume of *Construction Management and Economics* reviewed, virtually all of the studies which employed exclusively qualitative methods relied exclusively on semi-structured interviews. Within the social sciences, the apparent over-reliance on interviewing has been attracting criticism from researchers who see it both as symptomatic of the 'interview society' and as belying the fact that interviews are themselves methodologically constructed social products and not 'experientially authentic truth' (Gubrium and Holstein 2002). In the past, those critical of interviewing have questioned their efficacy based on practical and pragmatic considerations such as the truthfulness of the informant and the differences between what people say and what they actually do (see Hammersley and Gomm, 2005). However, a more radical critique of interviews as a research method has recently emerged in which the social construction of what is said, and the fact that they reflect the particular context within which they take place, has been seen as limiting their methodological validity. Regardless of whether such a radical perspective on the efficacy of interviews is accepted, the acknowledgement that they are in any way flawed reinforces the need for data from different sources to triangulate the inferences and outcomes that they provide.

5. THE CASE FOR METHODOLOGICAL PLURALISM IN CONSTRUCTION MANAGEMENT RESEARCH

Debates in social sciences during the 1970s focused on questioning the long-standing positivistic hegemony in sociology. This reflected the widespread realisation that there were many competing philosophies of social science and methodology rather than a single, unifying discourse. Mingers (1997: 3) noted that philosophers such as Hanson, Kuhn and Popper demonstrated flaws in the cornerstones of induction, and theory- and observer-independent observation. In social science, this legitimated the emergence of the various schools of interpretivism such as phenomenology and hermeneutics. Similar trends emerged in management science in the 1980s with the emergence of soft systems methodology (SSM) and other soft operations research (OR) approaches. It was through the challenge to the positivist orthodoxy by the emergence of phenomenological and structuralist epistemological positions that the new perspective of *methodological pluralism* emerged, the basic principle of which is that the use of multiple theoretical models and methodological approaches is both legitimate and desirable if established models and understandings are to be questioned and knowledge furthered. Adopting the principles of methodological pluralism does not render the choice of method arbitrary, but emphasises the context-sensitivity inherent in research design. Many argue that multi-strategy research design yields the best social science research because theory building requires ‘hard’ data for uncovering relationships and ‘soft’ data for explaining them (Denzin 1970; Leedy 1993).

According to Mingers (1997) methodological pluralism may be conceptualised in a number of different ways. Loose pluralism suggests that a discipline should support and encourage a variety of paradigms and methods without prescribing how they should be used and applied. Complementarism views different paradigms as internally consistent such that each would be seen as more or less appropriate for a particular situation. Strong pluralism holds that most situations are best dealt with by a blend of methodologies originating from different paradigms. In a similar vein Hammersley (1996) classifies multi-strategy research into three broad approaches. *Triangulation* refers to the use of qualitative research to corroborate quantitative research (or vice-versa); *Facilitation* is where one research strategy is employed in order to aid research using another approach; and *Complementarity* is where two strategies are employed in order to dovetail different aspects of an investigation. In management science research, Complementarism (c.f. Flood and Jackson 1991) concerns the selection of a methodology for a particular intervention rather than the combination of parts of methodologies together (Mingers and Gill 2007). The emerging paradigm of linking of different *aspects* of methodologies has been termed ‘*multimethodology*’ by Mingers and Gill, and in many respects exemplifies the principles of methodological pluralism. Indeed, Mingers (1997) refers to this principle as “strong pluralism” because of its emphasis on blending methodologies from different paradigms within a single intervention.

The theoretical attractiveness of multimethodology is that it provides a framework for utilising the plurality of methodologies in order to understand or intervene in a complex situation. Given the inherent complexity of the construction industry as an arena within which to conduct research, and the problem-focused orientation of construction management research (see Harty and Leiringer 2007), the theoretical benefits of multimethodology seem obvious. Thus, in some respects the future development of construction management research will depend upon the willingness of its research community to see qualitative and quantitative research as complimentary rather than competitive and mutually exclusive (Loosemore *et al* 1996). However, a shift towards multimethodological perspectives on research design brings with it a need to embrace a greater multiplicity of different methods. For construction management researchers this will mean a greater emphasis on qualitative enquiry. There is not room within this paper for an in-depth treatise on the multiplicity of methods that fall under the broad heading of qualitative research (see Cassell and Symon 2004), but a broader outlook with regards to the application of research methods is a pre-requisite for embracing the principles espoused above.

6. CHALLENGES IN UNDERTAKING MULTI-PARADIGM RESEARCH

As could be expected given the polarised debate which divides those in the positivist and interpretisivist camps, combining methodologies is not without its critics. Indeed, a range of philosophical, cultural and psychological hurdles confront the multi-paradigm researcher, each of which renders it a highly problematic undertaking. According to Bryman and Bell (2003: 480) the argument against multi-strategy research methods essentially rests on two arguments. Firstly, research methods carry epistemological commitments. The embedded nature of methods is such that they inexorably connected to the views of the world from the paradigm from which they originate. This ‘paradigm incommensurability thesis’ suggests that researchers must choose the rules under which they undertake research based on the fundamental assumptions that they bring to their enquiry (Mingers 1997: 13). Thus, seeking to understand a practitioner’s perspective on a situation is consistent with intepretivism, but inimical to positivism. A second challenge is that quantitative and qualitative research represent *separate* paradigms. In other words, quantitative and qualitative approaches are underpinned by different assumptions and methods which are incompatible between paradigms. Given this backdrop, it is little wonder that most researchers nail their colours to a particular philosophical mast and root their work within a distinct methodological paradigm. The danger for those eschewing the tendency to position themselves in a particular camp run the risk of finding themselves in a methodological ‘no mans land’! Thus, those embarking on this journey must have the courage to challenge the historical values which have hitherto maintained the paradigmatic intransigence of those on both sides of the epistemological divide. But it is only by demonstrating the potential of methodological pluralism that entrenched attitudes are likely to shift, and a richer understanding of the practice of management in the built environment is likely to emerge.

7. CONCLUSIONS

This paper has discussed the implications of the apparent narrowness of the construction management research community’s methodological outlook and the implications for understanding of the practice of construction. The construction management field appears to be firmly rooted within the positivist tradition. It has shown both an entrenched adherence to positivist methods within the community, and a significant reliance on open ended interviews by those adopting qualitative methods. The apparent lack of methodological diversity, coupled to an apparent lack of adventure in interpretative research design, suggests a research community rooted in methodological conservatism and disconnected from the debates going on in many of the fields from which it draws. An enduring adherence to the positivist paradigm will do little to enable construction management researchers to grasp the meaning of social action from the perspective of the actors involved.

Adopting a diversity of approaches would move the construction management research community towards a more balanced methodological outlook and would begin to challenge the dominant positivist paradigm which seems so all-pervasive within the community. This is not to suggest that there is no place for positivism in construction management research, but that used in isolation such perspectives do not provide the types of insights required. Advocating the combination of methodologies rejects some of the traditional dualisms which have seemingly pervaded the discourse of how we should undertake management research in the built environment in the past ten to fifteen years. A more expansive outlook towards mixing methodologies and research paradigms could yield deeper insights into, and understanding of, the way that practitioners 'do' management in the construction sector. Techniques such as triangulation, facilitation and complementarity (c.f. Hammersley 1996) all offer the potential to overcome the weaknesses of single-paradigm approaches, whilst multimethodology – the combination of parts of methodologies together – offers particular advantages for the use of systems or operational research techniques (Mingers and Gill 1997). However, mixing paradigms in this way will require adventure and courage on the part of construction management researchers if they are to challenge the paradigmatic intransigence which is seemingly so ingrained within the construction management research community.

8. ACKNOWLEDGEMENTS

The empirical elements of this paper first appeared in the *Construction Management and Economics* 25th anniversary conference, University of Reading, 2007 (see Dainty 2007). An extended version of this paper is to appear as a chapter in the forthcoming book entitled *Advanced Research Methods in the Built Environment* edited by Andrew Knight and Les Ruddock and published by Blackwell.

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AN INVESTIGATION OF MENTORING RELATIONSHIPS OF NEW KNOWLEDGE WORKERS IN SOUTH AFRICAN CONSTRUCTION INDUSTRY

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Abstract: This study examines the nature of the mentoring relationships available within organizations in the South African construction industry, and addresses potential negative outcomes or problems of mentoring relationships within their organizations in the construction industry. Finally, the implications of mentoring relationships are discussed in view of the cultural divide of society taking into consideration gender and race. A descriptive survey was used to conduct this research, using structured questionnaires. The need for future research is also discussed.

Keywords: construction industry, mentoring, new knowledge worker.

1. INTRODUCTION

How do companies compete, build and maintain viable businesses in a rapidly changing global, marketplace and business environment? A major part of the answer is *"high quality human capital"* Aron (2001). Chand, (2006) and Aron (2001) further indicates that companies with high quality human capital perform better in the marketplace, and deliver higher and more consistent returns to shareholder than companies with mediocre workers. Competitive organizations worldwide in the information age rely on their employees to provide innovative, advantageous and original solutions to problems the companies may have. However Aron (2001) points out that the shift to the new economy has brought with it free agent market for skilled people.

Although implementing the right technology is critical to a company's success, sustaining a skilled, highly educated and motivated new knowledge work force is an equally valuable asset. Drucker, (1994) indicates that knowledge workers are high level employees who apply theoretical and analytical knowledge, acquired through formal education, to develop new products or services [new knowledge worker can therefore be defined as a person who is being mentored and developed to be a knowledge worker][1]. Mentoring is receiving much attention from contemporary business, organizational, behavioural and psychological researchers. Mentoring has been linked to better career development opportunities, higher levels of career maturity and greater overall job satisfaction by protégés (Peluchette & Jeanquart 2000; Flouri & Buchanan 2002; Genser 1998; Parnell 1998). Mentoring refers to an interactive and dyadic relationship, (Paice *et al.* 2002).

Obtaining a mentor is an important career development experience for individuals. Research indicates that mentored individuals perform better on the job, advance more rapidly within the organization (i.e. get promoted more quickly and earn higher salaries), report more job and career satisfaction, and express lower turnover than their non-mentored counterparts (Chao, 1997; Dreher & Ash, 1990; Fagenson, 1989; Scandura, 1992; Whitely *et al*. 1992).

Therefore a mentor is viewed as a senior, experienced employee, who serves as a role model, provides support, direction, and feedback to the younger employee regarding career plans and interpersonal development, and increases the visibility of the protégé to decision-makers in the organization who may influence career opportunities (Klauss, 1981).

A number of testimonials, case studies, and descriptive research studies suggest that mentors can facilitate personal development and advancement of their protégés in the organization by providing challenging assignments, guidance and counseling and increased exposure and visibility to top management and by serving as role model (Burke, 1984; Phillips-Jones,1983).

1.1 The nature of mentoring relationship

Philips-Jones, (1983) indicates that majority of mentoring relationships are informal. That is, the relationship develops because of shared interests, admiration, or job demands that require the skills of two or more persons. In informal mentoring relationships, discussion between the mentor and protégé usually go beyond career-related issues to more in-depth personal sharing of interests, needs and values.

Many organizations have tried to formalize mentoring relationships in order to capitalize on the potential development aspects of such relationships (Noe, 1988). Although the focus of formalized mentoring programs may be on completion of designated tasks, activities, or protégé skill learning, mentors may also provide valuable counseling, coaching, and role-modeling functions for the protégé.

There is a marked difference between formal and informal mentor-protégé relationships. Many organizations have established formal mentoring programs that attempt to meet the

[1] Authors own addition.

organizations employee development needs. The relationships that are cultivated through formal mentoring programs have characteristics that set them apart from informal mentoring relationships, and may result in different functions and outcomes (Ragins & Cotton 1999; Ragins *et al*. 2000). Formal mentor-protégé relationships tend to focus on short-term goals, and protégés participating in formal mentoring programs may not perceive a commitment to them as individuals on the part of the mentor, but rather, to the program. Another consequence is that mentors in formal programs may perceive that their protégés are low performers who have been assigned to a mentor in order to improve their work performance. Consequently, the degree of mutual disclosure, authenticity and empowerment in formal relationships may be markedly reduced from that inspired by informal relationships (McDowall-Long, 2004).

Mentoring relationships are strongly correlated to career success. As stated initially protégés tend to advance more quickly in their careers, feel more satisfied in their careers and express positive psychological coping skills. Human resource development practitioners must be aware of the established beneficial outcomes of mentoring in order to assess the success of their own mentoring programs (McDowall-Long, 2004). It has been recommended that organizations encourage managers to become mentors, set up formal (assigned) mentoring programs, and link mentoring to other human resource management systems such as compensation and performance appraisal to increase mentoring in organizational settings (Burke & McKeen, 1989; Kram, 1985). Thus the following question was posed.

Most mentoring relationships develop naturally through unstructured social interaction, and are known as informal mentoring relationships. In recent years, however many organizations have established formal mentoring programs, involving assigned pairing of mentors with protégés. Despite this trend, there is a dearth of research available about the outcomes of formal mentoring and the factors that make formalized relationship successful (Feldman, Folks & Turnley, 1999). While mentoring programs are used extensively as a career development tool, most of the empirical research is either based on informal or spontaneously developed mentoring relationships or has failed to ask protégés whether or not they are involved in formal or informal relationships (Wanberg, Welsh, & Hezlett, 2003). Thus the following question was posed. *Research question 1:* What percentage of construction organizations, use formal mentoring programs?

This represents a gap in the literature since formal and informal mentorships differ in terms of how the relationship is initiated e.g. spontaneous attraction versus third party matching and other relational characteristics e.g. formality of interaction (Ragins & Cotton, 1999).

1.2 Situations associated with negative mentoring outcome or problems

Notwithstanding the benefits of mentoring stated in the literature, this does not preclude the possibility that mentoring relationships experience problems or negative outcomes (Scandura, 1998; Eby et al. 2000). Initial research on social-psychological and interpersonal relationships notes that unpleasant incidents are common and often a neglected aspect of all relationships, these ranges from minor episodes, such as arguing, to serious incidents, such as physical or psychological abuse (Marshall, 1994).

Unfortunately, no empirical studies have attempted to identify problems encountered by new knowledge workers participating in a mentoring relationship in the South African construction industry. According to Noe, (1988) additional research is needed to identify the influence of protégés' personal characteristics and job and career attitudes on both the extent of interaction with mentors and benefits gained from the relationship. Given this large body of social psychological research, it is interesting that very little research has focused on the problems or negative outcomes of mentoring. Recent research by Eby *et al.* (2000) addressed the need to research further in the area of negative mentoring in individual disciplines which might be different from one industry to another. The purpose of this study was therefore to investigate the problems encountered by new knowledge workers' in South African construction industry. This study focused more on new knowledge worker and not mentors'. Thus the following question was posed. *Research question 2:* What problems are encountered by new knowledge workers in a mentoring relationship?

1.3 The Review of South African transformation

Due to socio-political changes in 1991, South Africa moved from a paternalistic to democratic society, which has had an impact on employee-manager relations in organizations. South African organizations are in an era of rapid and spasmodic transformation as the current ambiguities result in the disillusionment of the workforce (Visser, 2003). The construction industry delivers its products in a uniquely project-specific environment that continuously involves different combinations of:

- Investors, clients, contractual arrangements and consulting professions;
- Site conditions, design, materials and technologies; and
- Contractors, specialist subcontractors, skills and the workforce assembled for each project (Construction Industry Development Board (CIDB, 2004).

The construction industry is affected by the ongoing and necessary overhaul of the public service. The South African government 10-year review process has recognized that this process has been uneven, resulting in unintended dislocation and delivery constraints that have affected a wide range of services. It has been cited that public sector capacity is a key constraint to delivery and sustainable industry growth. Lack of capacity is attributed to the following factors:

- Loss of knowledgeable personnel during the transition has led to a reduction in management and technical skills;
- The mobility of personnel has interrupted the knowledge transfer and mentoring process;
- Appointment of non-built environment professionals to key project managerial positions;
- Lack of staff with appropriate training and experience; and

- Shortage of resources (CIDB, 2004).

The rise of a highly competitive, technologically based information society has caused a great need for skilled workers. The CIDB report (2004) indicates that many of the professional consultancy sectors are rapidly loosing capacity to the international market and to other economic sectors, including finance and information technology. This is particularly acute with engineers, who are in great demand. The Engineering Council of South Africa (ECSA) records, indicate that approximately 1400 registered professional engineers have formally emigrated since 1996. These trends may result in a shortfall of professional skills in the next decade and a discontinuity in the mentoring and knowledge transfer process.

Although South Africa shows great potential in some areas, the country is plagued by major deficiencies in other areas. For example South Africa is placed 46th in "people" area on the list and 40th for "management" out of a total of 46 countries. From the aforementioned it is clear that South Africa's attempts to create human capital needed for growth needs serious attention (Hinzelman & Smallwood, 2004). Thus the following question was posed. *Research question 3:* Are the negative outcomes due to the cultural divide in mentoring relationship in terms of race and gender of new knowledge workers?

2. PROBLEM STATEMENT

The overriding research problem is to investigate the problems encountered by new knowledge workers in the mentoring relationship in the South African construction industry. The study focused more on the new knowledge worker and not the mentor.

2.1 Objectives of the research

The objectives of the study are defined as follows:

1. To determine the nature of mentoring programs that exist in construction organizations;
2. To determine the problems encountered by new knowledge workers during mentoring in the South African construction industry; and
3. To determine the implications of the culture divide in mentoring relationship in terms of race and gender.

3. RESEARCH METHODOLOGY

As stated in the literature few empirical studies have investigated negative or problems encountered by new knowledge workers during mentoring. This accentuates the need for this study. The literature review led to the identification of 16 (sixteen) antecedents variables related to mentoring problems. A descriptive survey method was adopted, which involved the use of structured questionnaire in an in-depth exploration of the constructs underlying the subject matter of the research. Creswell, (1994) describes a survey as a quantitative or numeric description of some fraction of the population – the sample, which enables researchers to generalize their findings from a sample of respondents to a population within the limitations of the sampling method.

Purposive sampling was used where the researcher selected sample members to conform to some or other criterion in this case new knowledge workers. As no sampling frame exists and no parameters are known, probability sampling could not be used. The respondents were attending either bachelor of technology civil engineering, construction management or quantity surveying for (one year full time or two years part-time, twice a week for part-time and four times a week for full time students). 80 (eighty) usable completed questionnaires were gathered of which 30 (thirty) were for civil engineering and 50 (fifty) construction management and quantity surveying students at the University of Johannesburg. This sample size was sufficient to meet the statistical test requirements for group statistical testing. As part of the delimitation process of this research, new graduates who had finished the national diploma in either, civil or building, currently employed in an organization that has a mentoring program completed the entire questionnaire. This limits the generalisability of the sample as it excludes new knowledge workers who are not working and don't have mentoring program. The geographical aspect of the sampling further limits the generalisabilty of the sample.

Purposive sampling is a non-probability method of sampling it is impossible to evaluate the extent to which such samples are representative of the relevant population (Welman & Kruger, 2001). In some respects purposive sampling gives the research qualities of a case study (Creswell, 1994). These problems generalised from the sample to the whole population of new knowledge workers are limitations of the research design and fully acknowledged in this research.

The structured questions were analyzed using the Statistical Package for the Social Sciences (SPSS) and the Number Cruncher Statistical System 6.0. This determined the frequency (descriptive statistics) of respondents who answered various questions, a mean score was determined and a standard deviation was also calculated to determine the dispersion of the respondents.

The questionnaires of the research were administered under controlled lecture room conditions to ensure the standardization of data gathering, to decrease non-response errors and to increase response rates (Cooper & Schindler, 1998). The data was gathered by the intercept method (Cooper & Schindler, 1998) using self administered questionnaires (Leedy, 1997).

The need for content validity was not established as no pilot study and pre-testing was done on the questionnaire. The reliability for internal consistency of the factors was determined using Cronbach's alpha test (Cooper & Schindler, 1998), Nkado & Mbachu, (2002), validated a scale on client satisfaction and job satisfaction, and achieved a coefficient of between 0.73 and 0.78, this is a well accepted measure for the purpose of the present study.

As the questionnaires were completed anonymously, the collection of the data and the presentation of this report cannot harm the respondents or their employing organizations in any way.

4. RESULTS AND DISCUSSIONS

4.1 To determine the nature mentoring programs that exist in the construction industry organizations

From the result in Table 1 it indicates that majority of organizations employing new knowledge workers do not have a mentoring program, of the 80 respondents only 33 respondents had a mentoring program which represents 41.25%. The nature of mentoring program differed as 60.6% were in a formal mentoring program where as 39.4% were in an informal mentoring program. This result indicates that majority of new knowledge workers are in a formal mentoring program indicating that the organizations in the construction industry both government and private sector agree to the importance mentoring.

Table 1: Type of mentoring program

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**Formal**	20	57.1	60.6	60.6
	Informal	13	37.1	39.4	100.0
	Total	33	94.3	100.0	
Missing	**System**	2	5.7		
Total		35	100.0		

4.2 To determine the problems encountered by new knowledge workers during mentoring in the South African construction industry

The problems or negative outcomes in a mentoring relationship were obtained from related literature review and were analyzed using new knowledge workers who were in a formal or informal mentoring program. A listwise deletion method was used to process valid responses, only 24 respondents were valid. A reliability statistic test was undertaken using Cronbach's Alpha and Cronbach's Alpha Based on Standardized Items, the result indicates 0.965 and 0.966 respectively, which is greater than 0.7, which indicates the variables are reliable for analysis. The variables were weighed in a likert scale of 1= Never; 2= Occasionally; 3= Fairly many times; 4= Very often; and 5= Always, the results are tabulated in Table 2 and were analyzed using the (SPSS) and the Number Cruncher Statistical System 6.0 were used to calculate the means and standard deviation of the variables. The variables means are below the midpoint of 3. Twelve (12) of the stated problems were between 1.80 and 2.60, which indicates that new knowledge workers occasionally experienced problems during mentoring. Dissimilar personality and habits, was seen as the main problem as it fell in the band between 2.60 and 3.40 indicating that it happens fairly many times. General dysfunctional i.e. bad attitudes, personal problems e.g. alcohol abuse, family problems etc and deception i.e. not being truthful were never a problem to the new knowledge workers as they fell in the band between 1.00 and 1.80.

Table 2: Problems identified during mentoring relationship

Problems identified	Mean	Std. Deviation	Rank
Dissimilar personality and habits	2.83	1.239	1
Mismatch within the dyad value i.e. objected and prejudged my views	2.42	0.929	2
Self-absorption i.e. on his own career	2.42	1.349	2
Poor Work style i.e. reactive not proactive	2.38	1.096	4
Distancing behaviour and neglect	2.38	1.377	4
Manipulative behaviour, position, power and tyranny	2.29	1.334	6
Inappropriate delegation of duty	2.25	1.189	7
Intentional exclusion	2.21	1.351	8
Credit taking	2.04	1.160	9
Politicking i.e. self promotion	2.00	1.285	10
Technical incompetence	1.92	1.100	11
Lack of mentor expertise	1.83	1.007	12
Sabotage any efforts you made	1.83	1.090	12
General dysfunctional i.e. bad attitudes	1.79	0.977	14
Personal problems e.g. alcohol abuse, family problems etc	1.75	1.260	15
Deception i.e. not truthful	1.71	1.083	16

4.3 To determine the implications of the culture divide in mentoring relationship in terms of race and gender

The result in Table 3 indicates that majority of the mentors were blacks and whites i.e. 44.1% and 41.2% respectively, as compared to either, coloureds and Indians. 41.25% of respondents are in a mentoring program, majority of them are being mentored by blacks and whites. Table 4 indicates that male mentors are dominant as, only 8.8% represent female mentors.

Table 3: Race of mentor

Race	Frequency	Percent %	Valid percent %	Cumulative percent %
Black	15	42.9	44.1	44.1
Coloured	3	8.6	8.8	52.9
Indian	2	5.7	5.9	58.8
Whites	14	40.0	41.2	100.0

Table 4: Gender of mentor

Gender	Frequency	Percent %	Valid percent %	Cumulative percent %
Female	3	8.6	8.8	8.8
Male	31	88.6	91.2	100.0

5. CONCLUSIONS

In conclusion the results indicate that majority of construction organizations do have a formal mentoring program. New knowledge workers do not experience negative outcome frequently with their mentors, apart from dissimilar personality and habits of mentors. Cultural divide is not a problem in the mentoring relationships as majority of mentors are blacks and whites, and the variables were not indicative of any problems arising. Female integration in the construction industry needs thorough discussion in order for more female mentors to be initiated in the mentoring role in the construction industry. Further research is suggested in order to close the gap that currently exists in the methodology, which to the authors is a limitation.

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THE POTENTIAL OF EARTH-AIR HEAT EXCHANGER FOR COOLING BUILDINGS IN THE UK

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Abstract: This paper identifies and evaluates the key factors in the design of earth -air heat exchangers for passive/low energy cooling of buildings in the UK. Simulation studies of the earth-air heat exchanger have been carried out in TRNSYS simulation environment. Some of the performance characteristics of the system have been analysed and the potential for cooling ambient air under UK climatic conditions have been determined. Rising summer temperatures in the UK and the pressures imposed by the building regulations to increase energy efficiency and the use of low/ zero carbon technologies in buildings make it necessary to utilise natural heat sinks for cooling. Heat transfer with soil temperature in both summer and winter is an abundant renewable resource. The earth-air heat exchanger provides a sustainable way of improving indoor conditions in summer. The results show output air from earth-air heat exchanger to be significantly lower than ambient temperature summer and higher than ambient in winter.

Keywords: Earth-air heat exchanger, passive and low energy cooling, sustainable design, summer temperatures, zero and low carbon technologies.

1. INTRODUCTION

The subsurface soil environment has been used to maintain comfortable indoor condition in buildings using different strategies that exploit the high thermal mass of the ground to maintain stable indoor temperatures such as, buildings fully or partially buried below the ground surface, uninsulated ground floors, and ground source heat pumps systems. The earth-air heat exchanger is a simple ventilation system for pre-cooling/ pre-heating ventilation air, the system is an old concept dating back to Persian and Greek architecture (Trombe and Serres, 1994) (Argiriou, 1996). Recent application of the system however involves the use of fans to drive air through a pipe or series of pipes buried at reasonable depth below the ground surface.

Rising concerns about global warming that is attributable to greenhouse gas emissions has brought to the fore the need to meet comfortable indoor environment with responsible use of energy. Energy consumption in buildings is responsible for about 47% of UK energy consumptions (DTI, 2003). The effect of global warming is also showing in the form of rising summer temperatures which brings about risk of over heating in buildings. Due to the rising summer temperatures, CIBSE (CIBSE, 2002) published new set of design data in the form of Test Reference Years (TRY) and Dry Summer Years to take into account the rising temperatures for over heating assessments in naturally ventilated buildings. The risk of summer over heating is more in city centre buildings. Shorts, et al (Short et al., 2004) found that passive stack ventilation is unlikely to maintain a comfortable indoor environment in a proposed building within an urban heat island and that some form of cooling is required to maintain comfort conditions in these buildings.

The problem is that city centre buildings are further restrained by noise and air pollution which requires these buildings to be sealed.

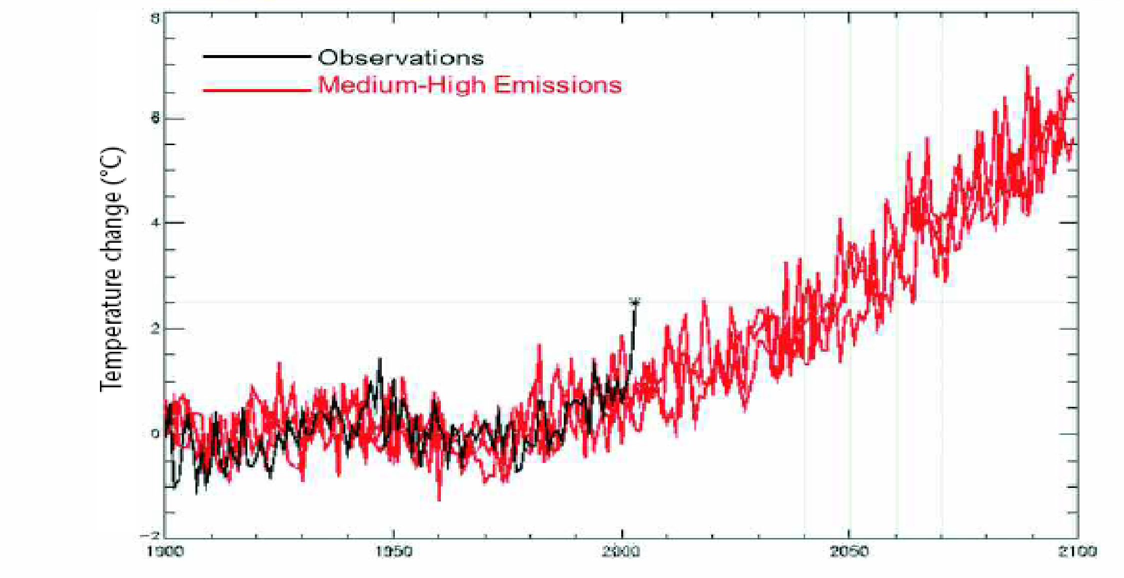

Figure 1: *Trend in global temperature rise (Source: Hadley Center for climate prediction and research (UKMO, 2003))*

The rise in summer temperatures and the increase in highly glazed buildings, increased lighting and IT equipment loads, worsening outdoor pollution and traffic noise have all contributed to the increasing likelihood of overheating in buildings. These combinations of problems will result in increase of the use of air conditioning to maintain comfort conditions in buildings. Already a forecast of about 40% of commercial office floor spaces in the UK will be air-conditioned by 2020 (Hitchin, 2000). The increased cooling loads are also reducing the likelihood of natural/passive stack ventilation to meet comfort conditions in city centre buildings. It is necessary therefore to study the potential of other natural heat sinks to reduce these loads and improve comfort conditions within buildings in the warming climate.

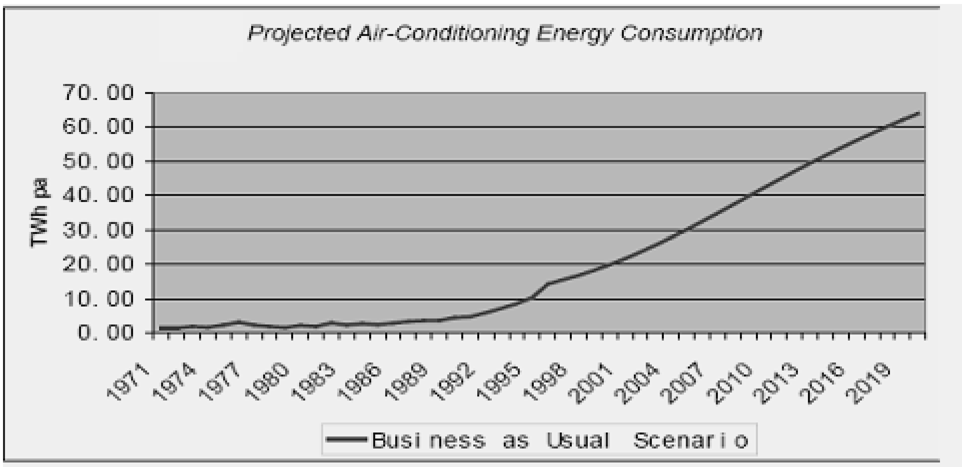

Figure 2: *Projected air-conditioning Energy Consumption (Source: (Hitchin, 2000))*

2. UK SOIL TEMPERATURE

In order to study the behaviour of earth-air heat exchangers there is a need to have a clear understanding of how the soil temperature changes with time. Subsurface soil temperature in the UK is lower than ambient in summer and higher than ambient in winter. Figure 3 shows the soil temperature at the depth of 10-100cm, for Reading in South East England, the record obtained from UKMO shows that the soil temperature becomes more stable with depth. The daily variation in ambient temperature is phased out at the depth of 50cm and lower. The main factors affecting the subsurface soil temperature are the soil surface temperature and soil physical and thermal properties such as thermal conductivity, heat capacity and density(Labs, 1989).

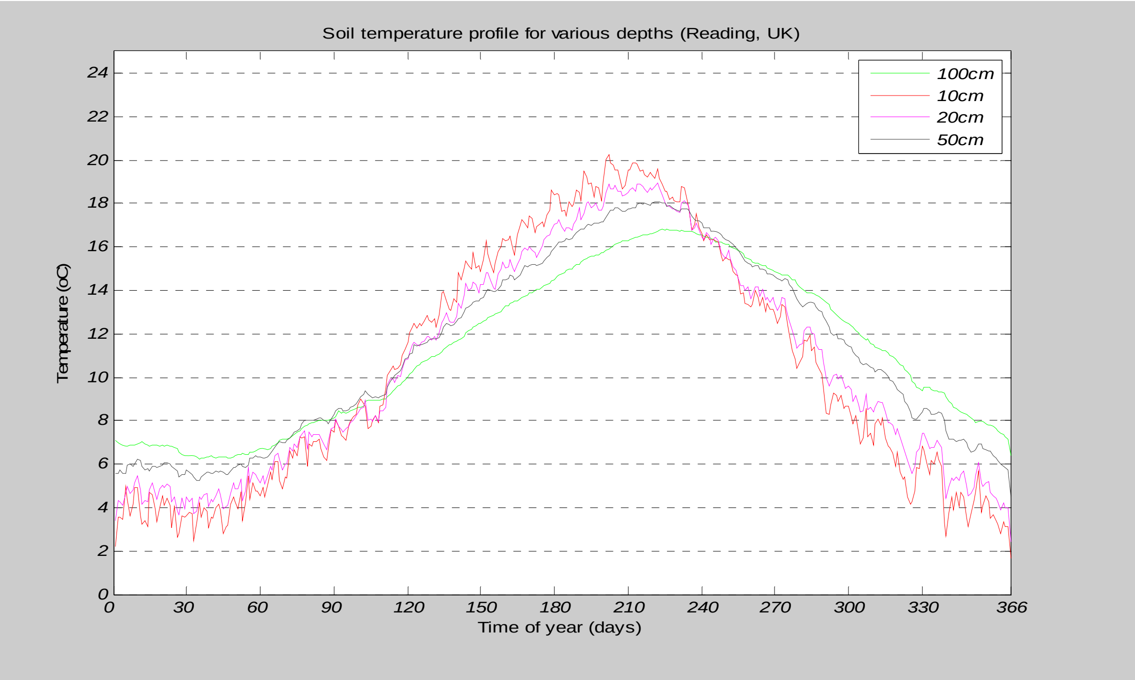

Figure 3: *Change in soil temperature with time and depth*

For the purpose of this study, soil temperature records for UK wide locations have been collected and analysed to understand the changes over time and location around the country. The data held by the UK Meteorological Office (UKMO) ranges from 10cm-100cm depth. Variation of soil temperature around the country have been studied, this is to gauge the potential of subsurface environment for cooling. Figure 4 shows the variation of soil temperature for 10 locations from Sutherland in Scotland to Hampshire in South East England, this shows significant increase in soil temperature from higher to lower latitudes which is directly linked with ambient temperatures.

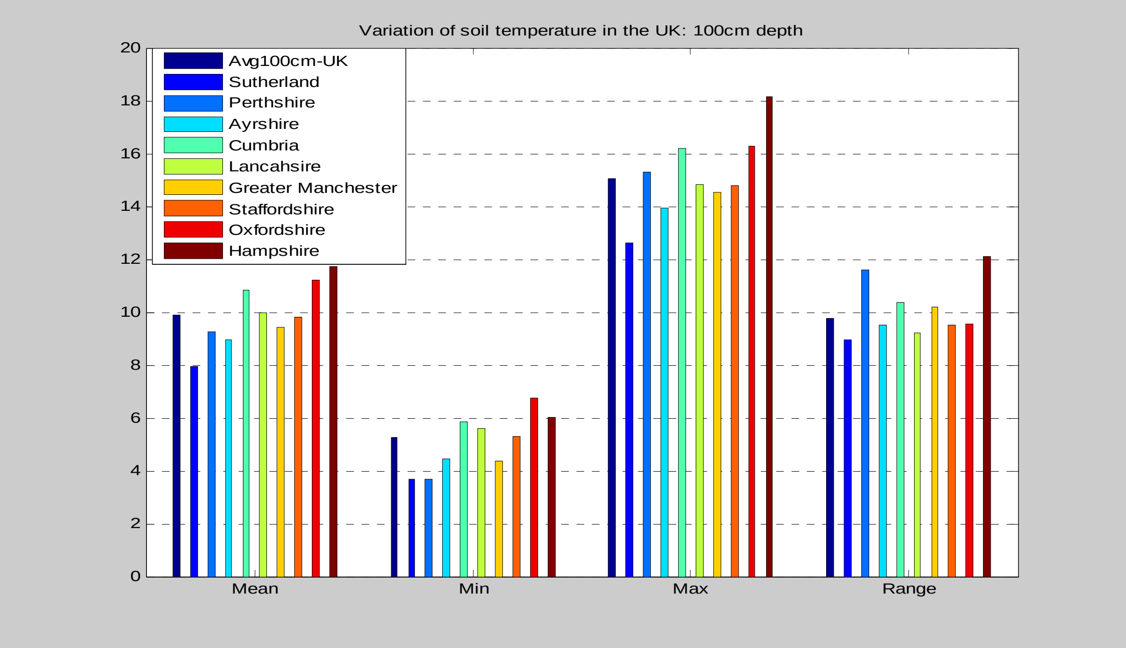

Figure 4: *Variation in soil temperature for 9 UK locations*

Figure 5 show the statistical variation of soil temperature in South East England. The result shows variation of less than 1°K difference between the nine locations studied. This shows that results of simulations carried out on regional basis will be acceptable for locations within the same region. Simulation studies have been carried out for each region of the country in order to give indication of potential of the system in that area. Each location within the region may have different soil type/properties but this does not appear to cause any significant change in the soil temperature at 50cm and below.

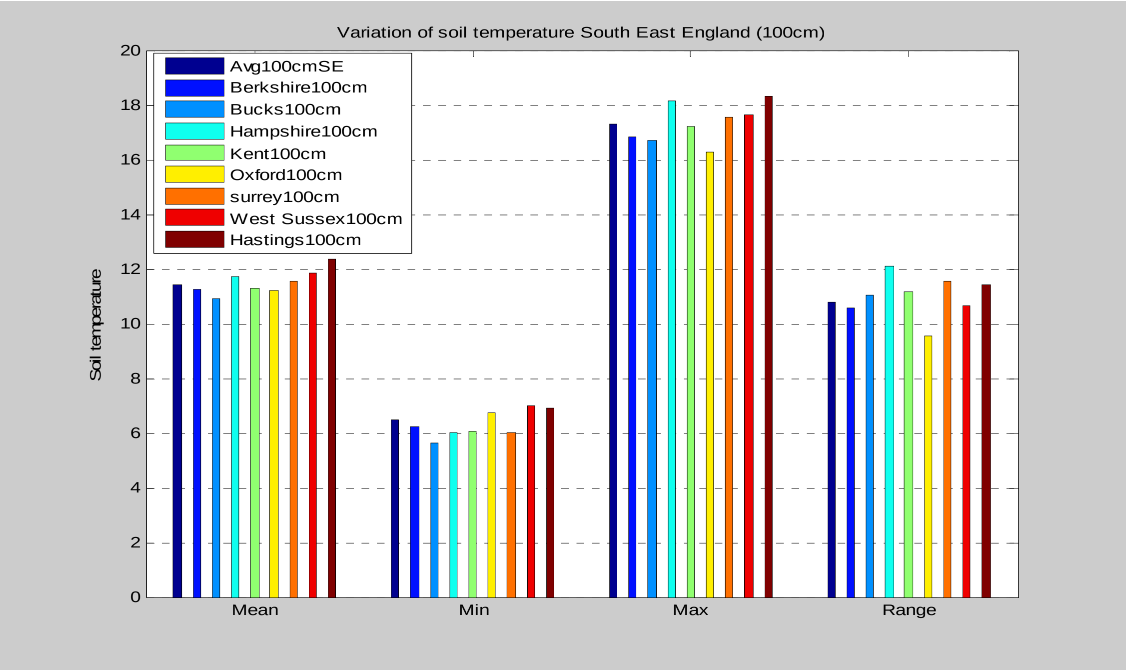

Figure 5: *Variation of soil temperature in South East England*

3. EARTH-AIR HEAT EXCHANGER

Earth-air heat exchanger is a simple subterranean ventilation system that takes advantage of the stable soil temperature at some distance below ground surface. The high thermal mass of the ground reduces the daily fluctuation of ambient conditions to the top 20 cm of the soil, this leaves the lower soil mass relatively lower than ambient in summer and higher than ambient in winter (Givoni, 1991, Labs and Harrington, 1982). The difference in ambient air and subsurface soil temperature at any time around the year provides an opportunity for a renewable heat sink/source for the ventilation pre-cooling/heating.

The application of this system in the UK is lagging behind other EU countries with only one application in commercial offices (CIBSE, 2006, Building, 2006). The commercial office sector have over 40% of installed capacity of air-conditioning in UK buildings, with about 20% of total floor area air-conditioned and 16% for retail spaces (Hitchin, 2000). This provides ample opportunity for reducing the rising trend in air-conditioning. This study evaluates the potential of this system under UK climatic and soil conditions with a view to putting forward more design information on the dynamic behaviour of the system.

3.1 RESEARCH AIM AND METHODOLOGY

The aim of this research is to evaluate the potential of the earth-air heat exchanger for cooling under UK climatic and soil conditions. This has been achieved through understanding of soil type, properties and soil temperature profiles in the UK. The study of the dynamics of the earth-air heat exchanger has been evaluated by thermal modelling using TRNSYS simulation environment (TRNSYS16.0, 2005). The outlet air conditions from the thermal modelling have been coupled with the building models developed using TRNSYS building interface TRNBLD to study the effect of earth-air heat exchanger for improving indoor temperatures.

Because of the dynamic nature of both earth-air heat exchangers and buildings it is important to study the system behaviour within a flexible and transient simulation environment. TRNSYS is a transient systems simulation programme, which has a modular structure that allows for addition of mathematical models that are not included in the standard TRNSYS library. It is very suitable for the study of systems whose behaviour is time dependent. Figure 6a show the interconnection of components used for the study of earth-air heat exchanger and figure 6b show the coupled earth-air heat exchanger and building project.

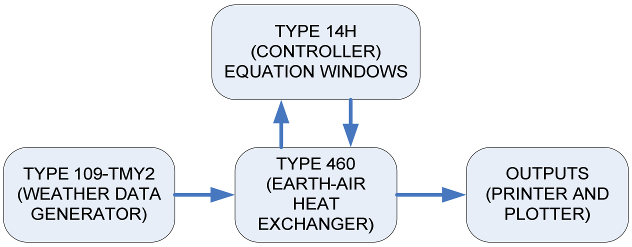

Figure 6a: *Earth-Air Heat Exchanger TRNSYS simulation project*

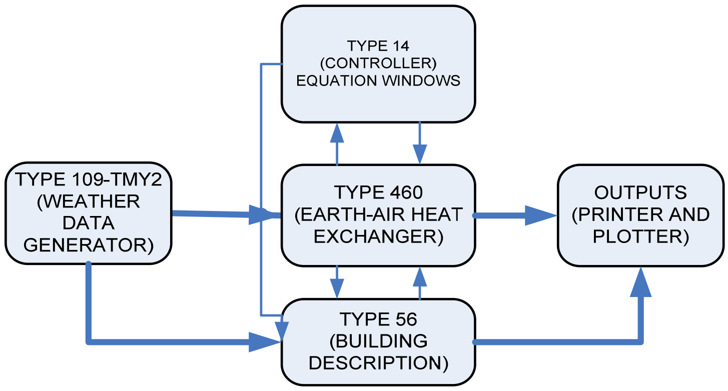

Figure 6b: *Coupled Building and Earth-Air Heat Exchanger TRNSYS simulation project;*

3.2 THERMAL BEHAVIOUR OF EARTH AIR HEAT EXCHANGER

Various factors affect the tube outlet air temperature such as, tube configuration (length, diameter, burial depth,), air velocity in tube, inlet air temperature, soil physical and thermal properties, and subsurface soil temperature (Kumar et al., 2003, Mihalakakou et al., 1994, Sodha et al., 1985). Because of the complex inter-relationships of various parameters that affect the thermal and fluid dynamics of the system, the solution of the problem requires detailed thermal models that can predict both sensible and latent heat transfer between air and tube and the conduction of heat from pipe surface to the soil mass.

Figure 7 shows the maximum and minimum outlet air temperature for simulation carried out for a period of one year using climate data for Heathrow airport. The simulation was carried out using air-velocity of 1-8 m/s. With maximum and minimum ambient temperature at 28.8 and -3.0 ºC respectively, the figures show the maximum and minimum temperature for the simulation period at each air-velocity. The effect of air velocity for sensible heat exchange is greatest at low air velocity and diminishes at higher air-velocity. The decision of which air-velocity is used depends on the size of tube, volume of ventilated space and the ventilation air-changes required for the given building.

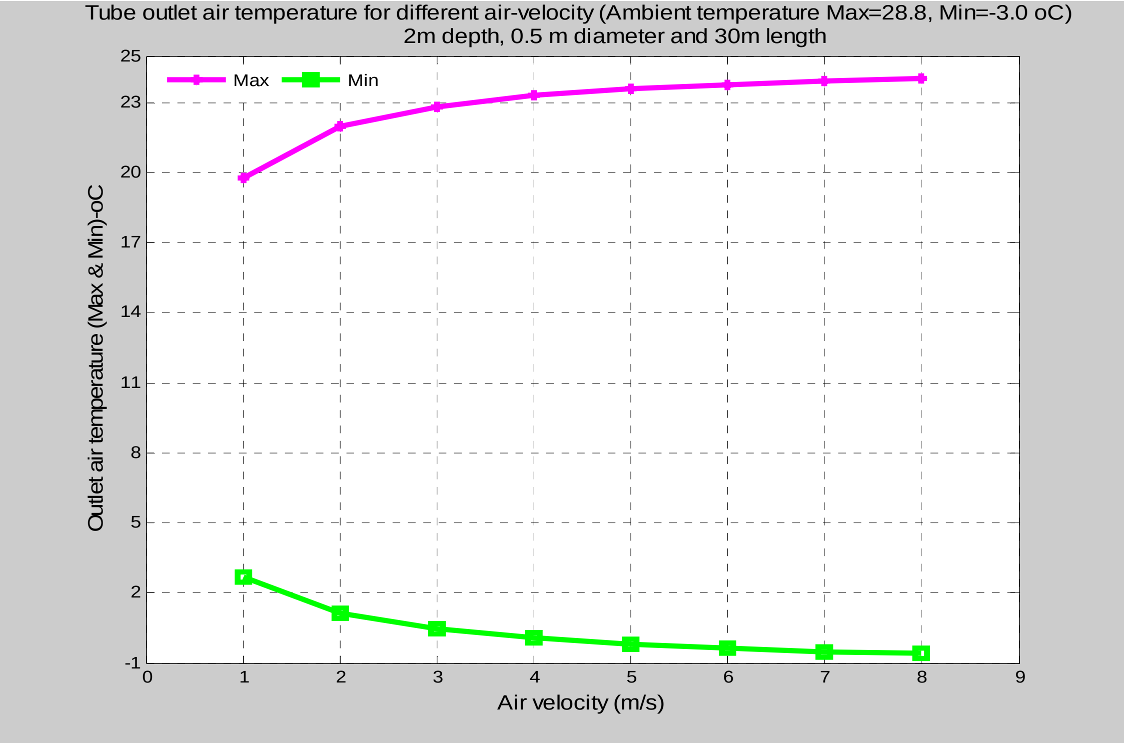

Figure 7: *Outlet max and minimum air temperature for various tube air-velocity*

3.3 POTENTIAL FOR REDUCING VENTILATION AIR TEMPERATURE

Three locations within the UK have been studied Dundee, Birmingham and London. Figure 8, shows the reduction of ambient air temperature through earth-air heat exchanger using a single 30m length, 50cm diameter pipe and climate data for the three locations under study. It shows significant reduction of air temperature which can be used for ventilation air supply in summer. Table 1, shows the total number of hours for which the pipe outlet air and ambient temperature exceed 18, 20 and 22ºC for the three locations studied.

Table 1; Distribution of tube outlet and ambient temperature over 18, 20 and 22ºC

London	**Tube outlet (hours)**	**Ambient air (hours)**
>18ºC	354	1074
>20ºC	71	544
>22ºC	11	249
Birmingham		
>18ºC	96	640
>20ºC	21	284
>22ºC	0	111
Dundee		
>18ºC	0	180
>20ºC	0	28
>22ºC	0	0

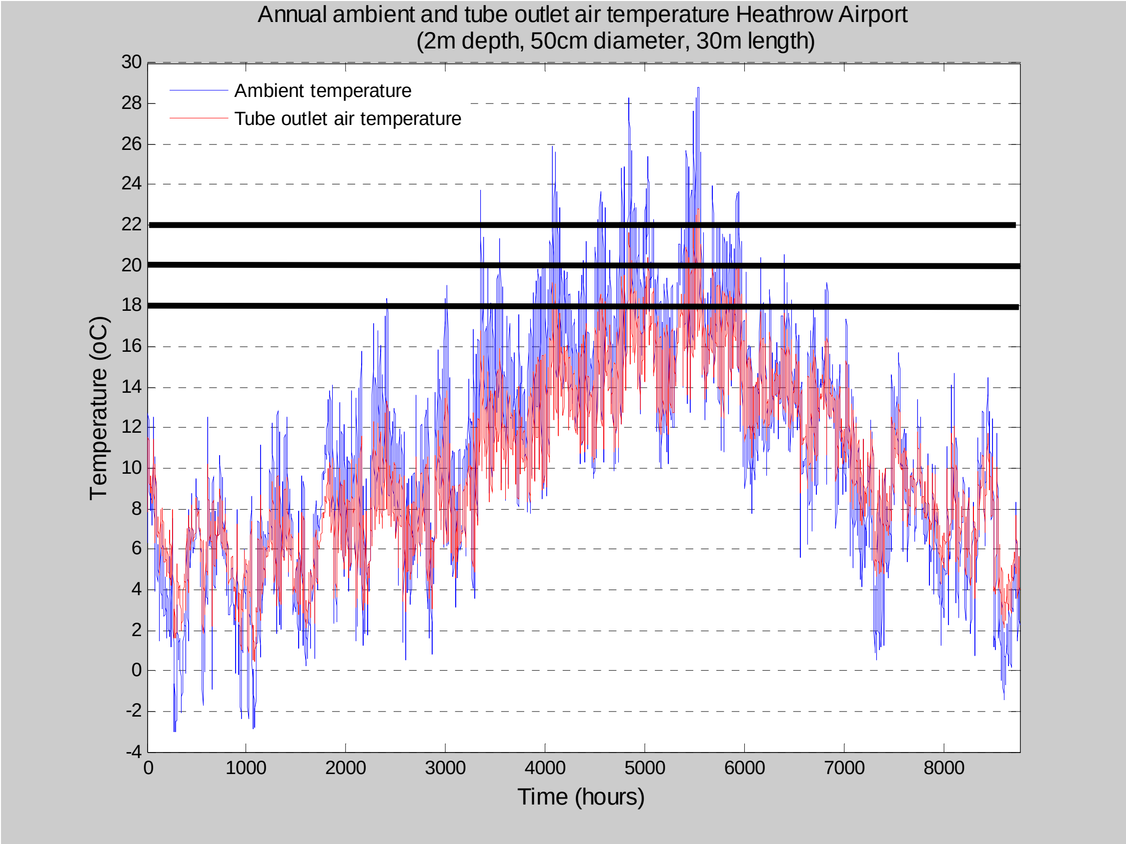

Figure 8: *Ambient and tube outlet air temperature for London,*

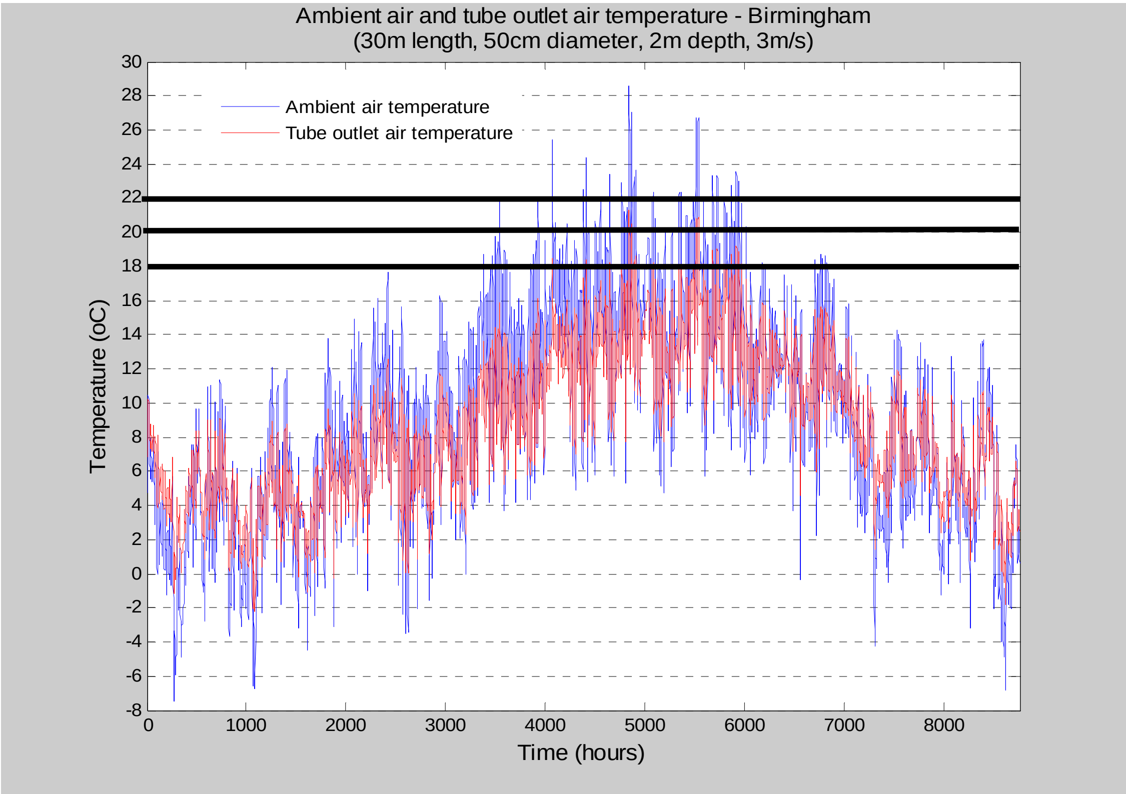

Figure 9: *Ambient and tube outlet air temperature for Birmingham.*

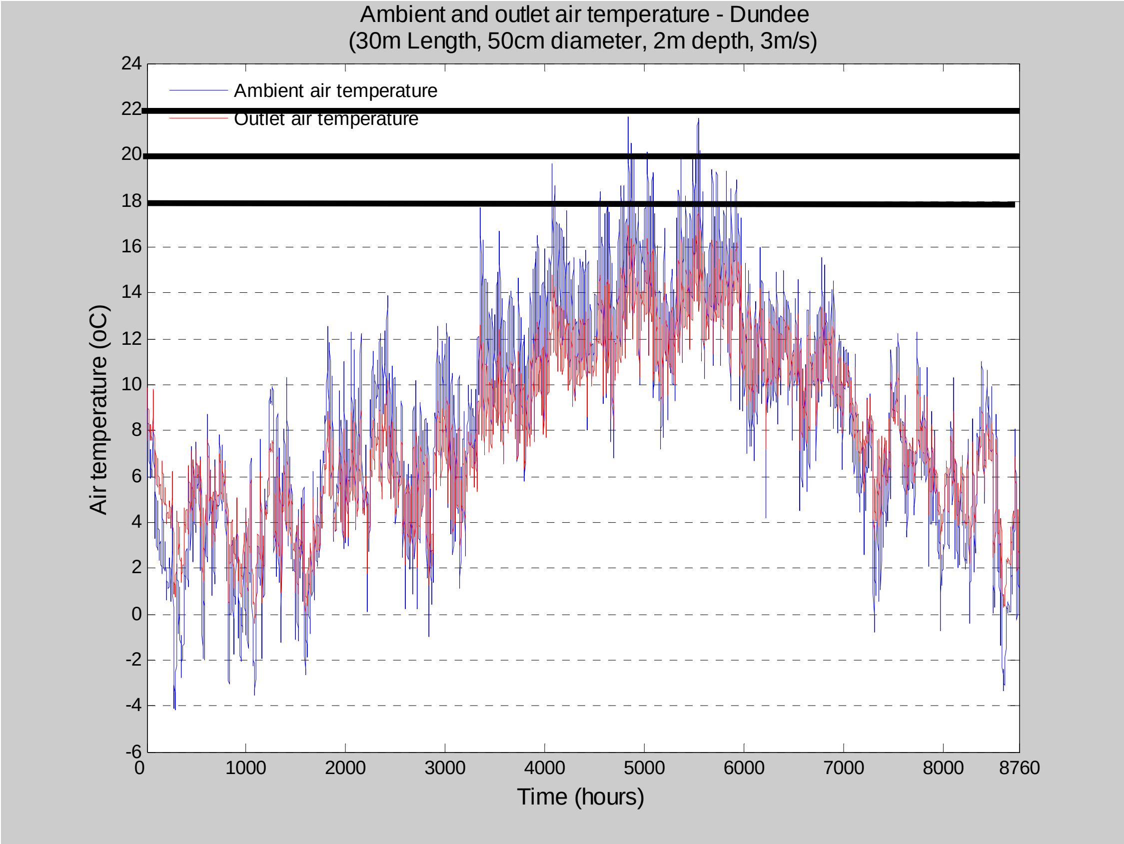

Figure 10*: Ambient and tube outlet air temperature for Dundee*

4. CONCLUSIONS

The paper presents studies of the potential of earth-air heat exchanger for lowering ambient temperature. It shows significant potential for reducing ventilation air temperature which can be used to reduce ventilation cooling load in buildings or used at higher air velocity for comfort cooling. The thermal study has been carried out within the TRNSYS simulation environment. The effect of air velocity on outlet air condition also shows that lower air velocity present higher potential for sensible cooling in a 50cm diameter tube. The potential of the system for reducing outdoor air temperature have been presented for three UK locations Dundee, Birmingham and London. Future work will study the impact of outlet air condition on indoor temperature and comfort conditions within different building types.

5. ACKNOWLEDGEMENT

Many thanks to British Atmospheric Data Centre for giving access to the MET Office climate database, this is the source of soil and air temperature used for this study.

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FACTORS AFFECTING EMPLOYEE PRODUCTIVITY IN THE UAE CONSTRUCTION INDUSTRY

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Abstract: Productivity of various trades in construction is the basis of arriving at estimates for time and cost required to complete a construction process. Productivity figures however vary from country to country, region to region, and from company to company. More specifically the factors affecting productivity could be related to how motivated the employee feels to do his work in the most efficient manner given a set of common conditions for him and his team.

This research paper therefore considers significant factors categorized broadly as general work environment, organizational work policies, group dynamics and interpersonal relationships and personal competence of the employees, as applicable in the Middle East region, especially the United Arab Emirates (UAE), where the construction industry depends largely on foreign expatriate labour.

The broader research aims at utilizing further sub-factors within the broad categories above and developing an appropriate model that can be used to monitor, measure and enhance the trade specific productivity of the employees in the UAE. A significant saving potential exist in maximizing productivity of the employees contributing to the profit in each project, not mentioning the harmonized relations and overall high morale of the employee.

A survey was conducted amongst the different levels of personnel within the construction industry. A total of 238 responses were received and the various sub factors have been ranked in terms of importance index, frequency index and the combined severity index identifying the first 8 significant factors affecting the productivity in the construction industry in the UAE.

Keywords: construction, factors, productivity, performance measurement

1.0 INTRODUCTION

The construction industry in UAE is a multibillion dollar industry, contributing approximately 20 % to the nations GDP. It is buoyed by high liquidity, high oil prices, stable political environment and availability of cheap labour from the Asian countries. (Gulf News, 26 Dec 2006). The fast and vast economic transformation has resulted in dramatic changes to the labour market which has affected the work, employers and employees in many ways. The result is that the labour market is subjected to influences from a variety of sources that are changing rapidly and drastically. The influences include different management styles, language barriers, customs, new currencies, availability of food materials, separation from families, level of supervisors, camp accommodations and so on. Such influences have direct impact on productivity rates.

Productivity – achieving quantity and quality of results while controlling the inputs is therefore a key challenge for all contractors. Improved productivity will help contractors not only to be more efficient and profitable whilst executing the jobs, knowing actual productivity levels could also make the contractors more competitive whilst bidding for the projects. On the other hand, the shortages faced by the construction industry could be overcome by better productivity on site and utilization of available manpower resources. All contractors within the UAE face the same amount of constraints; same specifications apply and therefore the bottom line performance of contractors is influenced by how effective & well planned, the construction methods are, and whether the construction operatives work at optimal productivity.

2.0 RESEARCH AIM & OBJECTIVES

For the sake of this paper the research is aimed at identifying the significant factors affecting productivity. It is worthwhile mentioning that - the overall research is still ongoing and only a part of the overall research is presented in this paper. The significant factors returned from this survey will then be varied during the ongoing research to determine the combination or a model which will give increased productivity.

3.0 CHARACTERISTICS OF THE UAE CONSTRUCTION INDUSTRY

The UAE Construction industry is made up of a mix of different nationalities, common to the overall Gulf region and has the following characteristics.

a) Demographic Influences:
The UAE population is relatively low compared to the influx of foreign workers in UAE, especially in the construction industry. Expatriate workers make up approximately 90% of the UAE labour force, with 98% of the workforce in the private sector. The total labour force is more than 3.3 million and this is dominated by foreign workers, especially from the Asian countries.

b) Diverse Background / Culture Differences
The labour force from these countries have a varied background in terms of culture, education, family background, and individual cases of the need to work overseas to care for specific requirements back home. Some are skilled, some are semi skilled; some have GULF experience, some do not. Productivity from a set of people with similar background also varies.

c) No organized unions or agreed productivity rates
UAE law does not allow organized unions for workmen, nor has statistics on standard productivity rates, except for some surveys on National Workplace Employment Relations (2001). Each contractor has his own experience and database to go by.

d) Environmental Conditions
The UAE has a hot humid climate with temperatures reaching upto 45-47 degrees centigrade and relative humidity, varying from 40 -80 and in some cases upto 95%.

The UAE Labour Law stipulates midday break from 12.30 -3.30 pm during the hottest months of July and August every year.

e) Living Conditions

Most of the workmen are housed in labour camps 8 to a room with / without cooking facilities. It is common to find that monthly salaries are retained for upto two months for workmen by most of the contractors. Most workmen go on leave once every two years. High inflation and cost of transport limits their ability to shop and move around.

f) Sponsorship Laws

UAE Labour laws does not allow free movement of labour, except for some exempt categories such as Engineers, Doctors, Qualified Accountants, etc. that too only after they have served at least one year with the current sponsor.

g) Cheap Labour & Short Term Focus

Compared to the liquidity in the region; and the value of the contracts / construction projects, the cost of labour is relatively cheap. This sometimes stifles productivity as contractors would rather push in more people and get the job completed rather than go in to the hassles of increasing productivity. Also most of the projects are of 1½ to 2 years duration; workmen allocated to the project are new / from other sites and teams are formed new.

4.0 FACTORS AFFECTING PERFORMANCE OF CONSTRUCTION OPERATIVES

The list of probable factors affecting productivity as identified below is derived from previous literature as referenced herein and from the author's experience of controlling / managing multiple projects of varying nature and price and the collection of theoretical considerations by numerous authors on organizational behaviour.
These are grouped and discussed further as below.

- **Environmental envelope which includes factors and parameters**
- **Organization work policies which include factors**
- **Group / Team Dynamics & Interpersonal Relationships**
- **Personal Factors**

4.1 Environmental Envelope

4.1.1 Work timings and working hours

A balance is presumed to exist between the paid work that employees perform and the lives that they hold outside their job. (Sparrow, 2003, pg. 215). R. Tyler in his book the Future of Work Life Balance (Tyler, 2002, pg. 217) states that the word "balance" implies the existence of a settled equilibrium that can be achievable between paid employment and a life outside the job. A proper balance of work timings and work hours sets minds at rest and enable people to perform better.

4.1.2 Safety and job security

Safety and security are among the basic requirements and needs of human beings. Once the basic physiological needs are relatively well gratified, then according to Maslow's Hierarchy of Needs, a new set of needs emerge, which we may categorize roughly as the safety needs (Maslow, 1987, pg. 18). Much of the management of job security lies in the hands of the management, especially building confidence about the future expectations of employment security and promoting progressive human resources policies and practices (Guest, 2000, pg. 144).

4.1.3 Welfare schemes

Welfare schemes are one of many mechanisms that control the relationship between employees and organizations. They help in creating a sense of belonging and the fact that you are well looked after.

4.1.4 Appraisal schemes

While appraisal schemes are basically beneficial to organizations to enable the management to reward able employees or improve their work conditions, they are equally important to the employee since – if carried out properly – would give him the assurance of fair treatment and an opportunity to improve upon his weak areas. At the individual level the most important factor to employee would be the perception of fairness and the desire for equity (Rosinski, 2003, pg. 202).

4.1.5 Company Brand Name

The knowledge that you are working for a good company and a return acknowledgement from your associates and friends motivates an individual to do his best. In short that is his contribution to the company.

4.1.6 Timely Payment of Salaries

The prospect of being paid monthly – rather a known source of income rests one's mind about the ability to fulfil his and his family's needs at the right time. This factor is pertinent in UAE as some of the contractors do not pay on time and have arrears of more than 4-6 months at a time. Unfortunately, although not legal, some companies still retain a two month salary from the workmen and pay off all dues before the workman departs for his leave.

4.1.7 Overall Well Being of the company

Similar to the brand image, if all is well with the company, and if this information is communicated and known amongst the workforce, a contagious sense of overall well being is felt by the employees.

4.2 Organization Work Policies

4.2.1 Discipline/hierarchy order

Discipline represents the abidance by statutory rules and regulations of the work, this means following up general company's policy or directives from superiors. Although discipline and hierarchy order are two different entities, yet they are very much inter linked. It helps put plans into actions and ensures accountability down the ranks and vice versa. However this could stifle creativity and block a worker from doing a thing more efficiently if he has to only follow instruction!

4.2.2 Delegation

It is broadly accepted that delegation leads to success and proper expansion of organizations. Organizations that are sized according to one man capabilities remain limited regardless of the abilities of that man or his dormant team members (Rosinski, 2003, pg 120), where as, a hierarchal orientation can lend itself to the making of unilateral decisions and efficiency in dealing with a crisis situation, delegation orientation will naturally cause managers to foster team work and an individual sense of autonomy and responsibility.

4.2.3 Reward Schemes

Reward schemes play an important role in employee's performance and achievement of the feel of care and fair treatment. The role of organization justice in the reward given to employees plays an important fact in employee /organization relationship. It lends better to the employee's perception of fair or unfair treatment and subsequent work behaviour and performance (Sparrow, 2003, pg. 96).

4.2.4 Competencies of supervisors/seniors/managers

In many cases superiors represent the example to be followed by the subordinates or give an example to the degree of achievement one can reach. The degree of competence of the supervisors and managers shape in many ways the employees performance whether positive or negative. Most of the professionals at all levels tend to be unenthusiastic about being managed. They prefer to do things their own way without reference to the ideas and view of colleagues (Smith, 2004, pg 7). Much depends on the competencies of supervisors/ seniors/managers in improving the employee's performance by advising how to achieve the goals and setting the example. Moreover a good effective supervisor will know the team members strength and weakness and using this knowledge to get the best out of his team.

4.2.5 Management involvement and awareness.

Management involvement and awareness can be constructive or destructive at the same time, depending on the degree and type of involvement. It plays a constructive role if played to exhibit commitment and care about the organization and the employee, yet can be destructive if played in such a way to imprison initiative, creativeness and new methods of operation without proper communication.

4.3 Interpersonal Relationships/Groups/Teams

4.3.1 Group/Team structure.

Working in a group or team does not mean over shadowing individual or personal skills but rather enhancing them by integrating them with other individuals' skills. A work group is two or more people in a work setting with a common goal (Gordon, 1999, pg 165). There is a subtle, yet distinctive difference between a group and a team. When a work group emphasizes collaboration to achieve its stated goals, then it becomes a team.

4.3.2 Individual skills (talents)

Individual capability (talents) and individual engagement (heart and mind) is now becoming a key differentiator for many organizations in the effectiveness of the employment relationship (Sparrow, 2003, pg 155). However Maslow says it is important to distinguish between special talent creativeness and self actualizing creativeness (Maslow, 1987, pg 160)

4.3.3 Nature of work/assignment

The nature of the job and type of assignment given to an employee has much to do with his performance. Dewey (1939) and Thorn Dike (1940) have stressed one important aspect of motivation that has been completely neglected by most psychologists, namely possibility. On the whole, we yearn consciously for that which might conceivably be actually attained (as in Maslow, 1987, pg. 12). Therefore setting realistic attainable targets is important.

4.3.4 Demography of team / nationalities

The Asian workforce within the company comes from India, Pakistan, and Bangladesh – i.e. countries which have fought wars with each other. Although there is no real life animosity between common people, there are subtle overtures, remarks, comments which antagonize people at work and this could be a factor which could influence behaviour and performance at work.

4.3.4 Current Wars or Political Situations

As in 3.3.3 above, if there is an ongoing war between countries, workmen from those countries are prone to discussions, analysis and comments. This does not bore well for their mental state and in turn productivity.

4.4 Personal Factors

4.4.1 Level of academic achievements or education

Level of academic achievement or education plays an important role in performance. It starts by giving the first and common ground for communication between people. Although academic level is important in employee's performance yet it is not always a decisive factor on how well the employee performs as experience together with accumulated training, together determines competence of an individual.

4.4.2 Past experience

Professional service firms with a good record for taking able people usually place a higher value on basic ability and attitude of mind than on specific technical skills (Smith, 2004, pg. 166). However, this does not undermine at all the past experience of the employee which involves knowledge, skills, practice and situational familiarity.

4.4.3 Age

Age plays an important role in performance. Generally speaking there is a direct relationship between age and performance, assuming that we learn something every day and become more experienced every day. However, we must note that with some specific jobs that need physical attributes the performance is generally inversely related to age. Age also inhibits ambition and could make man complacent.

4.4.4 Individual culture

Because of the socio-economic conditions in certain countries or environment conditions, we note that some people are more knowledgeable, fit or experienced for certain type of work than others. Here in the UAE we have Indians from say Punjab area being good carpenters and masons and heavy duty operators. Most of the drivers in the company are Pakistanis.

4.4.5 Motivation

Human beings have an innate tendency to move towards higher levels of health, creativity and self fulfilment. Business efficiency and personal growth are not incompatible. In fact, the process of self-actualization leads each individual to the highest level of efficiency. Performance is goal oriented, this means that individuals are motivated to perform. The level of motivation therefore differs in individuals and affects productivity. Moreover, motivation is not related to the nature of the individual only, but also related to the situation or environment in which the individual finds himself (Friday, 2003).

4.5 Significant Factors Affecting Productivity

Results of Pilot Survey

Whilst it is possible that all factors somehow contribute to productivity at different levels of significance, some of the factors are more significant than the others.
The construction industry players consist of:-

a) Clients - Major Property Developers / Oil Companies / Private Owners
b) Consultants also called as Engineers
c) Contractors – of different categorizations from the Town Planning Department
d) Subcontractors – specialist trades

As a first point of research, we intend to narrow down the significant factors affecting performance. A questionnaire, ref. Annexure 1 - was designed which was sent to different levels of personnel amongst the players identified above. Efforts are still on to secure at least 50% response to the survey by personal interviews, telephone conversations and email follow up from the targeted respondees. See table 1 below.

Table 1: Survey Response Reckoner

	CEO / Sr. Management	Project Managers	Sr. Engineers	Foremen / Chargehands	Operatives
Clients x 5	X 2	X 2	X 3	-	-
Consultants x 5	X 2	X 2	X 3	X 3	X 5
Contractors x 5	X 2	X 2	X 3	X 3	X 5
Subcontractors x 5	X 2	X 2	X 3	X 3	X 5
= 20	8	8	12	9	15
= 20	= 52				
= 1040 responses					

However, for the sake of this paper and as a means to test out the questionnaire, a pilot study was conducted amongst selected company employees and similar levels from other contractors. Results from this pilot study are being reported in this paper.

Following this pilot study, a detailed survey has been planned to include a cross section of all interested parties – clients, contractors, subcontractors together with different levels of personnel involved as depicted in table 1 above.

These questions asked were related to the four groups identified at the start of this section earlier namely -

- Environmental Envelope
- Organization Work Policies
- Group / Team Dynamics and Interpersonal Relationships
- Personal Employee Factors

Following formulas have been used to determine the importance index, frequency index and severity index. (Kadir, et, al, 2005, pg 47)

$$\text{Importance Index} = \frac{5n1 + 4n2 + 3n3 + 2n4 + n5}{5(n1 + n2 + n3 + n4 + n5)}$$

$$\text{Frequency Index} = \frac{3m1 + 2m2 + m3}{3(m1 + m2 + m3)}$$

$$\text{Severity Index} = \text{Importance Index x Frequency Index}$$

Where,
n1 = number of responses for "Very Important" degree of importance
n2 = number of responses for "Important" degree of importance
n3 = number of responses for "Neutral" degree of importance
n4 = number of responses for "Not Important" degree of importance
n5 = number of responses for "Strongly Not Important" degree of importance, and
n1, n2, n3, n4, and n5 each have a weight of 5, 4, 3, 2, and 1 respectively.
And,
m1 = number of responses for "High" frequency of occurrence
m2 = number of responses for "Medium" frequency of occurrence
m3 = number of responses for "Low" frequency of occurrence, and
m1, m2, m3 each have a weight of 3, 2 and 1 respectively.

Table 2: Significant Factors Affecting Productivity (First 8 within groups)

Significant Factors – First 8 within groups

Ref. No.	Category	Probable Factors affecting productivity	Importance Index	Frequency Index	Rank (Severity Index)
1	Environmental Factors	Proper Work Timings giving a balance between work and recreation and time with family	0.9025	0.7339	0.6624
2		Salaries on time	0.8496	0.7507	0.6378
3		Reasonably well paying job	0.8462	0.7465	0.6317
4		Safe Secured Job	0.8412	0.7479	0.6291
5		A job where your voice is heard and experience is valued	0.8361	0.7297	0.6101
6		Employee Welfare oriented schemes ? Health, Recreation, Vacation	0.8361	0.7101	0.5937
7		Appraisals where improvements needed are identified	0.8067	0.7269	0.5864
8		Free and Frank Two Sided Performance Appraisals	0.8202	0.7087	0.5812
1	Organizational Factors	Leadership Skills of supervisors	0.8437	0.7619	0.6428
2		Transparency and Accountability of each level of management	0.8555	0.7283	0.6230
3		Overtime Paid for work done beyond normal Working hours	0.8353	0.7381	0.6165
4		Materials available on time	0.8580	0.7185	0.6165
5		Defined policies and procedures by management	0.8185	0.7521	0.6156

6		Competence of supervisors	0.8244	0.7451	0.6142
7		Systematic method statements / procedures in place and known?	0.8345	0.7353	0.6136
8		Setting of goals and targets	0.8496	0.7115	0.6045
1	Group Dynamics	Individual or Personal Skills	0.8050	0.7633	0.6145
2		Knowledge of Work	0.8261	0.7423	0.6132
3		Overall Work Group / Team Skills	0.8126	0.7395	0.6009
4		Self Initiative and Competence	0.8118	0.7157	0.5810
5		Reasonable / Achievable targets given	0.7975	0.6961	0.5551
6		Nature of work given	0.7815	0.7059	0.5517
7		Frequent changes in teams	0.7412	0.7129	0.5284
8		Frequent changes in work allocation	0.7496	0.6961	0.5218
1	Personal Factors	Technical qualified / educated for the trade	0.8437	0.7507	0.6334
2		Attitude of person	0.8210	0.7255	0.5956
3		Overall appreciation of ones work	0.8303	0.7101	0.5895
4		Previous Experience	0.8143	0.7199	0.5862
5		Overall job satisfaction	0.8017	0.7269	0.5827
6		Accumulated Training	0.8151	0.7087	0.5777
7		Motivation of the Operative	0.7849	0.7269	0.5705
8		Overall appreciation of ones work	0.8925	0.7164	0.6394

Results / Analysis of Pilot Study

Following is a summary of the results from the pilot study.

Total Questionnaires sent	=	500
Medium	=	hard copies
Follow Up Medium	=	telephone /personal interviews / email
Time taken to respond	=	1 month
Total Responses Received	=	238
% Response	=	48%

Significant Factors Analysis

Table 2 returns the results of the overall pilot study. The factors have been sorted for ranks within the group for identifying the most significant of the group. As the rank scores differed within each group, it was difficult to put a threshold value; so the first 8 within each group have been retained in the table. Table 2 has been reproduced as a matrix below for comparisons within the groups.

	Environmental Factors	Organizational Factors	Group Factors	Personal Factors
1	Proper Work Timings giving a balance between work and recreation and time with family	Leadership Skills of supervisors	Individual or Personal Skills	Technical qualified / educated for the trade
2	Salaries on time	Transparency and Accountability of each level of management	Knowledge of Work	Attitude of person
3	Reasonably well paying	Overtime Paid for	Overall Work Group /	Overall appreciation

	job	work done beyond normal Working hours	Team Skills	of ones work
4	Safe Secured Job	Materials available on time	Self Initiative and Competence	Previous Experience
5	A job where your voice is heard and experience is valued	Defined policies and procedures by management	Reasonable / Achievable targets given	Overall job satisfaction
6	Employee Welfare oriented schemes ? Health, Recreation, Vacation	Competence of supervisors	Nature of work given	Accumulated Training
7	Appraisals where improvements needed are identified	Systematic method statements / procedures in place and known?	Frequent changes in teams	Motivation of the Operative
8	Free and Frank Two Sided Performance Appraisals	Setting of goals and targets	Frequent changes in work allocation	Overall appreciation of ones work

Thus the most significant amongst each of the groups are:-

Work Timings	**(Environmental Factor)**
Leadership Skills of Supervisors	**(Organizational Factor)**
Individual or Personal Skills	**(Group Factor)**
Technical Qualifications for the trade	**(Personal Factor)**

This is followed by the second set of factors such as

Salaries on Time	**(Environmental Factor)**
Transparency & Accountability of Management	**(Organizational Factor)**
Knowledge of Person	**(Group Factor)**
Attitude of the Person	**(Personal Factor)**

Thus the most significant factors affecting productivity is related to the players involved – the supervisors and their leadership skills, the workmen themselves – their competency and attitude, work timings and whether salaries are paid on time and how transparent and accountable the management is.

Other factors within the environmental envelop affecting productivity are related to whether the workman is paid well, feels a sense of security and feels appreciated and effective appraisals.

Organizational factors also include whether overtime is paid, whether materials are made available, known management policies, procedures and method statements, set goals and targets, how competent the supervisors are and whether goals are set.

Group factors also include the team skills, self initiative, achievable targets, nature of work, whether teams are changed frequently and work allocation is disturbed.

The personal factors further include overall appreciation of ones work, previous experience, overall job satisfaction, training, motivation and overall competence of the workman himself.

The above discussion summarized the factors within groups – however when we assign the ranks and sort them out – the most significant factors with overall ranking are:-

No	Probable Factor affecting productivity	Importance Index	Frequency Index	Rank
1	Proper Work Timings giving a balance between work and recreation and time with family	0.9025	0.7339	0.6624
2	Leadership Skills of supervisors	0.8437	0.7619	0.6428
3	Salaries on time	0.8496	0.7507	0.6378
4	Technical qualified / educated for the trade	0.8437	0.7507	0.6334
5	Reasonably well paying job	0.8462	0.7465	0.6317
6	Safe Secured Job	0.8412	0.7479	0.6291
7	Transparency and Accountability of each level of management	0.8555	0.7283	0.6230
8	Overtime Paid for work done beyond normal Working hours	0.8353	0.7381	0.6165
9	Materials available on time	0.8580	0.7185	0.6165
10	Defined policies and procedures by management	0.8185	0.7521	0.6156
11	Individual or Personal Skills	0.8050	0.7633	0.6145
12	Competence of supervisors	0.8244	0.7451	0.6142
13	Systematic method statements / procedures in place and known	0.8345	0.7353	0.6136
14	Knowledge of Work	0.8261	0.7423	0.6132

These factors will then be used further within the study as variable parameters to see how the productivity is affected.

On the other hand a review of the factors which did not return high rankings are also worth a mention – For example – political situation, high temperature / humidity or in general climate conditions scored low – giving a possible indication of the mindset of most of the expatriates in the UAE.

Again on organizational front, contract system of getting a fixed volume of work in a day scored low as against what is normally practiced on the sites! Further financial and non financial incentives scored lowly compared to the systematic delegation of tasks and a demonstration of management commitment.

On the group / team front, the cultural differences seem not to matter as is the nationality of the team members, structure and the language.

Again on the personal front, the age of person, creativity, overall communal feeling and camp conditions seemed not to matter much in productivity.

5.0 FUTURE RESEARCH

The significant factors found from this survey are being utilized to formulate how a combination of these could affect productivity in the construction industry. Average productivity rates currently used by Target Engineering Construction Company are being used as a basis for comparison with specific productivity rates derived from data collection from the selected sites. Data collection is currently under progress. Following trades are being considered.

Table 3: Site Teams & Activities

Trade Code	Trade Description
1	Shuttering / Form Work) preparation and installation
2	Rebar cutting and bending
3	Concrete Casting
4	Block Work
5	Plaster Work
6	Tiling (Ceramic, Terrazo, Marble)
7	Excavation.

The study is being carried out at current projects being executed at different site locations, varying the factor, then comparing the results and trying to find out the correlations. The different sites have been purposefully selected as each of them is unique in nature and productivity rates vary tremendously due to nature of client involvement, location – remote / city based and the workmen demography / competence levels will vary considerably.

6.0 CONCLUSIONS

Productivity of various trades in the construction industry are critical for an accurate estimation of the time and cost of a job. Having better productivity would mean optimal utilization of manpower resources; more accurate estimates of cost to build, better profits, high morale of employees and better relations between employer and employee. This is all the more important in UAE as the construction industry workforce come from a varied background, and different cultures and there is shortage of manpower.

Factors affecting productivity have been classified broadly as - Environmental Factors, Organizational Factors, Group Factors and Personal Factors. A pilot study has been conducted amongst the various levels of personnel from company and competitors giving weightage to each of the factors in terms of importance and frequency of occurrence. Ranks or severity index of each factors was then determined using the product of the importance index and the frequency index. The significant factors were established on the rank / severity index in descending order.

The most significant factors in their order of ranking are proper work timings giving a balance between work and time for family, leadership skills of supervisors, technical qualifications, whether they are well paid or not and on time, security of job, transparency and accountability of management, payment of overtime, whether materials are available, procedures, policies, work method statements are available, an finally personal skills, competency of supervisors and knowledge of work on an individual level.

The overall study is still ongoing and the best combination of factors that will lead to increased productivity will be determined in due course of time in the form of a model.

Further the study for significance itself could be limited by possible bias of the company personnel and it is expected that as more responses come from non company sources, the results might change a little.

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Annexure 1 - Significant Factors Affecting Productivity

Ref. No.	Probable Factors affecting productivity	Degree of Importance					Frequency of Occurrence			Importance Index	Frequency Index	Rank (Severity Index)
		5	4	3	2	1	3	2	1			
		Very Important	Important	Neutral	Not Important	Strongly Not Important	High	Medium	Low			
1	Proper Work Timings giving a balance between work and recreation and time with family ?	145	71	21	1	0	101	84	53	0.9025	0.7339	0.6624
2	Proper Work Timings giving due consideration for climate ?	95	88	32	23	0	80	102	56	0.8143	0.7003	0.5702
3	Will high temperatue and humidity affect productivity ?	83	81	44	20	10	96	92	50	0.7739	0.7311	0.5658
4	Does political situation affect productivity ?	52	63	51	48	24	78	71	89	0.6597	0.6513	0.4296
5	Safe Secured Job ?	122	67	25	24	0	108	80	50	0.8412	0.7479	0.6291
6	Reasonably well paying job ?	116	80	23	19	0	104	87	47	0.8462	0.7465	0.6317
7	Salaries on time ?	125	64	32	17	0	111	76	51	0.8496	0.7507	0.6378
8	A job where your voice is heard and experience is valued ?	111	78	30	19	0	101	81	56	0.8361	0.7297	0.6101
9	Reasonably stable / brand name of company ?	91	87	41	19	0	92	85	61	0.8101	0.7101	0.5752
10	Future Expectations of Job Security ?	91	82	48	17	0	89	84	65	0.8076	0.7003	0.5655
11	Employee Welfare oriented schemes ? Health, Recreation, Vacation	109	83	26	20	0	90	89	59	0.8361	0.7101	0.5937
12	Free and Frank Two Sided Performance Appraisals ?	97	86	37	18	0	87	94	57	0.8202	0.7087	0.5812
13	Appraisals where improvements needed are identified ?	85	100	29	24	0	91	99	48	0.8067	0.7269	0.5864
1	Defined hierarchy of management ?	98	99	39	2	0	87	90	61	0.8462	0.7031	0.5950
2	Defined policies and procedures by management ?	97	91	25	25	0	105	89	44	0.8185	0.7521	0.6156
3	Transparency and Accountability of each level of management ?	111	82	45	0	0	99	84	55	0.8555	0.7283	0.6230
4	Systematic delegation of tasks / activities ?	101	85	46	6	0	88	101	49	0.8361	0.7213	0.6031
5	Systematic method statements / procedures in place and known?	99	88	44	7	0	90	107	41	0.8345	0.7353	0.6136
6	Materials available on time ?	123	73	31	10	1	91	93	54	0.8580	0.7185	0.6165
7	Works uninterrupted for the day ?	96	78	33	31	0	80	89	69	0.8008	0.6821	0.5462
8	Overtime Paid for work done beyond normal Working hours ?	112	73	36	17	0	107	75	56	0.8353	0.7381	0.6165
9	Instant Cash Award Schemes ?	79	74	59	26	0	80	91	67	0.7731	0.6849	0.5295
10	Contract System - fixed volumes of work per day ?	75	74	67	21	1	73	94	71	0.7689	0.6695	0.5148
11	Employees perception of fair or unfair treatment ?	92	85	44	17	0	78	103	57	0.8118	0.6961	0.5651
12	Employees behaviour in response to treatment ?	83	99	39	15	2	78	98	62	0.8067	0.6891	0.5559
13	Competence of supervisors ?	109	78	24	25	2	105	84	49	0.8244	0.7451	0.6142
14	Leadership Skills of supervisors ?	117	77	23	21	0	113	80	45	0.8437	0.7619	0.6428
15	Setting of goals and targets ?	111	83	36	8	0	86	98	54	0.8496	0.7115	0.6045
16	Rewards on achievement of the same ?	90	97	42	9	0	75	100	63	0.8252	0.6835	0.5640
17	Non Financial Incentives ?	84	84	52	17	1	74	91	73	0.7958	0.6681	0.5316
18	Amount of involvement by management ? To stifle or to kindle initiative	97	78	47	15	1	94	85	59	0.8143	0.7157	0.5828
19	To be told how and what to do ?	81	84	69	2	2	86	90	62	0.8017	0.7003	0.5614
20	Demonstration of management commitment ?	93	82	50	13	0	87	97	54	0.8143	0.7129	0.5805
1	Individual or Personal Skills ?	101	74	31	32	0	112	83	43	0.8050	0.7633	0.6145
2	Overall Work Group / Team Skills ?	106	70	33	29	0	98	94	46	0.8126	0.7395	0.6009
3	Structure of Team / Nationality ?	61	61	49	41	26	82	88	68	0.6756	0.6863	0.4637
4	Nationality of Team Members ?	56	47	60	43	32	87	84	67	0.6437	0.6947	0.4472
5	Do cultural differences affect productivity ?	52	58	61	34	33	83	74	81	0.6521	0.6695	0.4366
6	Does language barrier affect productivity ?	61	63	57	43	14	78	84	76	0.6958	0.6695	0.4658
7	Self Initiative and Competence ?	94	87	34	23	0	92	89	57	0.8118	0.7157	0.5810
8	Knowledge of Work	109	71	38	20	0	108	76	54	0.8261	0.7423	0.6132
9	Frequent changes in teams ?	68	84	42	36	8	93	85	60	0.7412	0.7129	0.5284
10	Frequent changes in work allocation ?	76	72	49	36	5	86	87	65	0.7496	0.6961	0.5218
11	Nature of work given ?	84	76	50	28	0	87	92	59	0.7815	0.7059	0.5517
12	Reasonable / Achievable targets given ?	83	92	40	23	0	88	83	67	0.7975	0.6961	0.5551
13	Current political situation in the country ?	56	59	53	50	20	86	65	87	0.6681	0.6653	0.4444
1	Technical qualified / educated for the trade ?	113	80	29	16	0	106	86	46	0.8437	0.7507	0.6334
2	Accumulated Training ?	91	99	23	25	0	86	96	56	0.8151	0.7087	0.5777
3	Previous Experience ?	89	91	44	14	0	91	94	53	0.8143	0.7199	0.5862
4	Overall competence of Operative ?	89	78	42	29	0	86	103	49	0.7908	0.7185	0.5681
5	Attitude of person ?	102	82	31	23	0	95	90	53	0.8210	0.7255	0.5956
6	Age of person ?	62	70	64	38	4	72	83	83	0.7244	0.6513	0.4718
7	Nationality of Person ?	51	59	49	49	30	76	79	83	0.6437	0.6569	0.4228
8	Creativity of the Person ?	70	92	46	27	3	86	96	56	0.7672	0.7087	0.5437
9	Motivation of the Operative ?	79	89	43	27	0	94	93	51	0.7849	0.7269	0.5705
10	Overall job satisfaction ?	98	75	34	31	0	93	95	50	0.8017	0.7269	0.5827
11	Camp Conditions ?	103	76	25	34	0	85	93	60	0.8084	0.7017	0.5672
12	Lunch packets provided ?	76	88	43	27	4	89	83	66	0.7723	0.6989	0.5397
13	Lunch breaks given ?	80	83	49	26	0	88	94	56	0.7824	0.7115	0.5566
14	Overall communal feeling / belongingness with the company ?	92	72	37	37	0	88	96	54	0.7840	0.7143	0.5600
15	Overall appreciation of ones work ?	107	81	29	21	0	82	105	51	0.8303	0.7101	0.5895

LEED CREDITS AND THE USE OF A BUILDING ENERGY PERFORMANCE SIMULATION SYSTEM

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Abstract: Sustainable construction addresses a variety of key issues regarding climate change, energy, water, waste, materials, interior quality and human comfort. Recently, voluntary standards such as LEED (Leadership in Energy and Environmental Design) have appeared to guide the building environment towards a more sustainable construction. Software systems could help to perform simulations on energy performance of a building at the design stage. Also, these systems could use the same models to create more advanced calculations and perform specific analysis that could help users to achieve LEED certification. A number of LEED credits could be integrated into a single package saving the users from performing separate independent simulation for every credit. This paper summarises these LEED credits that could be incorporated in such a system and is a brief account of an ongoing KTP project.

Keywords: Energy, LEED, Model, Performance, Simulation.

1. INTRODUCTION

Tackling the change in climate has become a major concern for most developed nations. The increase in the emissions of CO_2 and other greenhouse gases, generated from the combustion of fossil fuels, will cause major fluctuations in temperatures and impact the global economy. The developed countries' dependency on fossil fuels and the depletion of these sources of energy will lead to an oncoming energy crisis (Stern, 2007).

The construction market is searching for new ways to minimize buildings' energy consumption that could have a direct impact on the energy savings of a building at the user-stage. Currently, construction companies focus on developing more efficient heating and cooling systems, improving the thermal properties of construction materials, creating designs that enhance savings in the heating and cooling systems as well as the lighting and ventilation systems, and integrating technologies to produce energy from renewable sources.

However, additional factors of sustainability must be considered. Sustainable construction should also take into account the protection of the environment by expanding sustainable development and the range in use of material and location of buildings in each region (Berge, 2000). Furthermore, human comfort must be considered in the design of the building. Taken together, these improvements aim to indirectly augment savings at the user-stage by increasing the efficiency of the users of the building. Protecting the environment and maintaining good working and living conditions help the users feel more secure and confident in their work and daily activities, thereby increasing the quality of labour and life (Shore, 2006).

Under this umbrella there are a number of new codes and voluntary standards that try to quantify how sustainable a building is taking into account different areas that influence the characteristics of the construction. These Standards work as integrated packages that require the input of several key players and professionals from different fields to create a single design that affect each stage of the project. The objectives of the Standards are to incorporate in the project every decision that would affect the design, the construction and the decommissioning stages; it is also important to combine the decisions taken by the owner of the project, the design team and the contractor with the needs of the potential users.

Nowadays, LEED is one of the most important series of voluntary standards for sustainable construction in the US. Created by the USGBC –US Green Building Council-, LEED follows a performance-oriented system where each credit demands specific requirements to be met in order to gain points for the project; also prerequisites are mandatory requirements that do not account for points. Different levels of green building certification are awarded based on the total credits earned (LEED-NC Reference Guide, 2006). For LEED New Construction Version 2.2 the building must receive a minimum of 26 points; higher levels of certifications include silver (33-38), gold (39-51) and platinum (52-69). There are six categories of criteria to be satisfied: sustainable sites, water efficiency, energy & atmosphere, material & resources, indoor environmental quality and innovation in design.

This paper is an overview of the LEED credits that could be analysed using a computer software. Using simulation software that integrates a number of LEED credits in a single model would save time and effort for the users that want to get a project certified with LEED Standard.

2. METHODOLOGY

With the intention of improving the calculations and analyses currently undertaken by the software programme <VE> (Virtual Environment), I had to familiarise myself with the programme and its functionality. Based on the IES office and working in the development team I was able to understand the complexity of the code.

The second task was to study the literature related to LEED provided by the USGBC and other organisations that had a direct impact on the Voluntary Schema.

Thirdly it was required to research on scientific articles and investigations that could help approach the problem from different perspectives.

The final outcome of this project is the creation of a series of documents that have detail documentation on every credit that could be included in <VE>, as well as other credits that could not be included with the current technology in <VE>. The later ones are also important since they could help to determine improvements required for future versions of the software.

2. LEED CREDITS THAT COULD BE GAINED USING A SIMULATION PROGRAMME

This section lists and briefly describes the various credits that could be gained for a building.

2.1 Credit EA 1 Optimize Energy Performance

Every credit assigns only one point to the project with the exception of 'On-site Renewable Energy' that can assign up to 3 points and 'Optimize Energy Performance' that can assign up to 10 points using the Whole Building Energy Simulation. This option requires a software programme to simulate the energy performance of the building and to demonstrate a percentage of improvement in the proposed building performance rating compared to the baseline building performance rating following the provisions of the Building Performance Rating Method (BPRM) in Appendix G of the ASHRAE 90.1 2004 Standard.

The energy simulation of the design pretends to force the use of technology and ideas that minimize the cost of running the building. BPRM differs from the Building Regulation UK Part L on BPRM is not a compliance method but a ratio of improvement from baseline. The second main difference is that the final result found on the cost of running the building based on the energy consumption and the tariffs of the energy types used in the building; while BRUK Part L is found on CO_2 emissions based on the energy consumption and the 'Carbon Emission Factor' for each energy type.

The points awarded to the project depend directly on the ratio of improvement:

Table 1: Points awarded by credit EA 1 Optimize Energy Performance

New Buildings	Existing Buildings	Points
10.5%	3.5%	1
14%	7%	2
17.5%	10.5%	3
21%	14%	4
24.5%	17.5%	5
28%	21%	6
31.5%	24.5%	7
35%	28%	8
38.5%	31.5%	9
42%	35%	10

BPRM requires the development of an energy model for the proposed design that meets the minimum mandatory requirements. This model is then used as a basis for generating the baseline design that meets the mandatory requirements plus the performance requirements that are established in the standard. This method allows the user to improve the characteristics and properties of the proposed design in comparison to the baseline design. The complexity of this methodology requires a software programme to generate the energy model that includes information regarding:

- Climatic data with statistical weather data for every hour of the year.
- Interior temperature and humidity setpoints for each room.
- Modelling heating and cooling systems including passive systems. The accuracy of system capacities is important to ensure that the requirements for human comfort are met but also to avoid extra consumption of energy by an oversized system.
- Profiling and schedules for the activity of the building, according to the building type and usage.
- Geometry and orientation of the building.
- Characteristics of the building envelope regarding materials and their thermal properties, geometry, configuration and layout. This includes external walls, internal partitions, roof, ceilings, ground floor, doors, external glazing, internal glazing and skylights.
- Installed power density of the lighting system.
- Process energy that includes all the general miscellaneous equipment that consumes any kind of energy.
- On-site renewable energy that is generated on the building.

There are also a number of LEED credits that offer an option to gain the point by means of using a simulation model. These points can be achieved using the same software programme as for the Optimize Energy Performance credit.

2.2 Credit EA 2 On-site Renewable Energy

This credit pretends to encourage the generation of energy from renewable sources embedded in the project and to reduce the consumption of external sources of energy. This category includes wind turbines, photovoltaic modules, solar thermal collectors, small hydro, biomass and biogas. A computer simulation would be able to estimate the energy produced using detailed weather data on the building site and specific geometry and orientation conditions for the device. The amount of energy on-site produced by these technologies is rated as a percentage of the building annual energy cost calculated for the Optimize Energy Performance credit. This credit can assign up to 3 points:

Table 2: Points awarded by credit EA 2 On-site Renewable Energy

Renewable energy	Points
2.5%	1
7.5%	2
12.5%	3

2.3 Credit EQ 8.1 Daylight and Views. Daylight 75% of Spaces

The project whose design ensures a minimum amount of daylight for the occupied spaces is awarded with one LEED point. A simulation programme could be able to analyse the area of the building that meets the minimum illumination of 25 footcandles of direct solar lighting. The simulation must take into consideration properties of the building materials such as glazing factors and surface reflectance settings for interior finishes, properties of the building type such as room occupancy, and climate factors for the location such as sky conditions and sunpath diagrams.

Table 3: Points awarded by credit EQ 8.1 Daylight and Views, Daylight 75% of Space

Daylight	Points
75% of occupied spaces	1

2.4 Credit EQ 8.2 Daylight and Views. Views for 90% of Spaces

This credit requires that 90% of the occupied spaces in the building have direct line of sight to the outdoor environment. The model included in the programme contains the geometry of the external walls and location of perimeter glazing, as well as internal partitions, internal glazing and permanent structures inside the building. The credit also requires the program to have the ability to analyse the direct line of sight to the perimeter vision glazing at 42 inches.

Table 4: Points awarded by credit EQ 8.2 Daylight and Views, Views for 90% of Spaces

Views	Points
90% of occupied spaces	1

2.5 Credits MR1.1, MR1.2 & MR 1.3 Building Reuse

The projects that use the structure from previously occupied buildings can be rewarded with one point for the case of reusing 75% of the external structure (external walls, floors and roof) and one extra point for the projects that reuse 95% of the external structure. Also the projects that maintain 50% of the interior non-structural elements are rewarded with one point. The simulation model could be able to keep the geometry and include some properties of the constructions such as percentage of structure, envelope and element reuse.

Table 5: Points awarded by credits MR 1.1, MR 1.2 & MR1.3 Building Reuse

Building reuse	Points
Maintain 75% of Existing Walls, Floors & Roof	1
Maintain 95% of Existing Walls, Floors & Roof	+1 (total 2)
Maintain 50% of Interior Non-Structural Elements	1

2.6 Credit EQ 1 Outdoor Air Delivery Monitoring

The ventilation system has to maintain a minimum ventilation design to ensure that the CO_2 concentration in the enclose spaces does not affect the human comfort. This credit requires the projects to provide evidence on how to analyse the CO_2 concentration inside each room. The simulation would need information on the room occupancy and the type of ventilation system in order to generate the sufficient documentation for gaining the point.

Table 6: Points awarded by credit EQ 1 Outdoor Air Delivery Monitoring

Outdoor Air Delivery Monitoring	Points
CO_2 monitoring	1

2.7 Credit EQ 2 Increased Ventilation

The credit requires the project to increase the ventilation rates 30% beyond the amounts required by ASHRAE 62.1 2004. Increasing ventilation rates would also increase the HVAC capacity and therefore its energy consumption. A simulation programme would help to see whether or not gaining one point through increasing the ventilation rate could have a larger negative impact on the points gained through the Optimize Energy Performance credit.

Table 7: Points awarded by credit EQ 2 Increased Ventilation

Increased Ventilation	Points
30%	1

2.8 EQ 7.1 Thermal Comfort, Design

Thermal comfort is a complex issue that integrates environmental conditions of the room (air temperature, radiant temperature, humidity and air speed) and personal factors (metabolic rate and clothing level) as well as personal preferences of the occupants. It is based on the Predicted Mean Vote that establishes a seven levels thermal sensation scale from +3 (hot) to -3 (cold) to determine the personal and environmental thermal comfort. The credit does not require calculations but documentation to describe how thermal comfort conditions were established. A simulation programme, making certain assumptions, could provide a report with a summary of all these variables including the Predicted Mean Vote for each room that would minimize the efforts of user to show compliance.

Table 8: Points awarded by credit Thermal Comfort, Design

Thermal Comfort, Design	Points
Not calculation required Relevant documentation on thermal variables	1

3. CONCLUSIONS

This paper has summarised and listed the first of a long list of credits that could be included in a energy performance simulation software. The main benefit from using a computer programme is that the model has to be created only once. The parameters and factors that affect the performance of the building many times are shared among the credits to gain points. Therefore, a simulation programme allows the use of one single design to calculate a number of credits.

Also a simulation programme allows the user to create variations on the design to analyse the energy performance of the building. The results from the simulation of different scenarios can be compared against each other and select the design with the best energy performance. But the connection among the credits is so close that small alterations on the design to benefit one of the credits could cause unexpected impacts on the other credits. If the computer programme has also the ability to perform the analysis for a number of LEED credits, the benefits of comparing the results are multiplied.

US Green Building Council is aware of the complexity of the calculations without a computer programme and the impact that this could have on users losing interest on LEED certification. This is why the Optimize Energy Performance allows users to gain up to 10 points using a computer programme, while only allows up to 4 points for specific cases using manual calculation. But also USGBC is pushing users to use a simulation programme making mandatory for a project to gain at least 2 points in this credit as a prerequisite to obtain LEED certification.

Therefore the advantages of a simulation model to obtain the Optimize Energy Performance calculations are obvious, but also the benefits of using a software programme on the same model to analyse other LEED credits should be considered by users that attempt to achieve LEED accreditation.

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APPROACH OF STANDARD DESIGN MODELS IN THE SAUDI MINISTRY OF INTERIOR PROJECTS

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Abstract: Construction is one of the major industrial sectors of the Saudi Arabian economy, accounting for 6.6 per cent of Gross Domestic Product (GDP) in 2004. There has been a steady and rapid increase in both number and size of building construction projects during the past decade. However, there have been concerns regarding achievement of high performance and value for money from these projects. The Saudi Ministry of Interior (SMOI) is responsible for providing security for the lives and properties of the citizens. The Ministry has a 20-year strategic budget of £4,515,738,575 for constructing buildings such as police stations, civil defence, hospitals, etc. In order to improve projects performance, the SMOI has recently adopted the use of Standard Design Models (SDMs) which have the same specifications, materials and quality requirements. However, many of the projects currently under construction still suffer a range of performance failures such as, completion delays, breakdown of execution and dissatisfied clients. This paper summarises the initial findings of research that sets out to develop a dynamic framework for improving the performance of the SMOI's SDM-based projects. The paper discusses the experience of SMOI in adopting SDMs, explores the process used to produce such models and the expected benefits of using these models. The main conclusion suggests that the SDMs used by the SMOI indeed have tangible benefits that are leading to improved project performance in the construction industry.

Keywords: Project performance, Construction Industry, Saudi Arabia, Project management.

1. INTRODUCTION

The construction sector plays an important role in the Saudi economy and is closely related to other economic sectors. It is also regarded as an important and reliable indicator of the trends and health of the national economy. However, there is considerable variation in the performance of contractors in the Kingdom and there are only few construction companies that meet international standards (MOEP, 2007). It has recently been recognised that the performance of classified contractors has improved due to the higher standards being required by Clients and the need to survive in competitive markets. The Ministry of Economy and Planning has suggested that there is a need to apply many new criteria to improve performance, requiring the development of effective regulations, improvement of management and technical qualifications of staff and encouragement of contractor specialisation (MOEP, 2007). Although a number of contractors in the Saudi Arabian construction industry already perform very well, particularly when they are encouraged financially, i.e. with regular payments, many small and medium companies are often responsible for project delays and poor quality work. These have been attributed to non-availability of adequate financial resources, credit facilities or other financing instruments to improve their capabilities (MOEP, 2007). Nonetheless, Bubshait (2003) argued that the use of intensive/disincentive (I/D) contract provisions encourage contractors to effectively manage and control project duration and/or project cost, as well as labour productivity.

Recent research work by Arain *et al.* (2006) on constructors' views of the potential causes of inconsistencies between design and construction in Saudi Arabia revealed that success in completing building construction projects depends mainly on the existence of strong and proper coordination, and cooperation and communication amongst all parties involved in the project. Particular attention was paid to the high level of communication between designers and contractors, and this was considered a key factor in the assessment of project performance and success. Furthermore, Arain *et al.* (2006) also reported that in order to achieve maximum project performance, there must be a significant presence and participation of the designer in both the design and construction phases. In addition, there should be a sufficient level of awareness by the designer regarding availability of materials and equipment. Unclear or incomplete plans and specifications for projects can also lead to delay and poor performance. Assaf *et al.* (2006) studied the causes of delays on large building construction projects in Saudi Arabia and established that change orders ranked the highest among causes of delays in projects, followed first by ineffective planning and scheduling, and then poor site management and supervision by the contractor. This paper describes the process for adopting the SDMs and presents its aims and objectives. It begins with a review of the SMOI and its departments, details the number of proposed projects followed by an exploration of the aims, objectives and various stages of the SDM approach, and the expected benefits of the approach.

2. THE STANDARD DESIGN MODEL APPROACH

The Kingdom of Saudi Arabia is one of the world's largest countries in terms of land area, estimated at about 2,250,000 Km^2, and comprises 16 administrative regions. The SMOI is one of the largest organisations in the Kingdom of Saudi Arabia and, according to the Development Projects Center (DPC, 1999) report, has 17 security departments, each of which contains a number of sub-departments. Over the last decade, it has faced many problems regarding to the need for many and sometimes very large buildings to house its departments. According to the DPC (1999), the number of projects being considered by the Ministry is estimated to be around 3600. The Ministry has also made considerable effort to cover all the different parts of the country with security department offices; each department needing to be housed in a separate building due to their distinct roles.

The large number of projects has prompted the SMOI to create a flexible design system, where changes are allowed to fit local needs. The SMOI has thus sought standard solutions to avoid huge expenditure in its projects. This target is being achieved through a new strategic approach in the form of a long-term plan over the next twenty years, divided into five stages with each stage spanning four years. This approach is named the Unified Proto-Typical Designs, herein referred to as Standard Design Models (SDMs), for SMOI buildings. The approach was created for executing the SMOI plan that focus on constructing all buildings needed by the SMOI departments. It involves launching different types of design models which are intended to be re-used over a number of projects. This system has many advantages regarding the uniqueness of its designs and the reduction of design costs by using only 85 standard design models instead of 3600 buildings being designed in isolation, thus representing huge financial saving for the Ministry. The system has also helped to: introduce Unified Standards for materials, specifications, building forms; and control operations during the construction phase. In the long term, the strategy is expected to achieve significant benefits in terms of lessons learnt, develop Unified Standards for furnishings, reduce procurement costs through a more strategic approach to bulk purchasing, improve supply chain management and reduce maintenance costs. This research will contribute to the attainment of the long-term benefits aimed at improving the performance of the projects.

3. GENERAL AIM OF THE SDM APPROACH

This approach aims to produce SDMs for SMOI projects, by stressing the importance of reducing design and construction costs, increasing quality, improving procurement and effective monitoring the construction phase (DPC report, 1999).

3.1 Pre-construction activities

The DPC report emphasised the importance of clearly identifying and articulating the needs of the projects prior to the commencement of construction has been recognised and the process below has been developed and adopted to ensure that this is achieved.

1- Determine the SMOI department's needs for the building.
2- Estimate the overall amounts, which are spent annually on rented buildings.
3- Identify all rented buildings.
4- Study all the buildings owned by the SMOI.
5- Study all the land owned by the SMOI.
6- Estimate the amount of land required for these building projects.
7- Distribute to, and collect from all sectors, the requirements of the approach.
8- Implement the design phase through engineering consultants.
9- Ensure the practical application of SDMs on projects to be put out to tender.
10- Invite contractors for tender.
11- Ensure readiness to start the construction phase.

3.2 The expected benefits of the approach

The DPC report also identified the expected benefits of the approach as follows.

- Programming of projects according to priority and a specific plan based on the building, whether it is government-owned or rented, and availability of land.
- Approval of the Ministry on beginning these projects according to the plan.
- Best designs are obtained for the least cost.
- Reduced project execution cost.
- Reduced maintenance and operation costs.
- The need for requested land for the Ministry projects being demonstrated.
- Flexibility in updating the designs and specifications for the unified model.
- Flexibility in assessing these designs after implementation in projects, and avoiding the defects, if any, in future projects.

- Flexibility of convincing the end user to reduce the models based on actual needs that will appear clearly after completion, and apply this to future projects.
- Evidence to convince the Ministry of Finance to increase the budget allocation of some projects due to their repetition.

4. STAGES OF THE APPROACH

This section aims to describe the process used to produce the SDMs as shown in Figure 1. It seeks to detail the stages that are to be followed in order to achieve the main target of SMOI plan. These stages involve drawing up a comprehensive inventory and requirements list, design, adaptation of the SDMs to the site, tender and construction (DPC contract, 2000).

4.1 Comprehensive inventory and requirements phase

4.1.1 Comprehensive inventory

To ensure better working practice, a comprehensive inventory has been built up. This involved designating staff across the country to collect the information required from each department. Specific applications were designed to gather this information. The main target of the inventory was to provide a clear figure relating to the number of items owned by each department. It also provided information about the level of expenditure on rented buildings and the current status of buildings belonging to the SMIO. In other respects, the building priorities for each department could be identified according to greatest need. Many significant challenges have faced the SMOI regarding the availability of the land it owned and these were made clear by this survey. Hence, the priorities and needs for each sector of land have been identified. As a result, there was successful coordination between the SMOI and the Saudi Ministry of Municipality in finding land for the planned projects and avoiding obstacles that might introduce delay. Future needs for projects relating to each department can be added to this plan as they emerge. This task includes the collection of all documents related to Ministry possessions, which may need to be reviewed further, in order not to hinder any future plan’s success. Ultimately, it provided a good database for all information related to Ministry possessions, which helped in drawing up the SMOI’s long-term plan.

4.1.2 End user requirements

The distribution of requirements over all departments was carried out to build a database of all information related to building needs. The major aim of this task was to gather information considered very important in preparing the SDM for a target project. The collected information provided the means to identify the necessary elements pertaining to project components for all departments. These requirements were subjected to many processes in order to ensure rich data gathering.

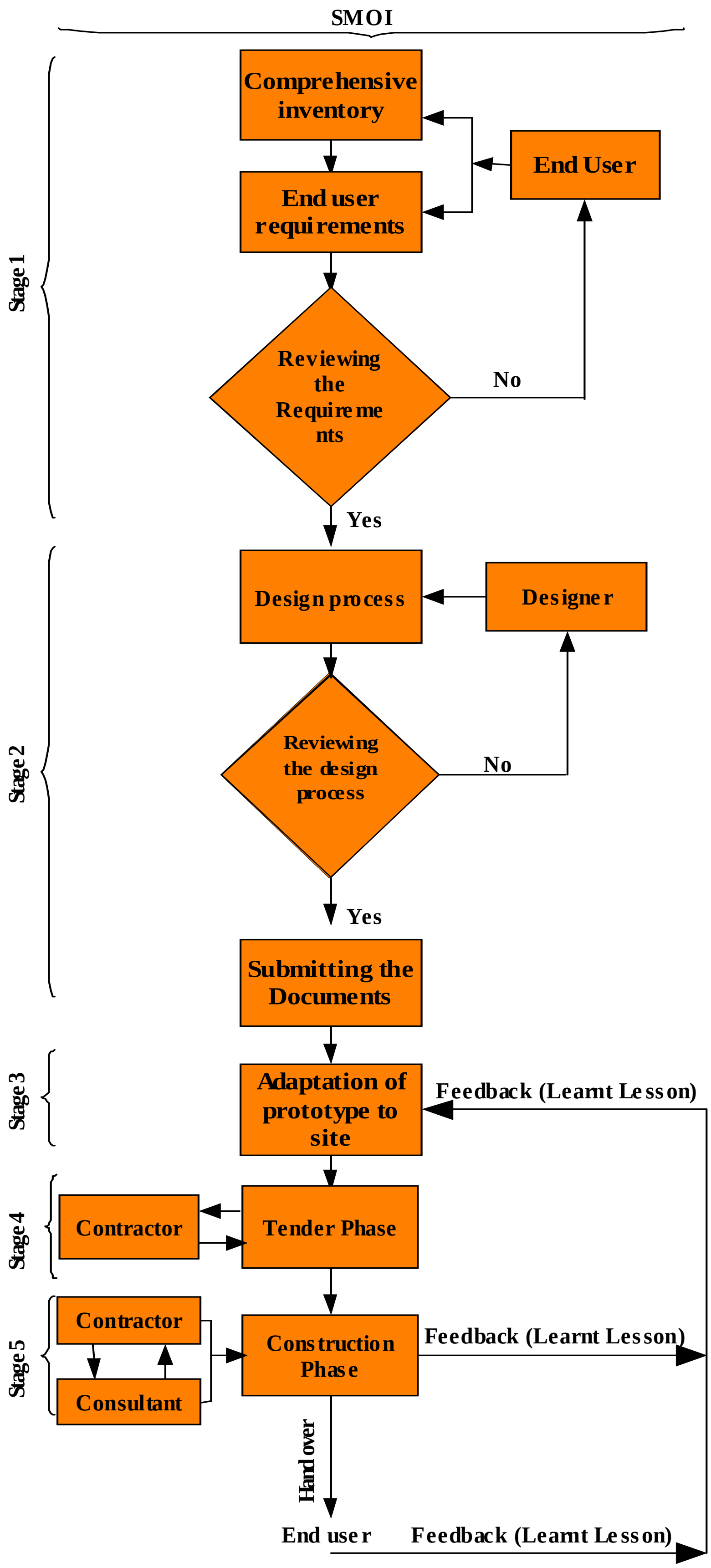

Figure 1: Standard design models process

4.1.2.1 Collecting the relevant information regarding the SDMs

The aim of this task was to gather relevant information regarding the preparation of the design model for the target project including the following.

- General information.
- Information about the administrative system.
- Information about needs and requirements.
- Support services.
- Information about the site.

4.1.2.2 Monitoring implementation of information gathering related to the SDMs

This phase aimed to: fill in any incomplete information related to the SDMs; discuss, perhaps, over-ambitious requirements and needs; establish the relationships between design elements; determine future requirements; and eliminate any shortfall in information as indicated in the first statement. This will take place through meetings with authorised people in the relevant departments to cover the following points.

- General information.
- Discuss of the exaggerated needs and requirements.
- Identify the working relationship between different directorates, departments and units.
- Fill any information gaps through discussions with the end user and the technical team.
- Adapt this information to the particularities of a specific site's situation.

4.1.2.3 Collecting additional relevant information regarding the SDMs

This statement refers to gaining additional information regarding the design model, particularly administrative and technical information, which included the following.

- Information regarding staff working overtime.
- Number of entrance gates.
- Information about security requirements.
- Information about electrical requirements.
- Information regarding fire safety systems.

The outcome of the above task provided useful information, which formed a basic model for the requirements of all departments. Moreover, this information enabled the specialists to map the design process and supported the idea underlying the need for SDMs. The information gathered was reviewed to provide a database for the design phase.

4.2 Feedback on requirements approach

The participation of the end user is critical for the SMOI and is one of its priorities. The aim of feedback is to ensure that all comments sent by departments are filed in accordance with applications. Many meetings take place between all relevant parties to discuss and resolve any issues or ambiguities, which might lead to mistakes in the design phase. This part of the process results in significant end user satisfaction with respect to requirements. The information gained from the above process provides guidelines for planning the design phase. A comprehensive review covers all details which are related to design elements in terms of area, number of floors, relationship between divisions and any special needs related to functionality of building. The reviewed information are documented and prepared as official documents ready for tender. The next step involves grouping the design phase into three groups based on a number of criteria such as the amount of money paid in rent, the availability of suitable land, the importance of the project, particularly with respect to the facilities provided for people. These criteria facilitate the coordination and agreement with the Ministry of Finance, in order to fund the planned projects, and many attempts are made to ensure the estimated budgets for all projects are obtained. This process offers a crucial insight for specialists, since it identifies the total requested land area, as well as the number of projects, as criteria for estimating the number of re-usable models for the present and future.

4.3 Design Phase

According to the DPC contract (2000), the SMOI wants to have Unified Standard Designs for Departmental Buildings surveyed and prepared in accordance with the contents of the Special Conditions of the contract documents. All of this, according to the aforementioned process, involves the documentation of all requirements and drawing upon the expertise of highly qualified specialist design engineers. This phase starts with a number of meetings with the consultants in order to discuss and draw up a detailed needs analysis. It also involves agreements on the regular meetings between the SMOI and the consultants. Although the end user only participates in the previous stage, the SMOI nevertheless attaches great importance to this participation, since it appreciates the vital role end users play in ensuring the success of the project. Requirements for the consultant are linked to the Ministry's requirement for Unified Standard Designs for Departmental Buildings, which can be implemented by the Ministry over different periods and in different places, in all regions of the Kingdom. Therefore, the consultant shall be obliged to prepare Unified Standard Designs for Departmental Buildings as specified in the needs analysis, and will take into consideration the following.

- While preparing these standard designs, usual (analogous) circumstances shall be taken into consideration.
- The design modifications will be prepared for the approved standard designs and to allow for any possible variations in nature and circumstances of the sites, and/or location in an earthquake zone.
- The consultant, after having signed the contract, shall suggest the dimensions of the model site for each category separately and obtain the approval of the Ministry to enter the phase of producing the standard design.

The following are the proper procedures that must be followed in this phase.

- During the preparation of the SDMs, all the standard site considerations are taken into account.
- Take into account all considerations regarding possible variations in sites in terms of relief or seismic activity risks when formulating modifications to the SDMs.
- Provide the suggested dimensions for each prototype design.

- Prepare SDMs that can achieve the flexibility, simplicity, and low cost, as well as the possibility of executing these models over different periods and locations covering the whole area of Saudi Arabia.
- Achieve all the project requirements.
- Study the relationship between project components and attempting to improve the connection between them, by considering the flexibility regarding movement inside the site.
- Consider any future growth.
- Select high quality and locally produced construction materials.
- Select a recognisable and homogeneous style, which reflects the functionality of building.
- During the preparation of the design, consider maintenance operations and their costs.
- Appreciate the social and religious considerations.
- Use the most contemporary technology regarding project preparations.
- Prepare the design to enable savings in energy consumption.
- The final cost should not exceed the initial cost.

The outcome of this stage involves the submission of design documents according to sequential stages, where they are subject to technical review by a committee representing all relevant parties to avoid mistakes at an early stage, and to reduce any defects that may affect the construction phase. SDMs save time and money for both client and designer, because at the design stage, the activity and focus are on one model, where it is subjected to many processes, in order to produce a perfect model. These processes involve providing a number of models for the client to review the architectural aspects and then select the best and most suitable model. After that, the selected model will be subjected to a structural review, mechanical review, an electrical review and a civil review. Eventually, at this stage it is possible to produce a number of re-usable models of this type. The SMOI thus establishes a new idea to adapt the SDMs to be suitable for a new situation.

4.4 Adaptation of SDMs to site

According to the DPC contract (2000), the SMOI implements the SDMs in any required project, by adapting these models to individual sites. It is considered one of the key stages for ensuring the success of the approach and in order to execute the comprehensive development plan drawn by the SMOI. To achieve this aim, many procedures are required in terms of survey data, soil investigation and the necessary design adjustments for each model.

4.4.1 Adaptation of SDMs to individual sites

The ability to adapt the SDMs is very important to the SMOI. There are many common issues involved in fitting the model to the site, such as: area, soil investigation, the direction of building and the entrances and exits. The following procedures describe the following adaptation stages.

a) Stage 1: Preliminary adaptation to the site

Having done the topographical survey and before conducting a soil investigation, the consultant should conduct a preliminary adaptation to identify all factors that will be changed due to the adjustment of the SDM, such as the number of parking spaces, the area and dimensions of the site, Qiblah (prayer) direction, changes in entrances, suggested services locations, and all other factors in the project. The consultant should then submit this to the Ministry for approval, supported by an initial study explaining the extent of this adaptation.

b) Stage 2: Pre-final adaptation and necessary modifications

After completing the preliminary adaptation, gaining the Ministry's approval and a soil investigation, depending on the previous collected information, the consultant should conduct the Pre-final adaptation and make the necessary modifications. These include drawings and contract documents, identifying the plans that will be modified according to the variables related to the actual site, and where it is possible to start the construction phase. The plans that will be modified are as follows.

- All plans related to master plans of the site in all engineering aspects, whether involving walls, gates, external extensions and site works.
- Foundations and other structural works, according to the soil investigation.
- Air conditioning and electrical works.
- The bill of quantities and specifications.
- All plans which need to be modified.
- Cost estimate for construction.

4.5 Tender Phase

This phase is subjected to the government procurement system, which is based on low-bid selection. This phase starts by inviting bids from contractors through advertisements, where they are given a specific period to return their bids for analysis. Added to the low-bid criterion, are many other criteria used to identify the winning bid, such as: contractor qualifications, previous experience and project cost.

4.6 Construction Phase

According to the DPC contract (2003 and 2004), the construction phase is equally regarded as key to the success of the approach. As a result, the SMOI pays attention to this phase in order to realise the planned benefits of the approach. Moreover, the Ministry established a substantial supervision and reporting contract for the construction phase to help control and monitor this phase as there are many projects awarded annually. Such comprehensive supervision and reporting can reduce client costs, increase quality control, reduce and resolve site problems, improve performance, and ensure timely project completion. The main aim of the supervision contract is to improve project performance through best practice. This can be done by providing all necessary technical views, and decisions regarding the plans, specifications and drawings to the contractor in accordance with the contract documents. The supervision contract involves the following procedures.

- Review the studies, specifications, plans and detailed drawings, and ensue that all are correct, accurate and according to contract, thereby meeting the client's requirements and needs.
- Study and review the approach taken to project implementation, report all comments and discuss them with the contractor, suggest any suitable modifications and take all necessary steps to ensure work progresses according to the approved schedule without any delay for whatever reason.
- Study all technical problems which may arise during the construction phase, propose recommendations and legal solutions to the client within one week during the contract period, where these problems do not lead to a delay in the project.
- Study qualifications of the contractor, supply chain and subcontractor, propose the technical view regarding any modifications suggested by the contractor or client, review and study specifications and drawings concerning these modifications and their impacts on schedule, propose effective ideas that affect project performance.
- Issue detailed monthly reports to the client regarding the progress of the project and the extent to which this progress is in line with the schedule. These reports must be supported by documents, pictures, bar graphs and soil investigation results. The reports must clarify the extent of overall project performance, percentage of implemented works, and the progress of payments.

5. CONCLUSIONS

The SMOI adopted the SDMs approach in order to reduce costs and improve projects performance. This has been implemented for its current and future projects by focussing on a number of considerations such as flexibility in updating the designs and specifications for the unified model. The anticipated outcomes of the adopted approach are: reducing cost of design, delivering project on time, and achieving high quality. Furthermore, this approach provides the opportunity for the SMOI to estimate the whole cost for implementing its projects through long-term plans, which might be a challenging task to undertake in traditional design due to the diversity of building types. As such, it is evident that the SDMs could play an important role in improving project performance and contributing to client and end users' satisfaction. Many lessons will be learnt with regard to design knowledge capture and re-use, and through the concept of adaptation of models to avoid inefficiencies and shortcomings which occurred in previous projects. The use of this approach should gradually materialise as quality of designs and construction processes improve due to standardisation of specifications and materials. Additionally, the procurement systems should also improve, with significant impact on the supply chain. Finally, the SDMs used in the SMOI indeed have tangible benefits that could act as an prototypical model for improved project performance in the Saudi construction industry.

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HOUSING FINANCE IN NIGERIA: AN APPRAISAL OF THE PERFORMANCE OF PRIMARY MORTGAGE INSTITUTIONS

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Abstract: Various attempts have been made by successive administrations in Nigeria for providing an enabling environment for financing the housing market. The current legislation is the framework of the National Housing Fund (NHF). Primary Mortgage Institutions (PMIs) draw on the NHF on behalf of their clients through the Federal Mortgage Bank of Nigeria (FMBN). This paper appraises the performance of the PMIs towards providing mortgage financing for construction rehabilitation and outright purchase of houses for their clients. Data for the study were generated through the use of structured questionnaires. The questionnaires were randomly administered. The data were analysed by the use of descriptive statistics. It was found out that on average only about half the number of applications received by PMIs qualified for access to the NHF. It was recommended that the spread of PMIs across the country should be investigated through a needs analysis.

Keywords: Housing finance, Primary Mortgage Institutions, National Housing Fund, Urban dwellers.

1. INTRODUCTION

In Nigeria, successive administrations have enacted policies towards the provision of housing to the ever increasing populace. The policies ranged from direct construction of dwelling units, to legislating the framework for providing financing to prospective house owners. However, Arilesere (1997) and Abiodun (2000) concur that the history of housing finance in Nigeria has been an appalling one. Mustafa (2002) stated that housing finance during the colonial days was limited to expatriates and a few selected indigenous senior civil servants in urban centres. Particular efforts include the establishment of the Lagos Executive Development Board (LEDB) in 1928; the Nigeria Building Society in 1956; Formation of Housing Corporations in 1956 and 1960; National Council on Housing in 1971; Federal Mortgage Bank of Nigeria in 1977; Establishment of Primary Mortgage Institution (PMIs) in 1991 and the National Housing Fund (NHF) in 1992.

The NHF was established by Decree 3 of 1992 and launched in 1994 with the sole aim of facilitating the constant flow of low cost funds for long term investment on housing, to nurture and maintain a stable base for affordable housing finance and to provide incentives for the capital market to invest in property development (Latinwo 2002 and Sanusi 2004). Olukayode (2004) stated that capital for the NHF is raised through three main sources, viz:

- 10% annual contribution of loanable funds by all commercial and merchant banks.

- Mandatory 2.5% tax on all wage earners earning the minimum national wage.
- Insurance companies are required to invest 10% of their non-life and 20% of their life policies in real estate with at least half of these amounts going to the housing fund at 4% minimal interest rate.

However due to the initial implementation problems encountered e.g. non-availability of take-off funds for the Federal Mortgage Bank of Nigeria (FMBN) for loan making operations to PMIs, the FMBN had to first collect the contributions and allow them to accumulate to an appreciable level before the commencement of disbursement. In fact, regulations governing the loan disbursement were put in place only in 1996. The loans operations commenced in June 1997 with the presentation of cheques to some PMIs that fulfilled the requirements to access the funds.

Latinwo (2002) stated that despite the initial delay in the operation of the fund and its adverse effect on the first set of licensed mortgage institutions, FMBN has been able to process loan approvals for PMIs for on-leading to contributors to the fund. Between June 1997 and August 2002, the FMBN had approved loans amounting to ₦1.4 billion to 2452 individuals who applied through 30 PMIs. As at August 2002, outstanding applications to FMBN from PMIs amounted to ₦887 million from 748 individuals through 17 PMIs.

2. PRIMARY MORTGAGE INSTITUTIONS (PMIs)

The promulgation of mortgage institutions decree of 1989 provided the regulatory framework for the establishment and operation of PMIs by private entrepreneurs, giving the FMBN the power to licence and regulate the activities of PMIs as second-tier housing finance institutions (Chiomuma, 2004, Sanusi, 2004). Olukayode (2004) mentioned that the criteria for licencing PMIs include the following: (Olukayode, 2004):

i). A minimum paid-up capital of ₦20 million (now ₦100 million)
ii). Proof of positive shareholders funds
iii). Creation of mortgages for use as security for NHF loans
iv). They should be in the NHF contributory system
v). Should operate within prescribed guidelines.

3. AIM

The paper aims to appraise the performance of PMIs in housing delivery within the framework of the National Housing Fund.

4. OBJECTIVES

- To determine the mortgage facilities offered by PMIs
- To examine the applications and approvals for purchase, rehabilitation and construction of houses
- To determine the performance index of the PMIs

5. METHODOLOGY

Data for the study were sourced from the PMIs. Data sourced included – respondents background, date of commencement of operations and mortgage facilities, applications received and approvals made, sources of funds and factors affecting services provided. From the latter, the factors for assessing the performances of PMIs were sought. Data were collected by the survey method. A total of 45 sets of the questionnaires were distributed among respondents in the six geopolitical zones of the federation. Out of the returned questionnaires only thirty six were found useable for analysis. The data generated were analysed both descriptively and statistically.

6. DATA ANALYSIS

6.1 Performance

The success or otherwise of applications submitted to the PMIs were evaluated by the use of formuli (i) and (ii). This gave their measures of performance.

$$AP_{PMI} = \frac{\Sigma Ar_1}{\Sigma Ap_i} * 100\% \quad \text{..............................} \text{(i)}$$

Where AP_{PMI} Performance of application in terms of approval by each PMI
Ar Number of approval given by the PMI
Ap Number of application received by the PMI
i the *ith*, period, AP_1, denotes total applications received in 1998, AP_2, in 1999 etc.
and

$$AP_C = \frac{MAr}{MAp} * 100\%, \; MAr = \frac{\Sigma Ap}{N} \quad \text{..............................} \text{(ii)}$$

Where AP_c is Category-based average performance of application

MAr mean approval given by all the PMIs
MAp mean application received by all the PMJs
AP Numbers of Approval given by each PMI
N Total number of PMIs

7. RESULTS AND DISCUSSION

7.1 General Information about PMIs

To get acquainted with the PMIs studied, information about their location, periods of commencement of their operation and the period that they were accredited were sourced from the respondents. The result of this finding is shown in Table 1.

Table 1 - General Information about Primary Mortgage Institutions

Location of firm		**Start of operation**		**Period of accreditation**	
Area	**%**	**Category**	**%**	**Category**	**%**
North	25	1988 – 1992	17	1992 – 1994	26
West	14	1992 – 1996	36	1994 – 1996	6
East	6	1996 – 2000	28	1996 – 2000	34
South	42	2000 – 2004	19	2000 – 2004	34
FCT	14	**Total**	**100**	**Total**	**100**
Total	**100**				

In terms of location, majority of the PMIs are located in the southern part of Nigeria which is accounted for by 42% of the thirty six PMIs studied, while 25% are situated in the northern part of the country with 14%, 14% and 6% located in the FCT, west and east respectively. The high concentration of the PMIs in the FCT, south and north is not surprising giving the population density and high volume of businesses carried out in such places thus determining the high demand for the services of the PMIs in terms of their intermediary role towards housing provision. As shown, in Table 1, 17% of them commenced operation between 1988 - 1992, with about a third (32%) starting between 1992 - 1996. As much as 47% of the PMIs started their operation 6 - 10 years after the promulgation of the decree establishing them. This seeming delay in commencing operations by these PMIs may not be unconnected with the uncertainty which besieged the financial sectors of the economy during the early 1990s. Another potential cause of the delayed takeoff by some of these PMIs may also be traceable to the period they were accredited with about 70% of them having been accredited between 1996 and 2004 as shown in Table 1. The Table further shows that only 26% of the PMIs got accredited shortly after they came into existence. It is expected that this delay in accreditation, and the wide gap between commencement of operation and accreditation, had a concomitant effect on the housing programme in a general sense.

7.2 Applications and Disbursement of Funds

7.2.1 Applications Received and Approvals Given

A main function of the PMIs is the collection of applications from contributors, which are further sent to the FMBN (only when such applications satisfy the conditions for access to the funds) for processing and eventual release of the approved amounts. Respondents were asked to provide data on the numbers of applications they received and the numbers approved within stated period. The mean values of these data were computed and the results shown in Figure 1.

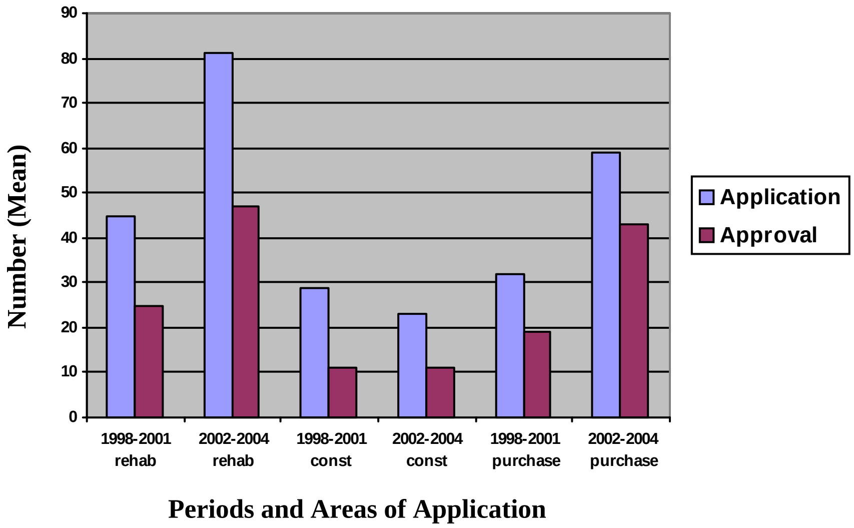

Figure 1 - Number of Applications Received and Approvals Given by PMIs

The numbers of applications received by the PMIs investigated were categorised into the three distinct areas of application namely rehabilitation, construction and purchase as discussed below:

7.3 Applications and approvals for Rehabilitation

Between 1998 and 2001 an average of 45 applications were tendered to 29 of the PMIs while 24 of these applications qualified for access to the loans i.e. those approved. For the periods between 2001 and 2004, 29 PMIs received an average of 81 applications while only about 47 of them were approved. From the aforementioned distribution, it is evident that only about half of the applications received by PMIs satisfy the conditions for access to the funds and that transiting between the two distinct periods i.e. from 1998 - 2001 to 2002 - 2004 there was a near doubling of the number in applications received.

7.4 Applications and approvals for Construction

On the average, 22 of the PMls received twenty-nine applications between the 1998 - 2001 period with only 12 of these applications qualifying for further consideration. During the 2001 - 2004 period, PMIs received 24 applications with only about 12 approved for access to the funds. The rate of approval in both periods remained virtually unaffected, similar to that of applications made for rehabilitation i.e. about half. The consistency of applications received during the 1998 - 2001 period and during the 2001 - 2004 period shows that despite the accreditation of the PMIs there was no increase in the number of applications to construct new buildings. This may be traceable to the difficulties associated with the acquisition of land as noted in the National Housing Policy (1991) that one of the problems of accessing the NHF is the conditionality of the use of land as a collateral.

7.5 Applications and approvals for Purchase

With respect to applications for the purchase of existing buildings, rather than to rehabilitate or construct, 20 PMIs received 33 applications during the 1998 - 2001 period with as much as 19 of them approved for access to the NHF. During the 2001 - 2004 period, 20 PMIs received 59 applications for purchase purpose and as much as 44 of these applications got approval for access to the NHF. As in the case of applications for rehabilitation, applications for purchase almost doubled during the 2001 - 2004 period compared to that of the 1998 - 2001, A possible explanation for this increase, in addition to those identified for rehabilitation, is the increase in the borrowing ceiling to ₦5 million in 2003, which was originally set at ₦0.5 million at the commencement of the NHF scheme in 1992.

7.6 Applications and Approvals for Various Mortgage Facilities

Out of the 36 PMIs studied only six provided data on mortgage facilities they provide, with only 3 of them giving information other than access to NHF. They all provided data for other credit facilities only. On the average, for those that provided data on other credit facilities, 15 applications were received during the period 1998 - 2001 and all of them were approved. During the period 2001 - 2004 only 9 applications were received and all of them were approved. The 100 percent approval rate of the applications may be due to the less stringent measures the PMls adopt probably as a strategy of improving their customer base and patronage. The low response of the PMIs to this aspect does not support the claims made by the PMIs on the mortgage facilities they provide aside access to the NHF as shown in Table 2.

7.7 Application Performance Index

The study investigated the performance of applications submitted to the PMIs. Computing the performances for the data collected for the two periods i.e. 1998 - 2001 and 2002 - 2004 revealed the results presented in Table 3.

Table 3 - Performance of Application for NHF

Areas of Application	N	1998 - 2001	2002 - 2004
Rehabilitation	29	0.536	0.575
Construction	22/27[a]	0.406	0.483
Purchase	20	0.583	0.741

* 22 *PMIs gave data for the periods 1998 - 2001; while 27 PMIs gave for 2001 - 2004 periods*

Generally, the performance of applications was ‘average’ during the two periods under study for the three purposes needed i.e. rehabilitation, construction, and purchase, having performances ranging from 40% to 58%. This is with the exception of purchase in the 2002 - 2004 periods, which had a performance of 74%, which is considered as ‘very good’. Applications meant for rehabilitation and construction exhibited very low movement in their performance score between 1998 - 2001 (54%, 41%) and 2001 - 2004 (58%, 48%) respectively. Conversely, applications for purchase purpose showed some increases in their performance increasing from 58% in 1998 - 2001 to 74% in 2002 - 2004 periods. Further analytical probing into the existence of differences reveals that the application performance of PMIs whose accreditation was within the 2000 - 2004 period was higher (62%) than those accredited during the 1996 – 2000 (37%), as shown in Table 4.

Table 4 - Mean of Application Performance for each Accreditation Period

Period of accreditation	Mean	N	Std. Deviation
1996 – 2000	36.7184	8	6.50385
2000 – 2004	62.2114	3	4.22846
Total	43.6710	11	13.22805

None of the PMIs accredited before 1996 gave full information about application received and *approved given*

However the results of this analysis should be used with great care since only 11 PMIs were used (i.e. those that supplied information for period of accreditation, numbers of applications received and approvals given). The sample size is statistically too small to base judgment on the mean values computed, for the purpose of generalisation. This may explain the high performance of application during the 2000 -2004 periods.

7.8 Disbursement of Funds

The effect of the PMls can only be ‘felt by the contributors by the amount of funds disbursed since this is the main purpose for PMIs creation - intermediating between the NHF and the contributors. The respondents were asked to provide data on the amount they disbursed for loans required for the purpose of rehabilitation, construction and purchase. The analysis of the data collected is presented in Table 5 and the mean values presented in Figure 2.

Table 5 - Mean Amount Disbursed between 1998 - 2004 (in millions)

Amounts Disbursed	N	Mean	Std. Dev.
Amt disbursed in 1998-2001 for rehab	29	15.26	7.34
Amt disbursed in 2002- 2004 Pot rehab	29	43.07	34.08
Amt disbursed in 1998-2001 for const	22	33.32	20.80
Amt disbursed in 2002 - 2004 for const	27	33.96	22.62
Amt disbursed in 1998 - 2001 for purchase	20	72.20	112.97
Amt disbursed in 2002 - 2004 for purchase	20	180.55	462.08

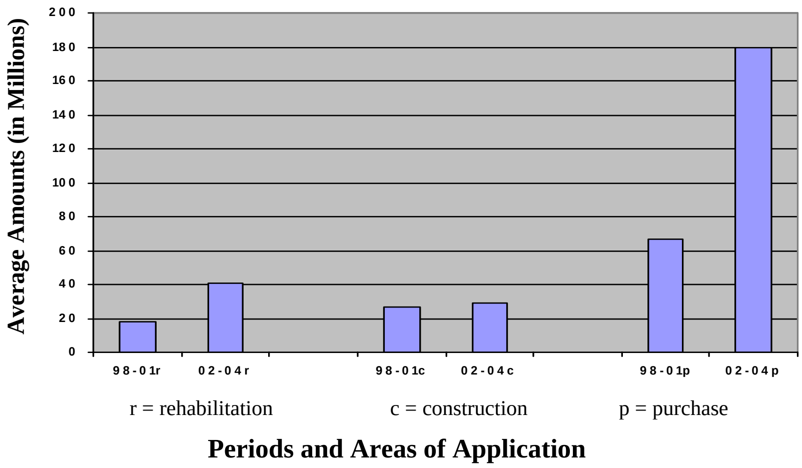

Figure 2 – Average Amounts Disbursed by PMIs from 1998 - 2004

7.9 Disbursement for Rehabilitation

For the period 1998 - 2001 an average of ₦15.27 million was disbursed by 29 of the PMIs. This figure more than doubled during the 2001 - 2004 period to ₦43.07 million as shown in Table 5. This is in line with the increase in number applications and approval between the periods as shown in Figure 1. The amount may seem small compared to the number of applications approved (i.e. 24) for that period. This may not be unconnected with the fact that approval of applications do not necessary translate into disbursement of funds. Further study of the data collected indicate that the minimum amount disbursed during this period was ₦2 million while the maximum was ₦33 million.

7.10 Disbursements for Construction

During the l998 - 2001 period, a mean amount of ₦33.32 million was disbursed by 22 PMIs for construction while during the 2002 - 2004 period ₦33.96 million was disbursed by a total of 27 PMIs. Though there exists an increase, but compared to that of rehabilitation, which doubled, the increase in construction between these two periods was very slight and could be considered as insignificant. Comparing this finding with that of applications received and approved for construction indicates a similar pattern i.e. there was only a slight increase in both applications received and approvals made between the 1998 - 2001 period and the 2002 - 2004 period. However, from the data collected, the minimum and maximum amounts disbursed for the 1998 - 2001 period was ₦5.0 million and ₦8l.0 million respectively, and for the 2002 - 2004 period ₦12.0 million and ₦91.0m respectively.

7.11 Disbursement for Purchase

Similar to the high proportion exhibited for applications received and approvals made during the periods under study, were the amounts disbursed during this periods. During the 1998 - 2001 period 20 PMIs disbursed an average of ₦72.20 million while ₦l80.55 million was disbursed during the 2002 - 2004 periods. There was a transitional increase in disbursements amounting to more than a doubling. A closer look at the descriptive statistics as shown in Table 5 indicates very high standard deviations for both the 1998 - 2001 and 2002-2004 periods, which is very unusual. The minimum and maximum amounts disbursed during these periods i.e. ₦9.0 million - ₦530.0 million for the 1998 - 2001 periods and ₦12.0 million - ₦2.l23 billion for the 2002 - 2004 period may explain the reason for the high standard deviations.

Despite the existence of differences between applications and approvals, there also existed positive and strong relationships between these variables for the following periods and areas - for rehabilitation during 1998 - 2001 *(r = 0.738),* rehabilitation 2002 - 2004 *(r = 0.757),* construction during 1998 - 2001 *(r = 0.605),* and for purchase during 2002 - 2004 (r = *0.911).* These correlation values indicate that as the number of applications increased, the number of approvals given also increases. For applications and approvals for construction during the 2002 - 2004 periods and purchase during the 1998 - 2001 periods the correlation values were relatively low i.e. r = *0.545* and r = *0.479* respectively.

7.12 Differences between Amounts Disbursed

From Table 6 only the amounts disbursed for rehabilitation showed the existence of a statistically significant difference between amounts disbursed during the 1998 – 2001 periods and the 2002 - 2004 periods, having a p - value less than 0.05 *i.e. p = 0.000.* For amounts disbursed for both construction and purchase there exists no significant differences between the two periods under study both having p - values greater than 0.05 i.e. p = *0.357* for construction and p = *0.194* for purchase. However, there existed inverse relationships for amounts disbursed between the two accounting periods for rehabilitation and construction purposes i.e. $r = -0.412$ and $r = -0.123$ respectively.

Table 6: Test Statistics or Applications – Approvals and Amount Disbursed

Paired items	₦	Correlation Statistics		Differences Test	
		Corre-lation	**Sig**	**Mean**	**Sig**
Applications and Approvals					
Application in 1998 – 2001 for rehab & Approval in 1998 – 2001 for rehab	29	0.738	0.000	20.93	0.003
Application in 2002 – 2004 for rehab & Approval in 2002 – 2004 for rehab	29	0.757	0.000	34.52	0.000
Application in 1998 – 2001 for const & Approval in 1998 – 2001 for const	22	0.605	0.003	17.18	0.000
Application in 2002 – 2004 for const & Approval in 2002 – 2004 for const	27	0.545	0.003	12.44	0.000
Application in 1998 – 2001 for purchase & Approval in 1998 – 2001 for purchase	20	0.479	0.033	13.65	0.001
Application in 2002 – 2004 for purchase & Approval in 2002 – 2004 for purchase	20	0.911	0.000	15.35	0.008
Amount Disbursed					
Amt disbursed in 1998 – 2001 for rehab & Amt disbursed in 2002 – 2004 for rehab	29	-0.412	0.026	-27.81	0.000
Amt disbursed in 1998 – 2001 for const & Amt disbursed in 2002 – 2004 for const	20	-0.123	0.604	-6.95	0.357
Amt disbursed in 1998 – 2001 for purchase & Amt disbursed in 2002 – 2004 for purchase	20	0.928	0.000	-108.35	0.194

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusion

- There is a high concentration of the PMIs in the southern part of Nigeria, which corroborates the severe housing problems, being faced, although the severity of inadequate housing is also prevalent in other parts of the Nation where low concentration of PMIs exists. The number of registered PMIs is generally small.
- There was a delay in the commencement of operation by some of the PMIs after the establishment of PMIs decree and after they (the PMIs) got their licenses to operate. This delay may be attributable to the delay that was experienced between the period of commencement and that of accreditation, which spanned a period of 4 year in some cases.
- Apart from their primary role - serving as windows contributors for access to the NHF, PMIs do appreciably provide other support services, for example, saving and credit facilities. Only half of the PMIs provide investment schemes for their customers while there is a very low participation in trading in stocks.
- On the average only about half the number of applications received by the PMIs from their contributors/customers qualified for access to the NHF for the various areas for which the loan is required. Out of the other facilities provided by the PMIs i.e. credit, savings and investment facilities, information provided from applications received

in these area was very scanty, though there was a 100% approval rate for applications made in these areas.

- There was an increase in the amounts disbursed during the 2002 - 2004 period over that of 1998 - 2001 for all the areas of application of the loan i.e. construction, purchase and rehabilitation. Despite the existence of differences between applications and approvals, there also exist positive and strong relationships between these variables for the following periods and the areas.
- There is a noticeable doubling, in the number of projects completed between the 1998 - 2001 period and that of the 2002 - 2004 for rehabilitation, construction and purchase.
- A comparative analysis of' the funds disbursed and the amount of funds approved for disbursement for the two periods under study reveals that as much as three times the amount approved for disbursement during the 1998 - 2001 periods was approved during the 2002 - 2004 periods. Total amount disbursed on the other hand did not enjoy as much of an increase, having only a 19.1% increase over the 1998 - 2001 and 2002 - 2004 periods.

8.2 Recommendations

- To properly address the problem of housing finance, the spread (prevalence) of PMIs in the country should be investigated through a needs analysis on a regional basis. By so doing, the regional requirements of the number of PMIs that can adequately service a given region can be ascertained. Hence, there should be some form of incentives to promote private participation in PMls ownership in the country.
- Existing PMIs should be encouraged to open up avenues for investment schemes and trading in stock for their teeming clientele, as this with increase their sources of financing and involve their performance in terms of meeting up approvals and eventual disbursement.

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BELONGING AND BECOMING AN EXPLORATION OF IDENTITY AND LEARNING FOR FULL-TIME QUANTITY SURVEYING STUDENTS

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Abstract: The construction industry requires a constant supply of appropriately educated and skilled staff at all levels. This paper explores the relationship between identity and learning, through the concepts of 'belonging' and 'becoming' in professional, vocational education. Case studies focusing on a cohort of aspiring Quantity Surveyors as they progressed through their studies allowed in-depth exploration of the formation of identity (ies) and the dispositions adopted towards learning at two key milestones: Level 1 (first year) when the participants had almost completed their studies, and Level 3 (third year) when the participants had returned from professional placement.

The conclusions raise issues for professional, vocational education in general, highlighting three key areas for further attention: the tensions inherent in providing discipline-orientated programmes within a semesterised, modularised, more generic-focused delivery system; provision of professional placement opportunities including the emotional aspects of same; and the resultant impacts on dispositions and identity, 'belonging' and 'becoming'.

Keywords: identity, learning, professional vocational education.

1. INTRODUCTION

1.2 Rationale for Study

This study was based in the School of the Built and Natural Environment, Glasgow Caledonian University. While the School has given considerable attention to student retention generally, little attention has focused on the specific issue of identity, how it fits with / is reflected in learning, and what part it might play in the general student learning experience. Within the School we talk of "educating the professional" and of students developing a 'professional approach' but what does this actually mean? How is it to be achieved? When students first join their programme of study, are they thinking of themselves as quantity surveyors in the making, or do other, different identities take precedence?

This study explores the relationship between identity and learning, in particular the concepts of 'belonging' and 'becoming' in respect of professional, vocational education. Adopting a case study approach, the study charts the experiences of one cohort of quantity surveying students as they progress through their studies, firstly as Level 1 (first year) students and then as Level 3 (third year) students.

1.3 Context for Study

The School aim is to provide graduates across a wide range of disciplines within the construction and property industry, each of whom has a specific role to play. Provision would be defined as 'professional, vocational' education; the promotion of programmes linked to specific career paths (or disciplines) is designed to meet both the needs of employers in industry and to enable graduates to progress within their chosen field. In such a framework, professional education requires close relationships with the profession and employers, to ensure a curriculum is developed to deliver knowledge for the discipline within the context of professional practice (Taylor, 1997).

For the purposes of this study then, professional education is defined as the development of:

- Understanding and application of an accepted body of knowledge and the demonstration of professional expertise;
- Competence in generic skills;
- Reflective practice and informed ethical judgement;
- Responsibility and accountability to others;
- Engagement in CPD and Lifelong Learning;

with an increasing emphasis on the importance of development of skills other than 'pure' discipline (Katz, in Bourner *et. al.*, 2000, adapted). Professional expertise and competence is defined as the requirement to develop one's continuing theory of practice, technical and interpersonal theory (Argyris and Schőn, 1974), more succinctly the development of two sets of skills: 'hard' (technical) and 'soft' (interpersonal, communication) (Kerka, 1993). These 'hard' and 'soft' skills sets as defined by Kerka (1993) are integrated within the modules which form the programme as well as via the period of professional placement.

1.4 The Quantity Surveying programme

Both full-time and part-time routes are available for study on the quantity surveying programme, but it is the former that is of relevance here. The structure of the full-time programme is provided in Appendix A. Level 1 (Year 1) is the foundation year, where there is a high degree of commonality across all programmes, and exposure to the specific discipline is limited. Commonality of modules at Level 1 not only facilitates ease of transfer from programme to programme, but it also reflects the subjects core to each discipline – technology, law, economics – where the context and application of knowledge is broadly similar and the existing knowledge base is generally limited. The majority of Level 1 entrants are school leavers for whom most of these topics are entirely new and so the development of a foundation knowledge base is required.

At Level 2 (Year 2) the development of discipline areas of expertise and the professional context for operation increases. Here, the emphasis is on preparation for professional placement and development of the core skills required to make a contribution to industry and practice. The professional placement period occurs at the end of Level 2 and the first semester of Level 3. This placement is paid and students are expected, as employees of the organisation, to undertake professionally-orientated tasks and activities. Thus the student becomes a learner in practice, with the opportunity to practice, develop and refine their professional skills. They are also exposed to the cultural mores of professional practice and the culture of the workplace.

Returning to their studies in Level 3 students now focus on consolidation of the core areas of professional activity. Level 4 requires students to take greater responsibility for their learning and development, primarily through the Dissertation module where they are required to research and report on a topic, area or aspect of practice of their choosing. The emphasis is on independent learning, reflected not only through this research project but also through the methods of learning and teaching employed in the modules.

2. IDENTITY AND LEARNING

2.1 Being a Learner in Higher Education

Student's early expectations of Higher Education are governed by who they are, the structural and cultural patterns they enter and the strengths and problems they bring with them to the new Higher Education environment (Silver and Silver, 1997). To assist first year students make the transition and develop skills as an independent learner, Kantanis (2000) argues that this must be a cumulative process, set within the context of discipline-specific requirements. Students themselves must be encourated to negotiate any initial feelings of alienation, dislocation and the like, and to recognise the differences in culture between university and school, including the nature of learning and teaching inherent in the former (Kantanis, 2000). Kantanis also emphasises the social aspect of university life and the need to belong to the institutional community (Nathan, 2005) which fosters same. Thus there are two dimensions to identity as 'belonging': as a member of the learning community and as a member of the specific discipline.

The rise of what might be termed a new vocationalism in Higher Education, where the focus of educational outcomes is as much on a person's characteristics and orientations as on skills and knowledge (Chappell *et. al.* 2003) has also changed the nature of demands placed on learners in respect of the concepts of self and identity (for example, the increased emphasis on 'Personal Development' and 'Employability' attributes) and has led to a requirement for new forms of identity and the construction of self. It can, of course, be argued that the link between education and identity has always existed, in that changing learner identity is – implicitly or explicitly – a part of every form of educational practice, and that education "invariably involves an element of self-formation and change" (Chappell *et. al*. 2003: p5). Learning is usually regarded as beneficial, to the individual doing the learning or to the wider community, involving the acquisition of new skills, information and knowledge which in turn helps people to widen their capacities for action, individual or collective. This is a simplification of Wenger's (1998) dimensions of identity; we become what we are by learning how to interact and how to work together, how we 'belong' and 'become' and it is therefore to his social theory of learning that I now turn. This theory views learning as social participation, the process of being active participants in the practices of social communities and constructing identities in relation to these communities. Such participation shapes not only what we do but also who we are and how we interpret what we do. In short, formation of identity, 'becoming', can be considered through 'belonging'.

For Wenger, learning is fundamentally a social phenomenon, where knowledge is a matter of participation and being part of a discourse community, ie an active engagement in the world, and that to permit this engagement we need to have a sense of self, a sense of our place in this world, and a sense of the place of those around us. Learning is not just an accumulation of skills and information, but the process of becoming a particular person by acquiring these skills and knowledge in the service of an identity, in other words through 'belonging' and 'becoming'. Within the Higher Education environment, students come together to deal with the requirements of the institution, the curriculum and associated activities, forming various communities of practice on the basis of: their chosen programme of study; their areas of interest; their shared experiences.

Formation of communities of practice is also negotiation of identities. Developing a practice requires the formation of a community whose members can engage with each other and acknowledge each other as participants. Identity is formed through participation in the community; our membership constitutes our identity. Within the community of practice we also learn certain ways of engaging with other people, and we become who we are by being able to play a part in the relations of engagement that constitute same. But our identities are not only produced through the practices / communities we engage in, but also through those that we do not. That is, our identity is constituted by what we are not as well as by what we are. Non-participation is an inevitable part of a coherent identity, in that a mixture of being in or being out simply reflects our membership of specific communities of practice and not others. But when non-participation interacts with participation to define each other it can become important to identity formation; a novice not understanding a conversation between old hands highlights the continuity of community formation.

Learning and identity are therefore all constructed socially within the communities to which we belong: "one needs an identity of participation in order to learn, yet needs to learn in order to acquire an identity" (Wenger, 1998: p222). Within an educational community, students are modelled as apprentice practitioners within their discipline or field of study, with a focus on the individual in relationship to this community. Identity evolves through their participation and non-participation in all the communities with which they interact, and all the experiences they have with these communities contribute to their learning.

Personal identity is also part of this exploration. Personal identity is defined by Chickering (1972) as development of those competencies: emotions, autonomy, interpersonal relationships, purpose and integrity, to form a solid sense of self. But identities are not constant: we can be different "I's" in different situations, and it is those different "I's" that the quantity surveying students adopt / demonstrate that drives this study.

2.2 Professional Education, Identity and Learning

But the theory of a 'bounded community' (Nathan, 2005) is not necessarily reflected in the reality of student life, which consists of a self-selected series of individual communities created by each student, each of which is competing for their attention. Nespor (1994) too identifies this multiple membership and connections across networks as problematic. Nespor also posits that learning in a discipline is not simply a matter of transforming one's psychological make-up, rather learning refers to changes in spatial and temporal organisations of the actor-network of which we are always a part. Further, he suggests that disciplines are constituted by cycles of accumulation within these networks, which organise flows of people and things through space and time. So 'closed' communities of practice are replaced by the more open processes which constitute disciplines, centring round incorporation of students into discipline-specific temporal and spatial representations of knowledge.

Students actually enter into disciplinary practices when they begin to construct worlds through discipline-based systems of representation, and learning moves from being the transformation of the individual and how one gets to be at home on isolated islands of practice to where identities are "crystallised in the tensions and pressures produced as different communities clash" (Nespor, 1994: p12). Having knowledge means participating in an actor-network that organises a field of practice such as a discipline, and participating means becoming spatially and temporally organised in a form that moves you into the material spaces of the field and becoming proficient at using the discipline's representational organisations of space-time. The discipline itself is, however, a stable entity in so far as it ties together spaces and times, mobilises elements and moves them across distances to a centre where they can be combined and acted upon. Enrolment in a programme is a product of struggle amongst actor-networks (friends, family) where materials organisation of space-time plays a critical role in organising bodies (eg timetabling classes). The student academic experience is not simply a series of unrelated academic categories and activities, it is the inter-relation and the forging together of those fragments which allows the student to form an educational 'whole' and participate in the network (Nespor, 1994). For Quantity Surveying students, the holistic application of the constituent subject knowledge and connection to the discipline is mainly via textbooks, note-taking and assessment activities within modules evaluated in terms of relevance to the world of work. Such reduction of the world to textual form allows students to construct linkages amongst the modules in the curriculum and textual practices mobilise the disparate, widely scattered phenomena of everyday material practice, bringing them into a work setting and under the control of practitioners, ie the teaching staff. Programmes themselves are connected to the network of practitioners via guest lectures and professional placement opportunities.

As the 'novice' quantity surveyors move to professional placement, knowledge is not simply a body of content codified in textbooks to be transmitted and acquired, it is also embedded in specific contexts, the property of groups and organisations as much as something which is possessed by individuals (Guile and Young, 1998). Thus when the world of work enters the actor-network, a further dimension – and tension – is created. Representations of practice are real, conveyed by practitioners active in the 'real world'. Representations of implicit practices – dress codes, terminology, behaviours – are demonstrated as well as the explicit – explanation of aspects of practice. Entry to a particular part of the community is facilitated by accepting employment with a particular organisation. The mores of professional life are revealed and students come to understand the conventions required (eg wearing a suit).

2.3 Identity and Learning in the Workplace

The inclusion of a period of professional placement allows students to act as mediators (Tuomi-Grőhn *et. al*. 2003) bringing new insights from work experience into university and vice versa. Students making the transfer from programme to work encounter differences, enter unfamiliar territory as unqualified entrants, which requires them to interpret, modify and reconstruct the skills and knowledge transferred. But this assumes, however, that students learn how to transfer knowledge and learning from the institution to work, and that such a transfer is one way; students acquire knowledge in their vocational programme and 'apply' it relatively unproblematically in the workplace. And such a transfer is not, nor is it a simple, mechanical process (Guile and Young, 2003). While programme curriculum focuses on the knowledge and skills content of the profession, with knowledge treated as a body of content to be acquired, and learning a process of transmission between programme tutors and learner, performance in the workplace typically involves the integration of several different forms of knowledge and skill; it is also a different knowledge culture from that of Higher Education. Modern workplaces are extremely diverse in the demands they make regarding learning and knowledge. Further, transition is not merely a matter of 'launching the student to learn in a workplace; workplaces are very different and learning opportunities are not equally distributed across them (Beach, 1999). Transferring an idea or concept from an educational setting to a workplace setting is also particularly difficult because of the differences in context, culture and modes of learning (Eraut *et. al.* 1998); their codified knowledge from university is confronted with more situated and episodic knowledge resulting from workplace experiences.

However, in vocational education, such practical training periods do play an important role in development of competence, where students are put in apprenticeship roles, confronted with authentic tasks and problems and have direct experiences with other employees and work-related events. But just as work places differ in respect of the learning opportunities offered, so students differ in the learning activities they engage with. Competence development during such practice periods is influenced by the characteristics of the workplace and the persons and personal relations (which can both often be negative), and so the differentials in conditions for learning have considerable implications for knowledge and skills transfer. Cultural identity is also an important facet of the workplace (Hall and du Gay, 1997). Organisations seek to represent this internally by defining the meaning of employment and the relationships employees should have with the organisation, including how they should behave, value, think and relate to their employer and colleagues (du Gay, 1997). Work is represented in distinctive ways, and these representations can also vary and be experienced in different ways. Understanding and knowledge is structured through shared meanings, and this shared framework is used to define and make sense of work (Hall and du Gay, 1997). Informal learning in the workplace is also important (Eraut, 2004) recognising the social significance of learning from other people and the emotional dimension of professional work, with relationships playing a critical role in workplace learning. In summary, success in learning depends on the quality of the relationships in the workplace; the amount of learning varies significantly with the person and the context.

3. METHODOLOGY

3.1 Participants' Profile

Identity as a developmental process meant that the most appropriate approach for data collection was to follow one specific group, and so the participants comprised one particular cohort of students on the BSc (Hons) Quantity Surveying degree programme. To chart their journey and allow them to tell their stories in the most meaningful way, two key milestones were identified: during their Level 1 studies and again as they moved towards the completion of Level 3. At Level 1 the participants were just beginning their studies, and so the interest here was how they dealt with issues of identity and whether greater emphasis was placed on personal/learner identity, given that their knowledge of the discipline and the professional environment was likely to be limited. At Level 3, however, the participants were almost three-quarters of the way through their programme of study, and have also experienced a period of professional placement, so exploration of discipline and professional identity as well as personal/learner identity was possible. The representativeness of the participants was pre-determined as the group comprised those who were registered for Level 1 of the programme at the start of the 2002-03 academic session. This cohort comprised eighteen males and four females. Appendix B provides full details of the participants' profiles and the referencing system used for data analysis purposes.

3.2 Methodology Framework

As this study explores how a particular group of students perceive their educational world and within this, the discipline and professional of the Quantity Surveyor, it can be defined as qualitative in nature. And as the focus is on student experiences and perceptions, an inquiry paradigm is most appropriate, resulting in the adoption of an interpretivist approach to data collection. More specifically, the approach adopted can be defined as Constructivist, where the aim of the inquiry is to understand the reconstruction of the reality, collecting and collating individuals' reconstructions to reach some sense of consensus, with the researcher a 'passionate participant' acting as facilitator in this multi-voice reconstruction (Guba, 1990). Such a method of enquiry primarily requires the use of qualitative methods, with data collection approaches centring on communication (Crotty, 1996) and in this study the following approaches were adopted:

- Focus group interviews
- Questionnaires
- Reflective journals
- Feedback interviews
- Participant observation

This range of approaches allowed exploration of individual experiences and perceptions for the specific group of participants involved. Each participant was afforded the opportunity to articulate their personal experiences and perceptions which, when collated and interpreted, provided a greater understanding of the student experience. The emphasis was on interaction, with research understanding enhanced via dialogue with the participant group and by the individuals within it.

In developing an appropriate operational framework for the methodology, it was also appropriate to draw from Symbolic Interactionism, and in particular, from the work of Charon (2004). Symbols are our reality, they form the basis for our social life, and they are central to what it means to be human. The most powerful of these symbols is language. Language allows us to name and categorise, to discriminate, differentiate and classify; it is through language that we come to know the world. Further, language does not simply just represent the world, it allows us to understand the world and construct knowledge through and with same. Through social interaction we communicate and interpret one another as we go along; we take others into account as we act, we interpret one another's actions. Particularly relevant for this study is the way in which such social interaction shapes our identities. Identity results from the negotiation process that arises in social interaction. We label others in interaction, we attempt to shape the identities of others in interaction, we tell others who we think we are in given social interactions. Through it all we come to think of ourself as something and "an identity is formed" (Charon, 2004: p156). At its simplest this is the name we not only call ourselves, but also use to introduce ourselves to others, telling them who we are as we act in situations.

Identities are part of what we mean by self, and defining or naming who that self is, is carried out in interaction with others. The theory of learning as a community of practice (Wenger, 1998) is one which can be situated in Symbolic Interactionism, therefore the methodology adopted for this study is one constituted around a Constructivist approach, framed around the concept of a community of practice (Wenger, 1998), but which integrates the dynamism of same, recognising the connections and links that are made across both time and space (Nespor, 1994) and incorporating the self as social object (Charon, 2004). Put more simply, it is an exploration of how the participants' world(s) is(are) created by them, how these are negotiated within the group to reach consensus / dissensus, and in doing so, how an agreed (re) construction is reached to create their own community of practice, including the language used (inclusive / exclusive) to frame and form this (re) construction.

4. RESEARCH FINDINGS

4.1 Participants at Level 1

For the level 1 participants, transition to Higher Education as students had generally been effected without difficulty. Their decision to take up their place on the quantity surveying degree programme had been made on the basis of the potential career opportunities it offered at a later date; 'belonging' to the programme with the prospect of full participation in the quantity surveying community of practice through 'becoming' (Wenger, 1998). Their anticipations and expectations, a mix of academic and social transitional factors (Kantanis, 2000) had largely been met, although they did not particularly consider themselves as belonging to a wider community (Nathan, 2005), ie as belonging to the university itself. These participants therefore had no real need of 'socialisation' (Silver and Silver, 1997) in the wider community of the institution; their 'belonging' was primarily through the quantity surveying programme of study and the modules / activities undertaken during their studies.

More specifically, participants' 'belonging' was manifested through their being members of multiple communities of practice, via the series of separate communities created by the discrete modules within the level. But membership of these communities had not, however, been entirely unproblematic, highlighting the tensions between a generic approach and a discipline-focused approach. For these participants, making connections – between each of the discrete modules and to the quantity surveying discipline itself – had proved difficult, particularly in modules where no clear discipline context was provided, or where the delivery of the module was by staff from a different discipline background. Contextualisation and location for the knowledge had to be provided by the participants themselves, which in turn led to issues of relevance and reduced participation; respondents felt themselves to be 'outsiders' rather than 'insiders'. Discipline identity was therefore an important factor in assisting membership and participation. For those modules delivered by a member of the teaching team within the quantity surveying discipline, participation and engagement – the 'belonging' – had proved less problematic, the role of the 'old hand' was an important aspect in initiation to membership.

But even with this degree of assisted membership, 'belonging' was expressed in terms of the future; being a quantity surveyor and a member of the profession was something participants aspired to; at this stage participants defined themselves primarily as students, which is perhaps unsurprising. New to Higher Education, and to the programme, and not really knowing what the discipline entailed, their focus was their studies with the expectation that this would provide the framework for their development as quantity surveyors. At Level 1 therefore, there is an apparent dislocation of 'belonging' and 'becoming', this is something that will occur at some future point – identity in waiting.

4.2 Level 3 and the Place of Placement

As the participants moved into professional placement, the world of work created a direct connection to practice, allowing them to enter the discipline as novice professionals (Eraut, 1998). But again, 'belonging' was not necessarily linked to becoming. Indeed, participants defined themselves as 'workers' and, while they were anxious not to be thought of or treated as students within the workplace, they nevertheless did not necessarily identify themselves with the discipline and their identities as quantity surveyors; what was important was their 'cultural identity' (Hall and du Gay, 1997). While the placement period had provided an opportunity for experiencing the 'real thing' it had not led to an automatic transformation in identity. It was, instead, identity in transition, making the connections (Nespor, 1994) to the discipline and its practices. 'Becoming' a quantity surveyor was still something to be aspired to, a transition of identity yet to be completed. For some, the placement period had actually led to a reconsideration of identity and a reservation of same, 'belonging' *without* 'becoming'. The effects of placement had influenced 'belonging' and 'becoming'; for some participants, professional placement had been a welcome opportunity, but for others it had led to a shedding of professional identity.

Only a few participants considered themselves to be 'apprentice' quantity surveyors at this stage, although the majority saw this identity transformation as a progressive development: on completion of their studies and re-entry to the world of practice 'belonging' and 'becoming' would merge. However, for one participant the dislocation from the world of work and return to study where a different facet of identity would take precedence was in fact welcomed. For these participants, identity in terms of 'belonging' and 'becoming' was significantly influenced by their learning experiences, including those of the 'real world' of professional practice.

The professional placement period does not, therefore, necessarily provide an opportunity for 'belonging' and/or 'becoming'. While participants are anxious to be viewed in the workplace in a different way, and want to move away from their identities as students, this is not necessarily facilitated and while 'becoming' involved a degree of transition, reflected in participants' use of 'insider' terminology and their identification of themselves as workers, this was not necessarily also as being quantity surveyors. Thus 'becoming' was also significantly influenced by the professional placement experiences; professional identity was put 'on hold' pending further experience, again identity in waiting.

5. CONCLUSIONS

5.1 Reflections on the research

This study was undertaken to explore identity and the learning experience for a particular group of quantity surveying students over a particular time period. The vocational nature of the programme and the fact that there is a specific set of discipline skills and knowledge involved suggested a discrete, closed community of practice (Wenger, 1998). The degree programme and the 'real' world of professional practice could each be considered to be separate communities, thus exploration of identity and learning, of 'belonging' and 'becoming' could be investigated within such a framework. As the study progressed, however, it became apparent that, rather than set in 'bounded, static' communities, participants were, in fact, participating in and making connections to, networks of communities of practice across both time and space. The study was concerned with charting the participants' movements – their 'belonging' and 'becoming' – through these networks during the course of their programme, therefore the actor-network theory of Nespor provided a more appropriate framework for the study, particularly in respect of respondents' experiences in the professional placement period.

Adopting a three-phased qualitative approach to data collection and analysis allowed the utilisation of a range of different methods to provide depth of data. The interviews were lively sessions, as participants provided insights into 'how things were for them'. By contrast, the questionnaires were more limited in providing the same degree of depth; a number of respondents made comments or statements without providing further commentary, which left things 'hanging'. This is not to say that what was provided was not useful, rather it left some loose ends, where further information would have been helpful. Likewise, while the use of reflective journals provided me with more personalised data, it would, perhaps, have generated a richer and more representative set of data if more participants had undertaken this activity.

Despite these limitations, this study has provided a snapshot view of how things were during the research timeframe for these participants in terms of identity and learning, their 'belonging' and 'becoming' raising a number of questions for further investigation.

5.2 Questions for industry and practice

Very little research in respect of identity has been undertaken in the discipline areas which constitute the construction and property industry. This study suggests that there is perhaps a need for a wider exploration around identity and learning in respect of professional, vocational education, including its connection to professional practice:

- How representative is this of other quantity surveying students' experiences on this programme?
- Are these experiences peculiar to the quantity surveying discipline or are they shared by other disciplines in the construction and property industry in the School (eg construction management, environmental civil engineering)?
- What are the experiences of quantity surveying students at other institutions?
- Are there differences in 'belonging' and 'becoming' between students in institutions whose programmes of study offer professional placement opportunities and those who do not?

The purpose of professional, vocational education is to provide opportunity for 'belonging' to and 'becoming' a member of a community of practice (Wenger, 1998), which commences with participation and engagement in a programme of academic study followed by transfer to the workplace as a novice professional (Eraut, 1994). However, participants in this study suggest that this is a complex process, not simply a smooth transition (Beach, 1999). Therefore a broader examination and exploration of how this is facilitated across disciplines, programmes and institutions is required to establish whether reality matches expectation.

5.3 Issues for the School and the Quantity Surveying Programme

More specifically, for the School and the programme there are issues of:

- The appropriateness of commonality of structure, content and delivery across programmes at Level 1;
- The Quantity Surveying programme structure, focus and content at Level 1;
- Level 1 module contextualisation, focus and content, particularly in respect of modules where delivery is generic and not discipline-specific;
- The role of non-discipline and discipline-specific staff in facilitating 'belonging' and 'becoming';
- Professional placement learning, particularly the ways in which students are prepared for and supported during the placement period, and the ways in which the School and Programme Teams should engage with employers.

Working within the confines of semesterisation and modularisation, the importance of providing a discipline-specific focus for students – the 'belonging' and the 'becoming' of the discipline – should not be overlooked.

A review of the School's approach to professional placement is also recommended. The current approach tends to focus on preparation for placement: how to construct a CV,; particular interview techniques. Students are provided with guidance and support in terms of which employers are offering placement opportunities, and what terms and conditions are likely to be on offer. But perhaps insufficient attention is padi to the potential difficulties of placement? Whilst not advocating such emphasis as to to discourage students from undertaking placement, it is nevertheless important to convey as accurately as possible both the positives and the negatives of professional life, to manage student expectations of the placement period.

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APPENDIX A

Full-time Programme Structure:

<table>
<tr><td>Level*</td><td>Description</td><td>Content</td></tr>
<tr><td>1</td><td>Foundation:
Development of a foundation knowledge base;
Limited exposure to the specific discipline</td><td>Six taught modules:
Construction Technology 1
Introduction to Construction Costs
Measurement &Practice 1
Property Economics
Property Legislation
Professional Orientation and Practice</td></tr>
<tr><td>2</td><td>Preparation for Practice:
Emphasis on preparation for professional placement;
Development of core discipline skills</td><td>Six taught modules:
Construction Development Economics
Construction and Property Contracts
Construction Process Management
Construction Technology 2
Measurement & Practice 2
Tendering, Procurement & Contract</td></tr>
<tr><td>3</td><td>Professional Placement Learning / Consolidation:
Practical Experience in the Workplace;

Consolidation of core discipline skills</td><td>Professional Placement Period
Three taught modules:
Contract & Project Finance
Construction Technology 3
Interact Project (half module)
Measurement & Practice 3 (half module)</td></tr>
<tr><td>4</td><td>Deepening and Broadening:
Emphasis on independent learning;

Opportunity for specialisation</td><td>Dissertation
Four taught modules: two core & two options
Contract Administration (C)
Value & Risk Appraisal (C)
Project Management (O)
Facilities Management (O)
Dispute Resolution (O)
Corporate Strategy (O)</td></tr>
</table>

(In my institution, years of study are known as 'levels'; therefore Level 1 equates to first year, Level 2 to second year, Level 3 to third year, and Level 4 to final Honours year)*

APPENDIX B

Participants' Profiles and Identification Referencing

Reference No	Gender	Age Range	Employed By	Journal Respondent	Phase 1 Focus Group Participant
QR1	Male	17-20	Contracting organisation; site-based	J2	x
QR2	Male	21-25	Private QS practice		
QR3	Male	21-25	Contracting organisation; office-based		
QR4	Male	17-20	Private QS practice		
QR5	Female	17-20	Local Authority	J1	x
QR6	Male	25-30	Private QS practice		
QR7	Male	17-20	Contracting organisation; site-based		
QR8	Male	17-20	Private QS practice	J5	
QR9	Male	17-20	Contracting organisation; site-based		
QR10	Male	17-20	Private QS practice		
QR11	Male	17-20	Contracting organisation; site-based		
QR12	Male	21-25	Contracting organisation; office-based	J4	
QR13	Female	17-20	Contracting organisation; site-based		x
QR14	Male	17-20	Private QS practice		
QR15	Male	21-25	Private QS practice	J3	
QR16	Male	17-20	Private QS practice		
QR17	Female	17-20	Private QS practice	I1	x
QR18	Male	21-25	Private QS practice		
QR19	Male	17-20	Contracting organisation; office-based		
QR20	Male	17-20	Private QS practice		x
QR21	Male	17-20	No placement		
QR22	Male	17-20	No placement		

A simple reference coding was also employed to identify the students who submitted reflective journals (as crossed referenced in the grid above):

- J1 Female; local authority employer
- J2 Male; large contracting organisation
- J3 Male; small private QS practice
- J4 Male; large contracting organisation
- J5 Male; multi-disciplinary practice

COMBO SENSOR FOR EARLY DIAGNOSTIC APPLICATIONS FOR BUILDING AND STRUCTURAL PERFORMANCE.

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Abstract: The integration of combo sensors (multi-analyte techniques systems) within smart structures is discussed. Plasmonics is the basis of these sensors in addition to micro and nanotechnology. Experimental devices employ acoustic, photo and nanomass measurands as the diagnostic indicator for the monitoring of conditions for structural performance. Such performance indicators range from air quality to ageing effects. Combo sensor technology is on the increase with other disciplines but not within the Built Environment. Each condition may be monitored on site with results produced immediately, plus data may be networked to a central computer for in depth diagnostics. Conditions with their severity contain their individual fingerprints, which will be able to be cross referenced within a library of analysed fingerprints, allowing smart system feedback for timely maintenance. The advances and learning curves in the development of a new and novel combo sensor system for structural performance are presented and examined along with initial research findings.

Keywords: Combo sensors, Condition monitoring, Nanotechnology, Plasmonics, Structural performance

1. INTRODUCTION

The advances in sensor technology has resulted in the ability to sense fungi by its odour (Hamilton *et. al.,* 2006), to detect heavy metals in groundwater to below US EPA maximum contaminant levels (Foranzi *et. al.*, 2007), to measure drug kinetics in a real time, label free method (Abdiche and Myszka, 2004) and for structures to become self adaptive to external influences (Stavroulakis *et. al.,* 2005.) Chemical and biological sensors utilize ligand-analyte and antibody-antigen bindings respectively to provide real time observations and allowing the detection of a broad spectrum of measurands. Various sensors provide valuable information on the measurand, binding affinities, concentration and individual fingerprints. A combination of sensors resulting in a multi-analyte technique system (MATS) will provide unique combo fingerprints of measurands which can then be added to a library. Developments within nanotechnology has been advantageous in this research of chemical and biological sensors (Yonzon *et. al.,* 2005), allowing the combination of sensors for structural health monitoring within the Built Environment.

Smart structures have advanced due to sensor technology (Hurlebaus and Gaul, 2006). Smart structures, also known as intelligent structures are self adaptive to external influences such as vibrations and environmental effects (Stavroulakis *et. al.*, 2005).

Sensors and actuators are the basic components within smart materials; their integration controls the material enhancing structural performance (Hurlebaus and Gaul, 2006).
Smart materials were developed within the aerospace industry in the early 1980's (Swigert and Forwards, 1981) with the civil engineering industry developing their uses in the mid 1980's (Bailley and Hubbards, 1985), to reduce structural maintenance, prolong the lifespan and for structural health monitoring. Although the use of smart materials in the building of structures with health monitoring and active structural control, there are limitations in their use and what can be can be monitored. The use of a combo sensor to monitor biological and chemical loading and ageing effects due to environmental stimuli, would provide continuous and simple but in-depth diagnostics that can only benefit and enhance smart structures.

2. COMBO SENSOR

This paper investigates the use of Surface Plasmon Resonance (SPR), Surface Enhanced Raman Scattering (SERS) and Photoacoustics with the addition of thermal imaging for temperature analysis of each technologies/phenomena, with the possibility of future integration into a single device to provide 3D fingerprint spectra of the monitoring measurands.

2.1 Surface Plasmon Resonance

The interaction of electrons at the interface of dielectric and metallic layers is described within the field of plasmonics (Brongersma *et. al.*, 1999.) Surface plasmon resonance (SPR) utilises plasmonics and occurs when a polarised or monochromatic light of the visible or near infrared region passes through a dielectric and metallic interface, producing an evanescent wave. The evanescent wave interacts with the free electrons in the metallic medium propagating charge density waves known as surface plasmon waves. Immobilising a component to the metal layer and allowing an analyte to flow over and bind to the component causes a change in the optical properties of the interface, this results in a change in the evanescent wave resulting in the refractive index of the laser beam shifting. This feature is specific to each measurand and can be monitored by an electron multiplying charged density detector (EMCCD.) The detector will also plot a spectrum of the evanescent wave, from which the kinetic between the binding of the component and analyte can be monitored.

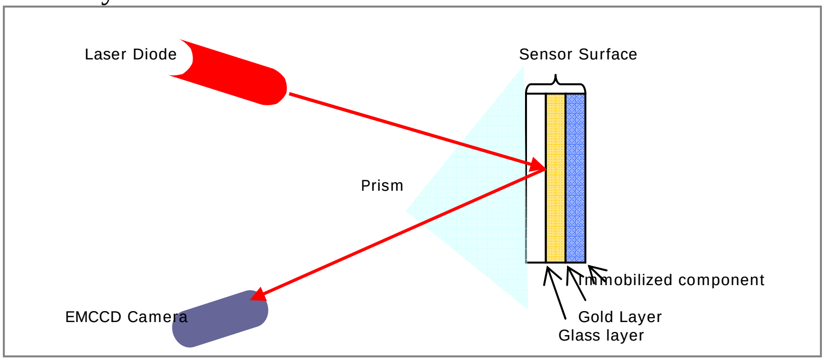


Figure 1: Instrumentation set up of SPR.

2.2 Surface Enhanced Raman Scattering

Surface Enhanced Raman Scattering (SERS) is a technique based on the enhancement of weak Raman signals during Raman scattering. When a monochromatic light is directed towards a sample, the majority of the light will pass through the sample. A small amount of this light will however be absorbed, approximately 0.1% of the light will be scattered elastically at the same frequency as the incident light, this is known as Rayleigh scattering and approximately 1 photon in 10^7 will be scattered inelastically, Raman scattering. The Raman scattering can then be sub-divided into Stokes and Anti-Stokes depending on electronic state, the amount of energy absorbed. The scattering can be shown as spectra of wavelength against intensity; however the signal is very weak and can be lost amongst other signals such as fluorescence (Fig 2.)
By enhancing the weak Raman signals, the technique is useful for the analysis of molecular interactions. Enhancement of Raman signals was first reported over thirty years ago by Fleischmann (Fleischmann *et. al.*, 1974). Enhancement may occur by one of two ways:

1. The increase in molecular polarisability known as the charge transfer model, involving chemical interactions at the sensor surface (Kambhampati *et. al.*, 1998).
2. By electromagnetic enhancement between molecules and surface plasmons by the use if a roughened metallic surface (usually gold or silver) (Browne and McGarvey, 2007).

The first method is prone to contamination due to extensive chemical reactions required for enhancement to be conducted and in its nature reproducing the reaction takes much skill therefore electromagnetic enhancement is favoured.

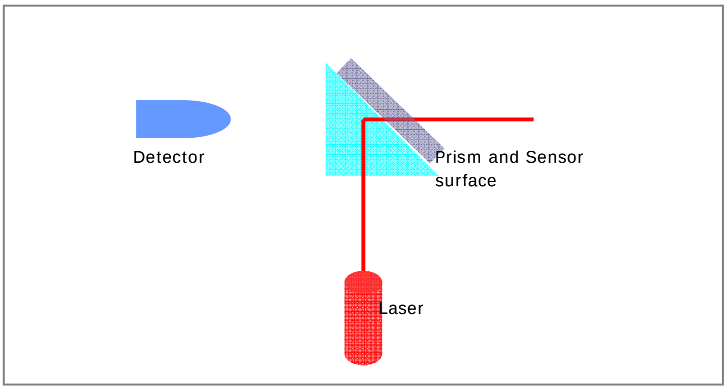


Figure 2: Instrumentation of SERS.

Photoacoustic effects

The Photoacoustic effect was first observed by Bell in 1880 (Bell, 1880). Like SPR and SERS, the photoacoustic effect is an optical phenomenon, involving the production of acoustic waves from a sample by the absorption of light. The converse effect of light production by sound is also possible as exemplified in sonoluminescence.
When a pulsed laser is directed towards a sample within a photoacoustic cell, some of the energy is absorbed by the sample causing a region of higher temperature. This results in

an expanding region propagating a pressure waves. This wave can be detected by one of two ways: direct contact with the sample with the use of piezoelectric crystals or in contact with the surrounding gas with a microphone (Fig 3.)

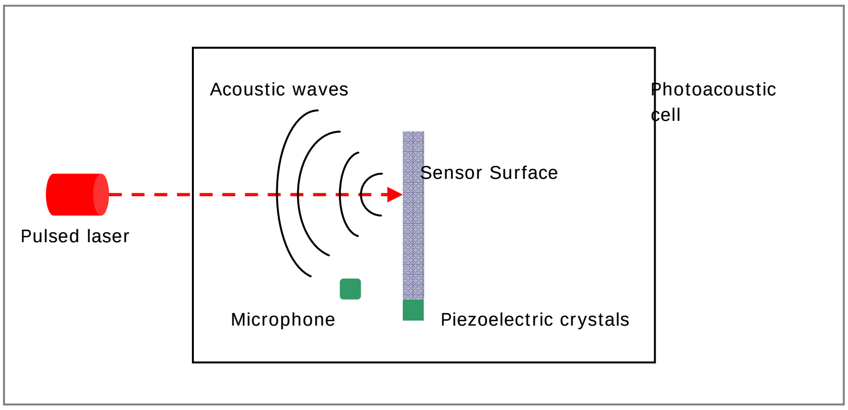


Figure 3: Photoacoustic effects

2.4 Thermal imaging

When a laser beam is directed towards a surface there is an energy transfer between the beam and molecules on the sensor surface. Some of this energy is results in thermal effects. Using a thermal imaging camera, FLIR Therma CAM P60 the infrared radiation emitted from the sensor surface is measured combined with other functions such as emissivity of the object, humidity and distance, the thermal profile may be calculates and related to structural performance of specific parts of a building.

3. EXPERIMENTAL WORK

Experimental work is still in its early stages in regards to gaining spectra from the various phenomena; however the manufacturing of the sensor surface for use in each phenomenon is ongoing. Once completed, the sensor surface is attached to a prism, aligned with a laser and detector (EMCCD camera, fluorescence instrument or thermal imaging camera,) for spectra to be developed.

3.1 Sensor surface manufacture

The sensor surface of all the technologies discussed consists of a glass slide coated with a thin film of chromium plus gold, silver or copper. These metal layers are deposited by vacuum deposition.

The metal is placed between two electrodes with the glass slides placed above; a vacuum is created within the vacuum deposition instrument (Edwards BOC Auto 306.) As the current flows between the electrodes the metal is melted and is splattered over the glass slides above with a smooth layer. The thickness of the coatings is built up by repeating the process.

The thickness of coated metal is critical for the phenomena to occur. This determination of thickness was the first problem to arise in research. Without the use of a thickness monitoring instrument, simply weighing the mass of the slide before and after deposition with a microbalance (ATI Cahn C-35) and calculating the mass and using the equation:

$$\text{Mass} = \text{Volume x Density and Volume} = \text{Area x Thickness}$$

Was not possible to be used to determine the thickness as the microbalance was not sensitive enough to detect any changes in mass.

Combining atomic absorption spectroscopy (AAS) with colorimetry could be used as a method. AAS by itself is a process that dissolves the metals and is not suitable for determining the thickness of every slide, however by plotting the optical density of a number of slides and then with the use of AAS to calculate the mass of them, it is possible to plot a calibration curve of mass versus optical density of the known slides. The graph would then be used for future thickness determination of coated slides.

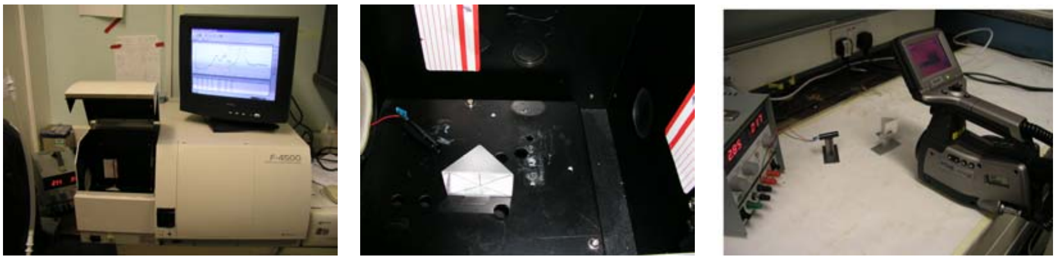
3.2 Analyte immobilization

Initial immobilization of analytes is by placing approximately 0.05ml, one droplet, onto the surface of the sensor surface and is allowed to dry within an extraction cupboard. A future technique will be to bind a ligand specific to the analyte to the surface and allowing the analyte to flow over the ligand and bind to it, this will be used in the final instrument.

3.3 Plotting Spectra

The experimental work of combination of the sensor technologies is still in its early stages. Primarily SERS has been explored with the use of a Hitachi fluorescence spectrometer (Hitachi F4500).

A solution of an analyte such as naphthalene in a buffer of hexane is made up to a known concentration. One drop, approximately 0.05ml is placed onto the metal side of the sensor surface and allowed to dry in an extraction cupboard. The sensor surface is then attached to a right angled prism, ideally with refractive index matching oil. It is then placed inside the fluorescence instrument aligned with a laser diode and the instruments detector. The instruments light source is blocked to prevent the unwanted wavelength passing through the prism, (Fig 4). The lid to the instrument is closed to prevent external light entering and a spectrum is taken of intensity against wavelength. This is plotted using the software FL solutions. This is repeated with the same analyte but of different concentration and of different analytes.



(a) (b) (c)

Figure 4: (a) The Hitachi fluorescence instrument. (b) The sensor surface attached to the prism, *in situ* within the fluorescence instrument. The laser diode, wavelength of 670nm, 3mW power and bandwidth of <10nm aligned with the prism and the detector. (c) The detection of thermal effects using a Therma CAM P60.

The experimental work on the other technologies, SPR, Photoacoustics and Thermal imagery are very similar to the set up for SERS, the main difference being the detector in use. SPR uses an EMCCD camera to detect the change in refractive index and various waves produced. Thermal imaging the thermal imaging camera is placed facing the sensor surface or directed towards the refracted laser beam. The photoacoustic effect is slightly different as an acoustic cell is required but again a change in detector is needed to detect the acoustic waves produced, a microphone or piezoelectric crystals.

Once the technologies have been fully explored, the aim is to be able to combine all three in the one instrument as a combo-sensor.

4. RESULTS

Initial results from the fluorescence instrument and thermal imaging camera are limited but provide promising detection methods.
Figure 5 is a spectrum gained using the fluorescence instrument. The analyte bound to the sensor surface is pyrocatehol in a hexane buffer of a concentration 0.25ppm. The peak around 670nm is from the laser beam plus one of the peaks around 500nm could be from the gold. Initial thoughts are that the other peaks correspond to the pyrocatehol. When the concentration of the analyte increases the peaks are in similar positions but intensity increases. This shows potential as a method for not only detecting the presence of an analyte but also plotting the concentration of the analyte.
Concerns that arose during these experiments were ensuring that the sensor surfaces were kept clean and were not contaminated by external factors. To prevent this occurring once the sensor surfaces were produced they were placed in a foam stand inside a box. This does not eliminate all possible contamination but it does reduce the concern until another method is put into place.
Uses of battery operated lasers were used during the first few experiments. The intensity of these varied dramatically between spectra. The intensity of the laser diode is more stable however a driver circuit will be developed to prevent any fluctuations in power to the laser.

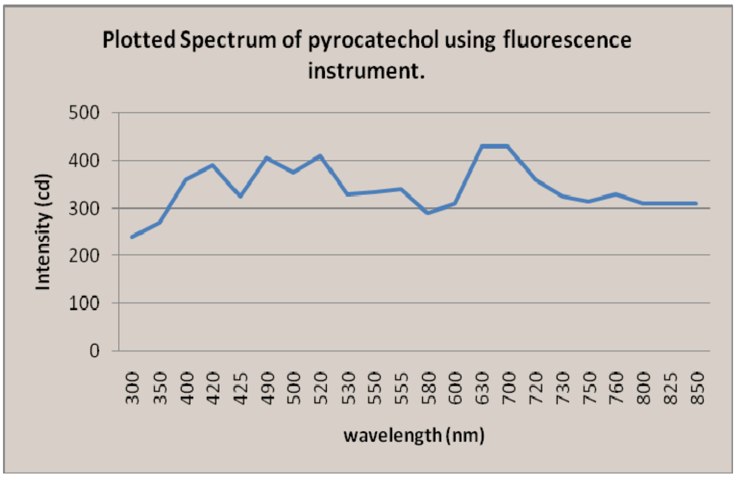


Figure 5: Spectrum produced from the Hitachi fluorescence instrument utilizing SERS. The analyte used was pyrocatechol in hexane buffer.

Figure 6 is an image from the thermal imaging camera. There are two slides on the prism, one with no analyte present on the sensor surface and to the right, one with pyrochatechol in hexane buffer. The laser beam is directed towards the analyte bound sensor. A definite peak is plotted however further examination is required. The possibility of using a laser line rather than a spot may be ideal for this experiment. This plot does show however, that thermal profiles could be incorporated into the research as another detection method of the monitoring condition.

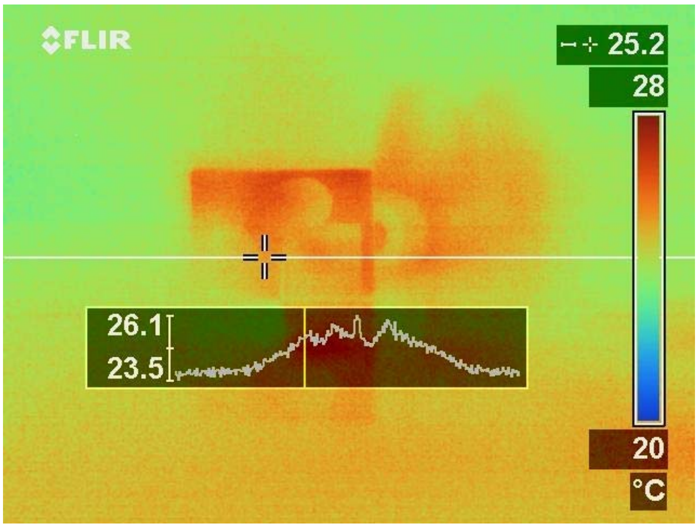


Figure 6: Development of a thermal profile of the sensor surface of pyrocatechol in hexane buffer.

Research on the technologies discussed has been ongoing for over 25 years. Data can be gained from previous published research and plotted into a suggested 3D Fingerprint (Fig 7). The data in figure 8 is taken from various sources and plotted; the examples used are of pigments. The data plotted is of SPR, SPR change in refractive index and SERS.
It provides an overview of possible fingerprints gained when technologies are combined as a combo-sensor plus it will be useful of comparing results gained in research with actual results.

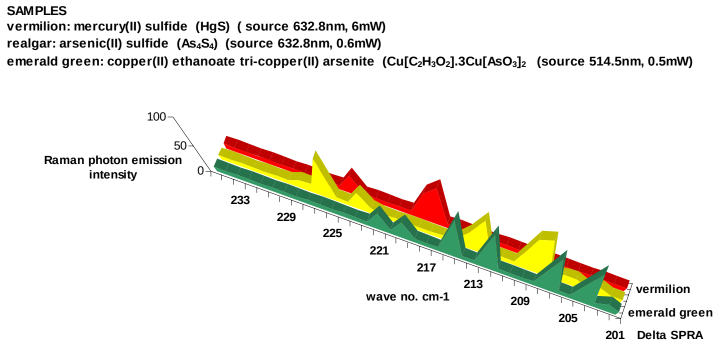


Figure 7: Spectra developed from various sources to show a possible 3D fingerprint. Sources: Imperial College Chemical; Spectra Library, London University

5.0 APPLICATIONS IN CONJUNCTION WITH SMART MATERIALS

The main aim of the research is to develop a combo sensor to be used within the civil engineering industry in conjunction with smart materials, whether to enhance the smart material or to monitor a condition unable to be monitored.
The possibility of embedding the sensor surface into a wall with fibre optics attached for the passage of light could make monitoring conditions within the wall a real time analysis without the interruption of external factors. Monitoring could include the deterioration of concrete by carbonation and natural material breakdown.
Following on from the introduction of anti-glare windows and temperature stabilising materials into buildings, the ability for continuous air monitoring of microbial and chemical loading would ensure the comfort and health of those individuals. The sensor zone of the device could be developed for fungal, pollen, influenza virus, and pesticides, each which could result in disease or allergic responses.

6. CONCLUSION AND FUTURE WORK

Although research is still in its early stages, initial results are promising. The manufacturing of the sensor surface has been successful and initial spectra plotted are showing expected peaks. It has been possible to hypothesise a 3D fingerprint of analytes using already published data on each of the techniques and so it’s possible to compare results from the research to known data.
Along with producing more spectra of various analytes using the three technologies, future work will involve thickness determination of the sensor surface with use of ellipsometry, the development of a flow cell for the analyte and
The combination of all three techniques into the one instrument is a new and novel approach for use along with smart materials; it would be of benefit to the smart structure sustainability, it would reduce maintenance coats and prolong the structures safe working life.

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RESEARCH MODEL FOR EVALUATING THE IMPACT OF TECHNOLOGY IN WORKPLACE DESIGN IN AUSTRALIA

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Abstract: This paper discusses the importance of the research epistemological and ontological position, which together with the adopted theoretical perspective, define the methodology and methods used by the study. The research approach not only shapes the research instrument and the interpretation of the results obtained by it, but sets all the assumptions and constraints adopted by the researcher about reality and knowledge that determine the type of conclusions that the study can arrive. The arguments here developed are based on academic readings and initial results from a pilot study designed for a PhD set to investigate the effects of technology in workplace architecture in Australia. The study proposes a provocative research paradigm that departs from traditional models in order to best understand the complex *reality* of workplace architecture. The results from the pilot suggest that workplace environments are subjectively interpreted to construct several realities of a single environment. However, these subjective realities reflect a common reality.

Keywords: Data analysis, reliability, research design, workplace architecture.

1. INTRODUCTION

Like its predecessors, the current technology revolution – the information revolution – has created an irreversible historical discontinuity that has transformed our society. Work continues to be at the core of the social structure, but its foundations are changing. Technology is revolutionising where we work, how we work, when we work and even in what we work (Becker and Steele 1994; Castells 1996; Linturi 2000; Marmot and Eley 2000). With so many options available to host new working paradigms – teleworking, hot-desking, virtual office, cottaging, caves, etc. – the future of workplace architecture is uncertain.

It is expected that the findings of the research "*Evolution of Workplace Architecture as a Consequence of Technology Development*", from which this paper is extracted, will provide information on today's complex office environment that will help forecast tomorrow's workplace architecture. This paper discusses the research design used in such research.

The research is based on two *Grand-tour* questions – the broadest questions that can be asked so as not to limit the inquiry (Creswell 1994) – a) *to what extent is information technology changing workplace architecture?* and b) h*ow is information technology changing workplace architecture?* Based on Maxwell (1996) question *'a'* is a variance question because it focuses on differences and correlations and tries to establish whether there is a particular relationship between technology changes and workplace architecture. On the other hand, question '*b*' is a process question since it focuses on '*how*' things happen. The focal point of process questions is not in explaining a difference in terms of some independent variables – e.g. cause and effect –, but in understanding how the phenomenon develops. As a consequence, each grand-tour question together with its sub-questions follows different approaches.

This paper has three sections. The first section presents a provocative research paradigm proposed to understand the complex *reality* of workplace architecture. The second part reviews the adopted conceptual model for evaluating work environments. Finally, the results of the pilot study provide useful information to assess the reliability of the research instrument.

2. THE RESEARCH APPROACH

"The assumptions we make about human knowledge and assumptions about realities encountered in our human world, will impact the meaning of research questions, the purposiveness of research methodologies, and the interpretability of research findings." (Crotty 1998)

2.1 Epistemology and Ontology

The justification of the use of a particular methodology depends on the research's assumption about reality (Crotty 1998). Epistemology is the relationship between reality and the researcher. Epistemology is a way of understanding and explaining how we know what we know. It deals with "*the nature of knowledge, its possibility, scope and general basis*" (Hamlyn 1995) "*and is concerned with providing a philosophical grounding for deciding what kinds of knowledge are possible and how we can ensure that they are both adequate and legitimate*" (Maynard 1994).

There are three main epistemological positions: objectivism, constructivism and subjectivism. Objectivism sustains that things exist as meaningful entities independently of consciousness and experiences. That is, truth and meaning reside in the objects. Thus, meaningful reality exists as such apart from any consciousness. Under this epistemological point of view, the objective truth can be exposed because understandings and values are objectified in the people being studied. On the other hand, constructionism sustains that the subject and object emerge together in the generation of meaning, which is a consequence of the mind and cannot exist without it. Under this epistemological position meaning is not discovered, but constructed. There is no objective truth to be discovered. Finally subjectivism, a variant of constructionism, sustains that meaning is imposed into the object by the subject rather than coming out of '*interplay*' between subject and object as in constructivism. In subjectivism the object does not contribute at all to its meaning (Crotty 1998).

As further discussed in section *3 Evaluating Workplace Environments* an individual's perception of a specific workplace environment is dependent on but distinct from the objective environmental attribute itself. That is, different people will perceive differently the same working environment and thus construct different meanings of the same phenomenon. Therefore, the epistemological position for this research is constructivism. Because of this, the research cannot unveil an objective truth independent to any consciousness – positivism –. Instead, it explores the humanly fashioned way of seeing things (Crotty 1998).

Parallel to epistemology is ontology. Ontology is the study of '*being*', of the '*what is*' with the nature of existence. This research adopts realism – reality exists outside the mind – as its ontology because it shares the principle that the world and things in it exist independently of our consciousness of them. Computers, desks, phones and the office building itself exist whether we are conscious of them or not.

However, this approach clashes with the traditional link between objectivism in epistemology and realism in ontology and that ontology in constructivism is defined by multiple local and specific "*constructed*" realities (Creswell 1994; Crotty 1998; Perry et al. 1999). Nevertheless, Crotty (1998) challenges this traditional posture and notes that "*realism in ontology and constructionism in epistemology turn out to be quite compatible*". Whilst he agrees that there is a world independent of the consciousness, he sustains that the world only becomes a world of meaning when meaning-making begins to make sense of it. Existence of a world without a mind is conceivable. Meaning without a mind is not. Therefore, it is possible for this research to adopt realism in ontology and still be compatible with its constructionism epistemology.

2.2 Theoretical perspective

The theoretical perspective is the philosophical stance laying behind the methodology and providing a context for the process as well as grounding its logic and criteria. It is an approach to understand and explain society and the human world. As a consequence, the adopted theoretical perspective will generate a number of assumptions that will impact in the methodology (Crotty 1998).

Given that work is a consequence of our culture (Castells 1996) the most suitable theoretical perspective for the research is interpretivism, because it looks for culturally derived and historically situated interpretations of the social life-world (Schwandt 1994; Crotty 1998).

From the three branches of interpretivism: hermeneutics, phenomenology and symbolic interactionism, it is the latter that best suits the research approach. The three main assumptions of symbolic interactionism are: a) human beings act toward things on the basis of the meanings that these things have to them; b) the meaning of such things is derived from, and arises out of, the social interaction that one has with one's fellows; and c) these meanings are handled in, and modified through, an interpretative process used by the person in dealing with the things he or she encounters (Blumer 1969).

2.3 Methodology and Methods

Methodology is the strategy behind the choice of particular methods, and as previously discussed it inherits all the assumptions established in the epistemology, ontology and theoretical perspectives.

It is important to note that the distinction between qualitative and quantitative research occurs at the level of methods, not at the level of epistemology or theoretical perspective. This model challenges the widely spread conception that objectivist research must use quantitative methods whilst subjectivist research must limit to qualitative methods. However, quantification is by no means ruled out within non-positivist research (Crotty 1998). Under this context, the adopted methodology is survey.

A survey provides a numeric description of some fraction of the population, known as the sample, through the data collection process of asking questions to people in such a way that allows the researcher to generalise the findings to the population (Creswell 1994; Fowler 2002). Due to the costs and impracticality of collecting information from everyone in a group, data from only some people reflecting the characteristics of such group is more efficient than surveying all members of the group (Vaus 1995). Paradoxically, sample surveys are often more accurate than interviewing every member of the population. The reasons for this paradox are a) the quality of the data collected in a large survey is usually lower than the one obtained in a smaller one and b) a large population requires a long interviewing period which makes impossible to specify the time to which the data refer to (Babbie 1990; Fowler 2002). However, the highest risk in survey samples is that the selected sample misrepresents the population from which it belongs (Babbie 1990).

Stratified sampling, a variant of Simple Random Sampling (SRS), uses a homogeneous population which produces samples with smaller sampling errors than a heterogeneous population (Vaus 1995). This is achieved by organising the population into homogeneous subsets – with heterogeneity between subsets – and selecting the appropriate number of elements from each subset (Babbie 1990).

3. EVALUATING WORKPLACE ENVIRONMENTS

Back in the 1980s when office technology started to change rapidly, the issue of performance on the job and how it is affected by the physical environment was reignited. Earlier studies support the debate that the design of the workplace can affect job performance and satisfaction of workers on the job (Marans and Spreckelmeyer 1982). Amongst the most relevant studies of environment and performance is the one undertaken at the Hawthorne Works factory. Between 1924 and 1932 Elton Mayo and Fritz Roethlisberger conducted a series of experiments to determine the optimum level of lighting for productivity. After an increase of productivity was reported regardless whether the illumination was increased or decreased, the conclusion was that people change their behaviour when observed. This, as noted by Hatch (1997) seems to indicate that the effects of physical conditions –lighting– are insignificant compared with social effects –pressure of being observed–.

A number of environmental researchers and designers have sought to isolate relationships between specific attributes of the workplace on the one hand, and satisfaction and performance on the other. Several have done so within the framework of empirically based post occupancy evaluations. However, Marans and Spreckelmeyer (1982) note that one of the failures of post-occupancy methods is the lack of a carefully developed conceptual link between physical environmental attributes and various levels of worker responses to those attributes. Thus, in their conceptual model they acknowledge that an individual's perception of a particular attribute is dependent on, but distinct from, the objective environmental attribute itself. Further, the characteristics of an individual are seen as affecting his or her perceptions and assessments of environmental attributes and the standard for comparisons that are used. These two principles are not only consistent with, but fundamental for the adopted epistemology, ontology and theoretical perspective as previously discussed.

The core of the model, refer to Figure 1, is represented by the direct and indirect links between objective environmental attributes, people's subjective responses to these attributes, overall environmental satisfaction, and specific behaviour or sets of behaviours.

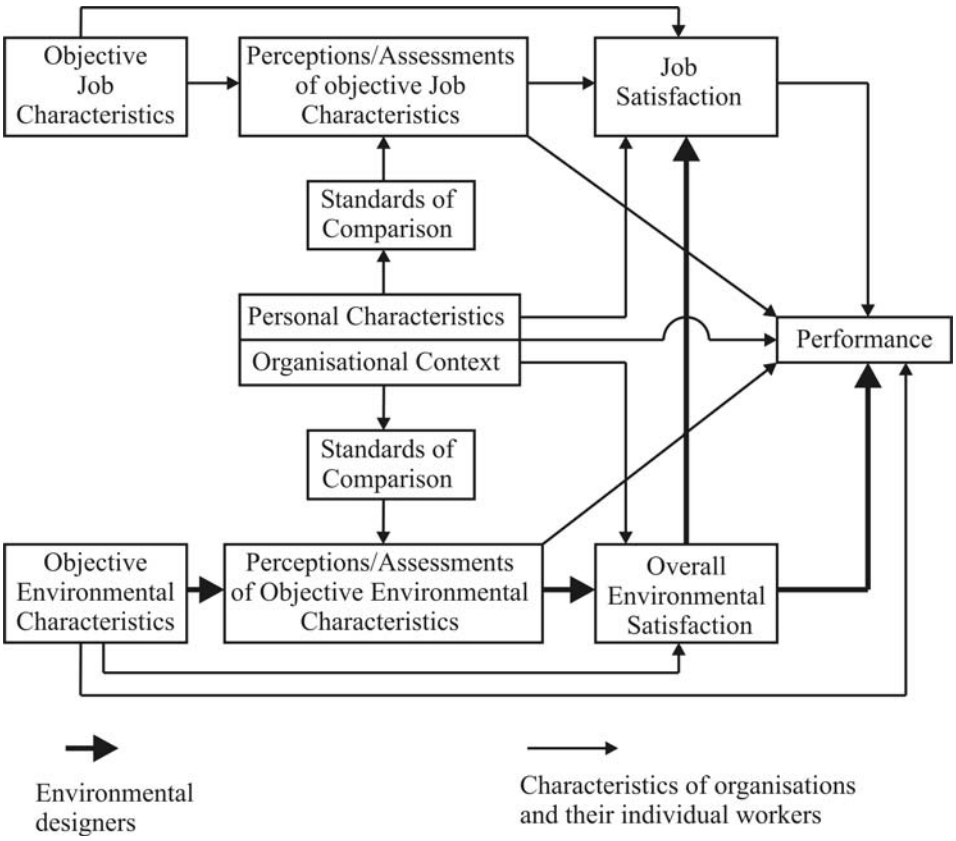

Figure 1: Conceptual model for evaluating work environments. (Based on Marans and Spreckelmeyer 1982)

Although this model considers three aspects: 1) overall environmental satisfaction, 2) job satisfaction, and 3) worker performance, it is the first – overall environmental satisfaction – the outcome of greatest interest to architects and most relevant to this research. Overall environmental satisfaction for an employee is dependant upon four factors: 1) the characteristics of the employee, including his or her position or job type; 2) the organisational context in which employees operate, the activities that take place within it, employee/employer relations, etc.; 3) the individual's perceptions and assessments of various specific attributes; and 4) the objective attributes themselves.

4. THE PILOT

The pilot package, which included a cover letter, research instrument, and feed-back form, was sent to a convenience sample –no sampling was used at this stage– on Monday 14th of August 2006 to 31 potential respondents of seven different companies within Melbourne metropolitan area. On the first week 35% of all sent questionnaires were returned. By the following week 42% and by the third week 58% of all sent questionnaires were returned. The last questionnaire was returned on week nine, reaching 71% response. No time limit was established for the recollection of questionnaires.

Since the main objective of the pilot test is to prevent the research instrument from not meeting its objectives due to unforseen errors (Babbie 1990), the pilot was used to test some indicators like response rate –as previously discussed–, suitability of the questions, and overall questionnaire design. However, this paper focuses on reliability not only because it is a fundamental aspect that more often than not is overlooked during the pilot stage, but because it puts to the test the whole research approach.

4.1 Reliability

A question is reliable when two respondents that are in the same situation answer it in the same way. Otherwise, random error is introduced making the measurement less precise (Fowler 2002). The following design guidelines as proposed by Babbie (1990), Fowler (2002) and Bradburn, Sudman et al (2004) for self-administered questionnaires were adopted in the design of the questionnaire to increase its reliability.

- Standardised instrument: Survey research makes the necessary assumption that differences in answers derive from differences amongst respondents, rather than from differences in the stimuli to which respondents are exposed. In order to best measure the former over the latter, the questionnaire was designed so that all questions meant the same to all respondents. Otherwise, two respondents could provide different answers to the same question just because they understand it differently.
- Sensible questioning: Respondents are asked only questions they are likely to know the answer to, and that are relevant to them.
- Single questions: When respondents are faced with two questions in the same sentence, they need to decide which to answer. Because such decision is made inconsistently by different respondents, the questionnaire becomes unreliable.
- Simple and short: If there is the possibility for the respondents to get confused about what they are supposed to do, they will be. Checking a box is the only task required in the questionnaire. Parallel, long surveys result in poor response rates, careless answers, and useless results. The quantity and quality of questions asked is strictly limited to the information required. "*Wouldn't it be interesting to know*" questions were avoided.

5. RESULTS

In this paper the results of the pilot are only interpreted and analysed to test the reliability of the research instrument and to assess the suitability of the research paradigm. Table 1 shows the results of the pilot by group, each group represents a company.

Table 1: Reliability assessment of research instrument.

		FREQUENCY TABLE: GROUP A Count 8					GROUP B Count 3					GROUP C Count 5					GROUP D Count 4					SCORE BY GROUP: GRP A	GRP B	GRP C	GRP D	SUBJECTIVE	OBJECTIVE
		1	2	3	4	5-9	1	2	3	4	5-9	1	2	3	4	5-9	1	2	3	4	5-9						
SUBJECTIVE PERCEPTION	1.A	-	-	3	5		1	-	2	-		1	1	3	-		-	2	2	-		2	2	2	2	2	
	1.B	-	1	5	2		-	3	-	-		2	2	-	1		-	3	-	1		1	4	1	2	2	
	1.C	-	1	5	2		-	2	1	-		3	1	1	-		1	2	-	1		1	3	2	1	1.75	
	1.D	-	-	1	7		1	-	1	1		2	2	1	-		1	1	1	1		3	0	1	0	1	
	1.E	-	1	5	2		1	-	2	-		1	1	3	-		1	1	2	-		1	2	2	1	1.5	
	1.F	1	2	3	2		2	-	1	-		2	-	1	2		-	2	2	-		0	2	0	2	1	
	1.G	3	5	-	-		2	1	-	-		2	-	2	1		-	2	2	-		2	3	0	2	1.75	
	1.H	-	-	7	1		-	-	3	-		-	1	3	1		1	-	2	1		3	4	3	1	2.75	
	1.I	-	-	7	1		1	-	2	-		2	1	2	-		1	1	2	-		3	2	0	1	1.5	
	1.J	-	-	1	7		-	1	-	2		3	-	2	-		1	1	2	-		3	2	1	1	1.75	
	1.K	1	2	3	2		1	1	-	1		2	1	1	1		3	1	-	-		0	0	0	3	0.75	
	1.L	-	2	4	2		-	-	3	-		2	1	-	2		2	1	1	-		1	4	0	1	1.5	
	1.M	-	2	2	4		1	-	1	1		1	-	1	3		1	3	-	-		1	0	1	3	1.25	
	1.N	-	-	5	3		-	1	1	1		3	-	2	-		1	3	-	-		2	0	0	3	1.25	
OBJTV.	3	-	5	3			-	3	-	-		-	-	5	-		4	-	-	-		2	4	4	4		3.5
	4	-	8				-	3				3	1				3	1				4	4	2	2		3
	5	2	5	1			3	-	-	-		2	3	-	-		4	-	-	-		1	4	3	4		3
	6	-	7	-	1	-	-	2	1	-	-	1	1	2	-	-	-	4	-	-	-	3	3	1	4		2.75
S	7	1	7	-			-	3	-			4	1	-			1	3	-			3	4	3	3	3.25	
OBJECTIVE DESCRIPTION	9	1	3	1	3		1	2	-	-		-	-	1	4		3	1	-	-		0	3	3	3		2.25
	10	3	3	1	1		2	1	-	-		-	-	3	2		4	-	-	-		0	3	2	4		2.25
	11	8	-				3	-				5	-				4	-				4	4	4	4		4
	14	8	-				2	1				5	-				2	2				4	1	4	0		2.25
	15	-	8				1	2				4	1				-	4				4	1	2	4		2.75
	16	1	-	4	3		-	-	3	-		1	2	2	-		-	3	1	-		0	4	1	3		2
	17	-	2	6	-		-	2	1	-		-	2	3	-		2	2	-	-		3	3	2	2		2.5
	18	7	-				2	1				5	-				3	1				4		4	3		2.75
	19	3	5				2	1				2	3				-	4				1	1	0	4		1.5
	20.A	-	3	5			-	-	3			1	-	3			-	1	3			2	4	1	3		2.5
	20.B	1	2	5			-	-	3			1	-	3			-	1	3			1	4	1	3		2.25
	20.C	3	5	-			1	1	1			1	1	2			-	3	1			2	0	1	3		1.5
	20.D	-	3	5			-	1	2			1	1	2			-	1	3			2	3	1	3		2.25
	20.E	-	1	7			-	-	3			2	-	2			-	1	3			3	4	0	3		2.5
	21	-	6	2	-		-	3	-	-		-	2	2	1		-	-	-	4		3	4	1	4		3
S	22	3	3	1	1		-	3	-	-		1	2	2	-		2	2	-	-		0	4	1	2	1.75	
																						1.97	2.57	1.54	2.51		

The first columns on the right (1.A, 1.B, etc.) are the IDs of the questions asked. The actual questions are not relevant for this paper – although further analysis provide more information for questions 1.A to 1.N. These questions are classified into subjective or objective questions. The former refers to assessments of subjective environmental characteristics like temperature, ventilation, illumination, etc. On the other hand, the latter provides information about objective attributes of the respondent workplace like type of building, Internet connection type and so on. The following four columns of table 1 show how many respondents provided a specific response by group –frequency table–. The next set of four columns is the score assigned to each question by group. This score is an indicator of how homogenous is the response. A perfectly homogenous question, that in which all respondents provided the same answer, scores '4'. A completely heterogenous question, that in which there is no consensus between answers, scores ‘0’. The scores were calculated using descriptive statistics indicators such as standard error, standard deviation, sample variance, skewness and range. The last two columns show the reliability score, which is the average of the score by group.

The average score of subjective questions is 1.67, the average score of objective questions is 2.55. As expected, objective questions are more reliable than subjective questions. However, further analysis indicates that whilst the assessment of the environment varied considerably between respondents, there is a relationship in the way such assessment is done.

Figure 2 is a scattergram that plots the score given to question 1N: overall satisfaction of the space environment at the workplace (Y axis) vs. each of the individual factors that contribute to the overall satisfaction – temperature, ventilation, etc. – (X axis). Regression lines are added for analysis.

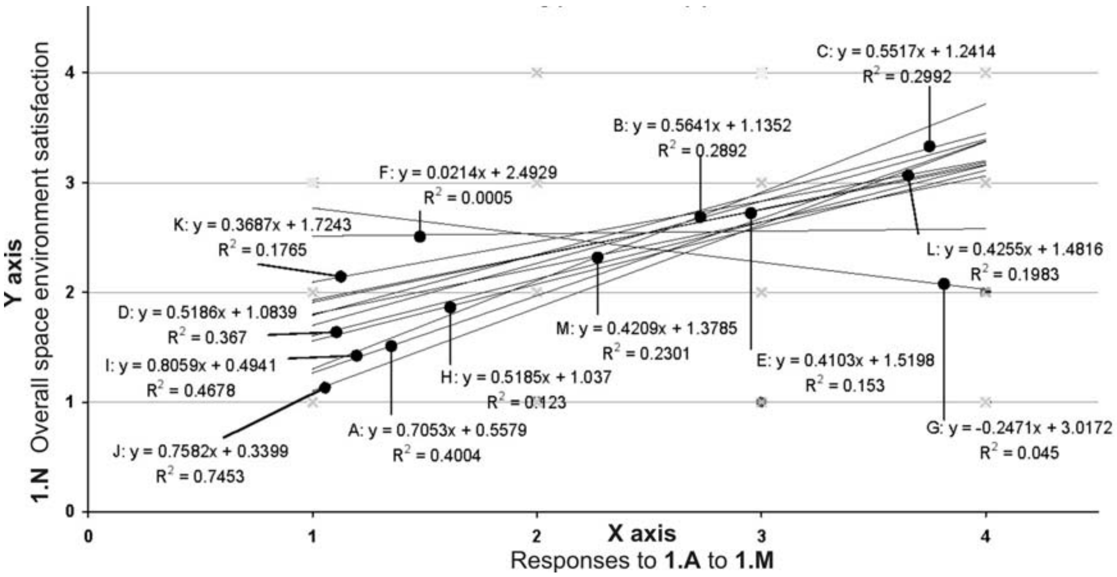

Figure 2: Overall satisfaction vs. individual environment parameters

The regression line predicts *Y* scores of individuals given knowledge of *X* scores and estimates the strength of association between *X* and *Y*. The impact of *X* on *Y* is given by the slope (m) of the linear equation. Therefore, the higher R2 value is, the higher the accuracy of predictability and the higher the slope (m) the higher the impact of *X* on *Y* (Vaus 1995).

Table 2 sorts the individual parameters by its predictability accuracy and impact. It is noted that the three most predictable parameters are also the ones that have the highest impact. With the exception of 1.G and 1.F, which also score the lowest predictability and impact, the trendlines suggest a directly proportional relationship between the overall satisfaction and the individual variables. This implies that whilst there is no consensus between respondents in assessing subjective parameters – as previously shown in table 1 – there is consistency in the way the variable is assessed.

Table 2: Trend line analysis: Parameters sorted by R2 and m.

		R2			m
1.J	**General office size**	**0.7453**	**1.I**	**General furniture arrangement**	**0.8059**
1.I	**General furniture arrangement**	**0.4678**	**1.J**	**General office size**	**0.7582**
1.A	**Temperature comfort**	**0.4004**	**1.A**	**Temperature comfort**	**0.7053**
1.D	Background noise level	0.367	1.B	Ventilation comfort	0.5641
1.C	Illumination comfort	0.2992	1.C	Illumination comfort	0.5517
1.B	Ventilation comfort	0.2892	1.D	Background noise level	0.5186
1.M	Work space available on workstation	0.2301	1.H	General office distribution	0.5185
1.L	Individual storage space	0.1983	1.L	Individual storage space	0.4255
1.K	General office storage space	0.1765	1.M	Work space available on workstation	0.4209
1.E	Frequency of distractions	0.153	1.E	Frequency of distractions	0.4103
1.H	General office distribution	0.123	1.K	General office storage space	0.3687
1.G	Voice privacy at your workstation	0.045	1.G	Voice privacy at your workstation	-0.2471
1.F	Visual privacy at your workstation	0.0005	1.F	Visual privacy at your workstation	0.0214

This constant relationship in which the variables are assessed is further corroborated by using a correlation matrix. A correlation matrix shows the level of relationship between all pair of variables. Variables with a correlation index of '0' denote no relationship between them. On the other hand, variables with a perfect relationship have a correlation index of '1'. A positive relationship means that respondents who provided a high score on one variable tended to obtain a high score on the other variable. A negative relationship means that those who obtained a high score on one variable tended to obtain a low score on the other (Babbie 1990, Vaus 1995).

In Table 3, the mirror image of the correlation table produced above the diagonal where the variable intersects with itself has been substituted by the correlation of random numbers. These random numbers were generated using the same range (1-4) and the same sample size (22) of the pilot study. The adjacent frequency table groups the correlations in five ranges. This table shows that the pilot correlation index exceeds that of the random sample.

Table 3: Correlation matrix: Pilot vs. Random

	RANDOM														
1.A	**1.A**	-0.11	0.01	0.28	-0.46	0.00	-0.10	-0.26	-0.16	-0.24	0.05	0.09	-0.30	0.31	**1.A**
1.B	**0.49**	**1.B**	0.06	0.02	-0.01	-0.03	-0.13	0.40	-0.03	-0.03	0.10	-0.20	-0.24	-0.22	**1.B**
1.C	0.65	0.49	**1.C**	-0.31	-0.11	-0.17	-0.21	0.33	0.08	0.02	0.07	-0.29	-0.02	0.18	**1.C**
1.D	0.55	0.50	0.34	**1.D**	-0.26	0.12	0.15	-0.22	0.10	0.16	-0.18	0.10	-0.11	-0.09	**1.D**
1.E	0.60	0.18	0.64	**0.50**	**1.E**	-0.02	0.16	-0.07	0.14	0.01	0.08	-0.25	0.11	-0.30	**1.E**
1.F	0.42	0.36	0.19	0.32	0.31	**1.F**	0.20	-0.16	-0.03	-0.10	0.19	-0.19	0.10	0.31	**1.F**
1.G	0.10	0.17	0.04	0.03	0.28	**0.69**	**1.G**	-0.23	0.10	0.23	0.15	0.13	0.34	-0.04	**1.G**
1.H	**0.36**	**0.22**	0.33	0.21	0.51	0.12	0.07	**1.H**	0.03	0.10	-0.10	-0.14	-0.38	0.02	**1.H**
1.I	0.68	0.35	0.42	0.48	0.46	0.18	-0.12	**0.58**	**1.I**	-0.33	0.14	-0.32	0.03	-0.12	**1.I**
1.J	**0.67**	0.52	0.65	0.58	0.43	0.07	-0.29	**0.35**	**0.78**	**1.J**	-0.33	0.29	-0.01	-0.14	**1.J**
1.K	0.63	0.28	0.54	0.21	0.49	0.18	0.02	0.39	0.59	**0.48**	**1.K**	-0.17	0.15	-0.23	**1.K**
1.L	0.60	0.26	0.63	0.11	0.44	0.33	0.10	0.40	0.37	0.43	**0.76**	**1.L**	0.04	0.07	**1.L**
1.M	0.55	0.24	0.28	0.18	0.28	0.31	0.03	0.15	0.42	0.38	0.65	**0.68**	**1.M**	-0.12	**1.M**
1.N	**0.63**	**0.54**	**0.55**	**0.61**	**0.39**	**0.02**	**-0.21**	**0.35**	**0.68**	**0.86**	**0.42**	**0.45**	**0.48**	**1.N**	**1.N**
	PILOT														

Frequency Table

	RANDOM		PILOT	
0.76-1.00	0	0%	3	3%
0.51-0.75	0	0%	25	27%
0.26-0.50	16	18%	39	43%
0.10-0.25	48	53%	17	19%
0.00-0.09	27	30%	7	8%
	91	**100%**	**91**	**100%**

However, not all correlations are relevant. As per Vaus (1995), variables can be related but not causally related, called a spurious relationship. For example correlation 1.B (ventilation comfort) and 1.L (individual storage) is a spurious relationship. Nevertheless, the correlation values – higher than the random results – indicate a tendency in the way the variables were assessed. Non spurious relationships are bolded.

6. CONCLUSIONS

The results from the pilot are compatible with the research paradigm in that they suggest that workplace environments are subjectively interpreted to construct several realities of a single environment. However, these subjective realities are not randomly created. They denote consistency and are constructed from a common reality.

The idea that appropriate methods will unveil an objective truth is staring to shift by the view that "*all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context*" (Crotty 1998).

This paper also supports that quantitative methods can effectively be used to analyse a non-positivist research, thus readdressing the widely accepted trend in social research. However, results are only meaningful under the context of the adopted research paradigm.

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IMPROVED CLIENT SATISFACTION: A STRATEGIC APPROACH IN THE CONSTRUCTION SECTOR

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Abstract: Client satisfaction has widely been recognised by researchers as one of the key challenges for quality improvement in the construction industry. It is a vital factor in the development and management of the construction process, as well in the creation of efficient company-client relationship. In addition, client satisfaction is a catalyst for client retention which is a success strategy for any organisation. This paper presents a novel theoretical framework for client satisfaction evaluation and assessment. It involves an integrated approach that considers the entire supply chain of a construction project as a tree structure and each member of that tree as an intelligent agent. Each agent will have processes and client satisfaction attributes associated with it. Relationships and interactions of the agents and how these affect the overall satisfaction levels of a single project, are analysed based on current practices in client satisfaction.

Keywords: client, integration, quality, satisfaction, team.

1. INTRODUCTION

The construction industry has remained a key industry within the UK economy. In 2002, it contributed approximately 7% to gross domestic profit (Cox & Ireland, 2002). An issue released in December 2006 (issue 5) by the constructing excellence states that the construction industry contributes 10% to the UK's gross domestic product. In view of this, to keep the industry sustainable, it is critical to devise measures on how to improve its client satisfaction level. This is because construction clients play a crucial role in the industry's distinction and survival. The subject on client satisfaction in the construction sector could be traced back to the 1980s**.** An investigation carried out by Ashley et al, (1987) on the determinants of the success of construction projects highlighted six criteria for measuring success. These are budget, schedule, *client satisfaction*, functionality, *contractor satisfaction*, and project-manager/ *team satisfaction.* Hence, the creation of a common client satisfaction measurement or approach is essential in the construction industry and this will be carefully explored through this study.
Client retention is a success strategy for organisations and is highly influenced by client/ customer satisfaction level (Fe??iková, 2004). Though his customer satisfaction measurement system is not emphatically for the construction industry, his analysis is relevant to this research. This is because his system recognises the importance and criticality of satisfying the internal customers (project team members) thereby satisfying the external customer (final customer/ project user).

Kärnä, (2004) asserts that customer satisfaction is a vital factor in the development of the construction process. The client satisfaction of the project team members is a prerequisite for maintaining good working relationships (Soetanto et al, 2001) and conditions.

Despite the emphasis that is being placed on client satisfaction, the construction industry lacks this added feature, probably because of the fragmented nature of the industry. This shortfall can be met by the adequate integration of the construction project team. This paper presents quality deployment (satisfaction attribute) and team integration as antecedents for assessing client satisfaction. In addition, to properly assess the satisfaction level of the supply chain or integrated team, an assessment rating framework/ model focussing on client/ stakeholder satisfaction and how it impacts on integration is proposed. Based on the aim of the model, a satisfaction-focussed questionnaire has been developed to solicit information from respondents in four major groups of the construction industry): User Group, Client Group, Project Management Group and Supply Chain Group, as identified by the Construction Strategic Forum (www.strategicform.org.uk) and Construction Online (www.constructionline.co.uk).

The User Group constitutes the user client (s).
The Client Group constitutes the main client or project owner, client advisor, client intermediary.
The Project Management Group constitutes the main contractor, specialist contractor (s), sub-contractors, engineers, designers, architects
The Supply Chain Group constitutes the suppliers, distributors, manufacturers**.**

2. QUALITY (SATISFACTION ATTRIBUTE) IN CONSTRUCTION

The construction industry faces a lot of criticism due to cost overruns, delayed project delivery, high accident rates and poor project performance. These problems are likely as a result of poor quest for quality and quality investment in the construction process. In other words, the construction industry is faced with increased pressure and demand for high quality project (Al-Momani, 2000) and delivery.

The issue of quality evaluation for assessing customer satisfaction in the construction industry has been identified by researchers (Barrett, 2000; Maloney, 2002; Yasamis et al, 2002; Tang et al, 2003; Kärnä et al, 2004). Al-Momani, (2000); Ling and Chong, (2005) identified quality of service as the major factor/ client need for addressing and assessing client satisfaction. Tang et al, (2003) present quality of service, quality of product and quality of manner to customers as the quality elements for creating client satisfaction. In identifying service quality as an antecedent for client satisfaction, Love et al, (2000); and Palaneeswaran et al, (2006) emphasise that contractors and firms need to implement the ISO 9000 quality assurance standards. ISO 9000 represents series of quality systems or standards that deal with the method of quality management in organisations and industries. The aim of the ISO 9000 standards is to enable the supply for quality assurance and to present a common and widely accepted standard for quality evaluation and reliability. Client satisfaction has been included in the 2000 version of ISO 9000 quality standards (Tang et al, 2003)

Quality in construction is discussed in this study from two perspectives:

Quality in design
Quality in service

There exists a dependency between the quality in design and quality in service to create a strong effect on the overall satisfaction of the project team.

2.1 Quality Attribute in Design

Here quality is defined as how well a product, project or service in the construction process meets the design specifications. Hence, quality is viewed with respect to its conformance to the project design specifications and customer requirements. However, since the utmost desire and aim of any industry is to retain its customers and spend less on its customer acquisition, it is important that the design requirements be planned such that it actively incorporates the user (customer) requirements. User requirements here include the client needs and client satisfaction attributes. This is because the customers are not particularly interested in the project design specifications but in having their needs and expectations met (Torbica and Stroh, 1999). Significant quality plans and decisions are usually made in the design phase. In his discussion on quality in design, McConachy, (1996) carefully considered and incorporated assessment of the requirements of the main customer and the project team members. Here, McConachy scaled the customer requirements with respect to quality on three key parameters, which are budget, schedule and technical specifications. These parameters are obviously user requirements or client satisfaction parameters. This is to say that quality assessment and delivery is a catalyst for constant focus on improved client satisfaction throughout the construction process. Arditi & Gunaydin, (1997) explain quality in design as product quality. Here the authors elucidate that product quality (quality in design) refers to quality achieved in the material and technology in the building process.

2.2 Quality Attribute In Service

Delivering excellent service stands out as a competitive tool with the touch of quality attribute in place. The pressure and demand generated by construction customers/ clients for quality service (Zheng et al, 2004) has challenged the industry to become more effective, devising and integrating means to meet, improve and possibly exceed its customer requirement and satisfaction. Quality in service is an exercise that needs to be carried out by every partner or construction team members so as to develop the concept within the industry’s culture (Nzekwe-Excel et al, 2007). Absolute care needs to be taken in implementing quality in service because quality is a subjective attribute so is not particularly measurable. But, it can be evaluated based on the user or customer’s experience with the construction project. This is to say that quality in service can again be expressed in the construction industry via defined factors or parameters. A good example is the ten customer factors (reliability, responsiveness, communication, knowing/ understanding the customer, etc) used for developing the SERVQUAL service quality instrument (See Parasuraman et al, 1988). The level of client satisfaction can be improved upon with constant assessment of quality and its factors. Hence Torbica and Stroh, (2001) assert that quality enhancement programme will create better quality in service, which will then result in higher customer satisfaction.

3. TEAM INTEGRATION

Team integration is the effective collaboration of the construction project participants. It enables true commitment and understanding of each member's needs and requirements.

What distinguishes the construction industry is its uniqueness in incorporating or involving several professionals (to make up a team) and different project phases to deliver a project.

Client satisfaction is a vital factor in the development and management of the construction process, as well as in the creation of efficient company-client relationship. Considering Homburgh & Rudolph, (2001)'s study, where the authors assert that the issue of client satisfaction in construction is relationship-specific rather than transaction-specific, it is therefore apparent that the project participants or integrated team need to function and collaborate (Nzekwe-Excel et al, 2007) simultaneously so as to have a profitable outcome. This implies that the relationship structure of the partners constituting a multi-dimensional pattern should encourage interaction and communication. A well-integrated team will help to eliminate most of the construction problems and criticisms mentioned earlier. This will most likely in turn result in improved satisfaction of the team. A survey is currently being carried out to work out the impact and extent of relationship between team integration and (construction client) satisfaction. The survey will investigate the key attributes influencing the satisfaction of different groups (User, Client, Project Management, and Supply Chain) involved in a typical construction project, and the level of importance assigned to each attribute or factor. This is because each participant or group member is considered a client depending on the stage or phase of the project.

The quality of the integrated team can be monitored and reported by how well the processes and tasks of the supply chain and project participants are integrated to enhance and improve project delivery. This then highlights the functionality and capability of the client satisfaction assessment model.

4. CLIENT SATISFACTION MODEL

The research presents a model as shown in figure 1 which integrates the four earlier mentioned groups, with constant focus to the groups' satisfaction attributes, in order to augment and improve the satisfaction of each group as well as the overall satisfaction rating.

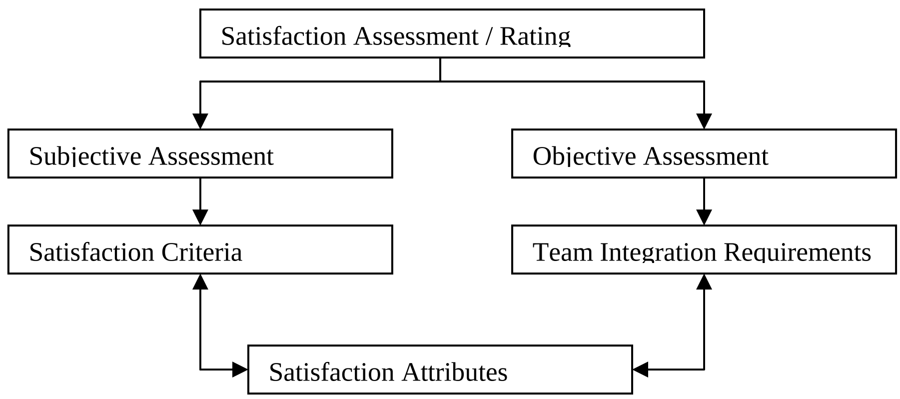

Figure1: Research Model

This study addresses and focuses on the existing limitations of current client satisfaction issues and models in the construction industry. A major limitation is:

- Relationships amongst the project participants have so far been addressed in a one-directional manner. This is a situation where client satisfaction attributes between the main client and the main contractor are addressed with little or no particular research on client satisfaction issues relating to other participants.

In view of the above limitation, the study scrutinises the satisfaction attributes and processes between the user group and the client group; the client group and the project management group; the project management group and the supply chain group. It also investigates and enables the integration of the entire network (see figure 2) with the aim to improve the satisfaction of the entire network.

The research relates its main case, which is high client satisfaction in the construction sector to the dependent variable (satisfaction). The independent construct or variables are the satisfaction attributes and team integration. However, team integration variable is considered as the independent moderator variable. This is because focus on the satisfaction attributes (independent variable) will help to improve satisfaction rating (dependent variable) only if the construction participants engage in consistent team integration (independent moderator variable). This is to say that the reason team integration affects satisfaction is because team integration enhances satisfaction attributes and vice versa, this in turn improves satisfaction rating. Satisfaction of construction clients and project participants hovers around achieving a better construction and adding value constantly for the user client. The need for integrated team in construction can be traced to as far back as the 60s (Emerson, 1962; Banwell report, 1964). The report on 'modernising construction' by Bourn, 2001 elucidate that the entire supply chain needs to be integrated in order to apply and manage value to the construction process. Pheng and Omar, (1997) explain how enabling integration in the construction environment will have a positive impact and improvement on quality. They elucidate that an integrative approach creates an environment where communication amongst the participants is encouraged thereby facilitating a unified and safe environment. This is because where every participant's ideas and views are considered, and their processes/ tasks are well integrated, it helps to motivate and positively challenge the participants. This, in effect, enables the construction industry as a whole to tap and benefit from the participants' invaluable contributions (Pheng and Omar, 1997).

4.1 Model's Theoretical Analysis for Team Integration

The user agent, client agents, project management agents and supply chain agents as indicated in figure 2 are the main agents of the model. Client agents are the agents that initiate the overall infrastructure of the model in response to the user agent's requirements. The project management agents are the agents that respond directly to the requests of the client agents. The supply chain agents are the agents that fuel the entire model by providing the required materials and/ or resources.
For each main agent, there are sub-agents associated with it. Each sub-agent has a set of satisfaction attributes or parameters associated with it. This is to say that each sub-agent has the ability to identify what satisfaction parameters it requires. Each main agent, which indicates a network, determines the sub-agents that need to be linked and integrated with the sub-agents of other main agents depending on the satisfaction attributes and the project phase. The links are set and established such that the processes and tasks of the sub-agents meet the defined satisfaction attributes. However the satisfaction attributes identified and defined at each network or node or by each main agent affect the satisfaction of another main agent. This is to say that where the satisfaction attributes of the project management sub agents are not fully met by the supply chain agents, this negatively impacts on and affects the satisfaction of the client and user agents.

The main agents ensure collaboration and integration of its sub-agents in order to solve satisfaction problem and improve satisfaction level up the network or tree structure.

The satisfaction attributes defined by Xsai determines the sub-agents' (team's) processes and procedures. Based on the results of the recently conducted pilot study which involved 30 construction clients/ participants, attributes such as quality, communication & information flow, responsiveness, time, safety, mutual support have a high rating impact on team integration. A likert scale of 1-5 was provided for each attribute to note down the respondents' level of importance where 5 is 'strongly agree', 4 is 'agree', 3 is 'somewhat agree', 2 is 'disagree', 1 is 'strongly disagree'. The mentioned attributes recorded a response rate of 4.5 to 5.0 (on average).
In view of the pilot study's results, the integration processes for a particular sub-agent i, could be defined as the function f_{spi} such that:

$$f_{spi}(x_{sp1}, x_{sp2}, \ldots, x_{spn} \mid x_{spj} \in Xsai) \qquad (1.0)$$

Therefore, for a given main agent, the integration model is represented by

$$\sum_{i=1}^{n} fspiXsai \qquad (2.0)$$

where fspi = agents' processes/ functions
Xsai = agents' attributes

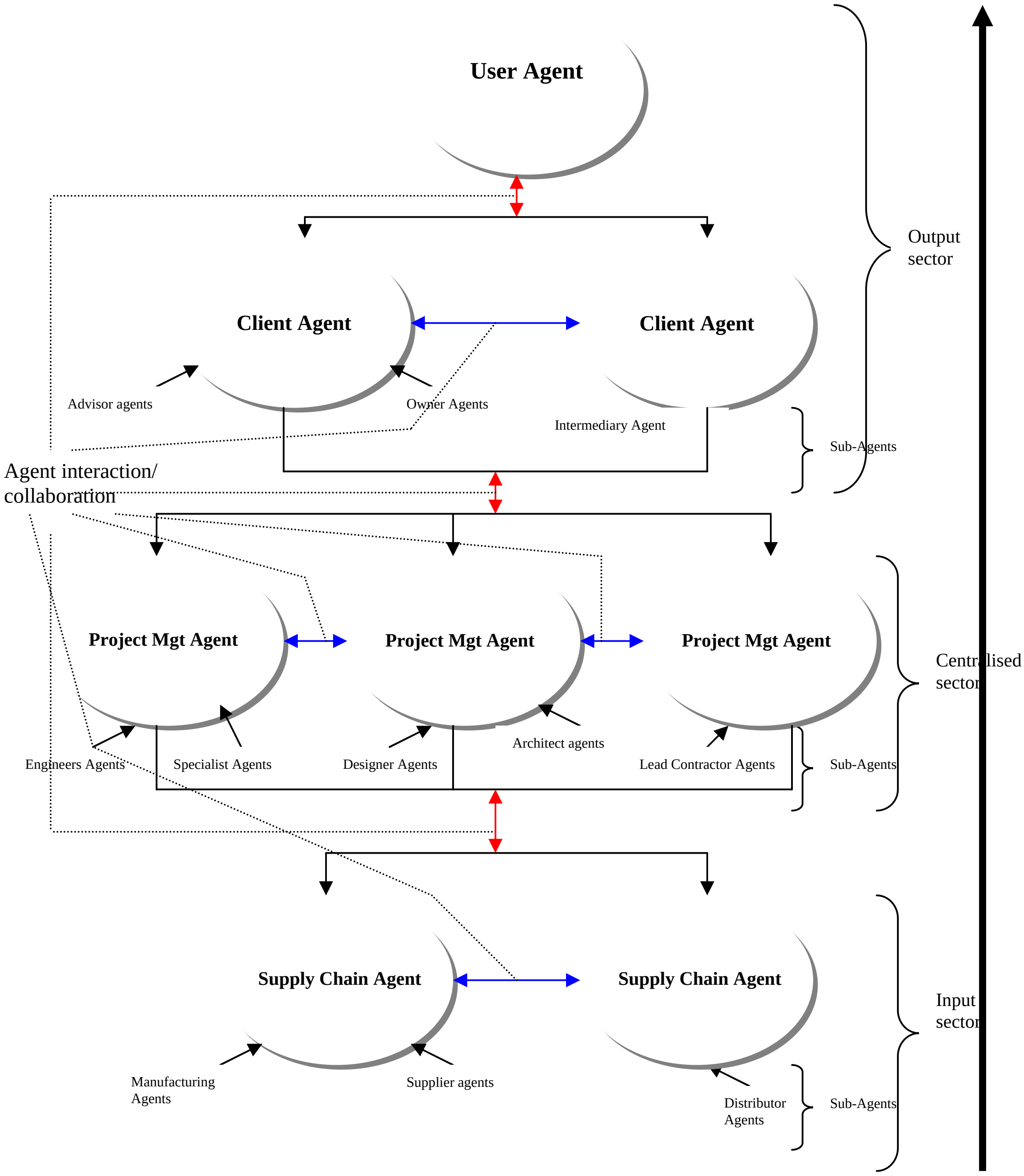

Figure 2: Satisfaction Tree Structure in (construction) agent-based integrated design/ model

Based on the models defined on equations (1.0) and (2.0), the integration model for the user agent could be defined as:

$$Ua = \sum_{i=1}^{n} fspuiXsaui \qquad (3.0)$$

The integration model for the client agent could be defined as:

$$\text{Ca} = \sum_{i=1}^{n} fspciXsaci + \text{Ua} \qquad (4.0)$$

The integration model for the project management agent could be defined as:

$$\text{Pma} = \sum_{i=1}^{n} fsppmiXsapmi + \text{Ca} \qquad (5.0)$$

The integration model for the supply chain agent could be defined as:

$$\text{Sca} = \sum_{i=1}^{n} fspsciXsasci + \text{Pma} \qquad (6.0)$$

Based on the models defined in equations 4.0, 5.0 and 6.0, it indicates that the minimum requirement for the client agent for instance, is:

$$\sum_{i=1}^{n} fspciXsaci + \text{Ua},$$

this shows that the client agents consider and focus on the user requirements while defining their satisfaction attributes and requirements.
Similarly, the project management agents consider and focus on the requirements of the user and client agents while defining their satisfaction attributes and requirements. The supply chain agents follow the same approach while defining their requirements and attributes for satisfaction. This is to say that the minimum requirement for the supply chain agents is:

$$\sum_{i=1}^{n} fspsciXsasci + \text{Pma}$$

Therefore, based on the above models and explanations, where the satisfaction attributes of a given sub-agent at the lowest level on the network or tree structure (the supply chain sub-agent) are not fully met, it affects the agent's satisfaction (delaying its contribution or processes). This is to say that, considering that the entire network is a two way process, adequate integration and collaboration of the entire team (agents) is required to continually enhance and improve the overall satisfaction of the agents (project participants).

5. CONCLUSIONS

The UK Construction industry has experienced obvious changes due to increasing pressures from customer satisfaction. The industry needs to devise more and better strategies into determining what is important to their clients so as to optimise client investments and opportunities. The study has explained that the failure to embrace and understand the problem of satisfaction issues, with particular reference to satisfaction attributes (example quality) and team integration, facing the industry will prevent it from achieving its objectives.

It is almost impossible to achieve high client satisfaction without the provision and delivery of the quality attribute. In order to ensure that quality is deployed throughout the construction process, it needs to be imbibed into the industrial culture. This is to say that quality needs to be taken and practiced as an attitude.

The construction supply chain or integrated team are susceptible to the range of problems arising from lack of understanding of each other's requirements and satisfaction attributes. Through this study, it has been explained that an understanding of the client (supply chain) needs is paramount in the decision making process and at the various stages of the project life cycle/ construction process because it helps in aligning the project outcome to client satisfaction.

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A STUDY OF CONSTRUCTION MATERIAL WASTE MANAGEMENT PRACTICES BY CONSTRUCTION FIRMS IN NIGERIA

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Abstract: Construction Waste Management is an aspect of Sustainable Development, which is fuelled by the growing concern for the effect of man's activities on the environment. The management of Construction processes to reduce, reuse, recycle and effectively dispose of wastes has a serious bearing on the final cost, quality, time and impact of the project on the environment. This research studied the practice of Construction Material Waste Management by firms in Nigeria by the use of structured questionnaires to senior construction-professional personnel of construction firms. The study found out that specific Government legislation on wastes from construction sites were non-existent and that the respondents considered other project goals of timely project delivery, quality and cost as more important than the impact of the project on the environment. Most respondents displayed a poor understanding of waste management and most companies did not have a policy on Material Waste Management. The paper recommends that the Nigerian Government puts in place legislation regarding construction site waste management. Professional bodies and academic institutions in the country should seek to further educate their members on the importance of effective material waste management strategies.

Keywords: Construction Waste Management, Government Legislation, Nigeria, Policy, Sustainable Development.

1. INTRODUCTION

The building or construction industry involves different processes and utilizes huge quantities of resources. These processes have severe impacts on the environment which according to Horsley (2003), occur over a variety of timescales from the extraction and processing of raw materials used in construction, through the duration of the construction process, the operation of the building, up to the eventual demolition of the structure at the end of its operative life.

Construction activities have been known to generate large and diverse quantities of waste. According to the US Green Building Council, (2001), it accounts for up to 30% of total waste output in the United States alone, put at about 136 million tons per annum. As a result, construction and demolition waste management has become one of the major environmental problems in many municipalities (Faniran and Caban, 1988; Kibert, 1994; Ferguson et al., 1995; Graham and Smithers, 1996; Guthrie et al., 1999; Symonds, 1999; Lawson and Douglas, 2001, cited in Poon et al, 2004).

In some more advanced countries, the concern for the effect of Man's endeavours on the environment and rising project costs has increased the drive for the application of Construction Waste Management. There has been a strong drive to 'do more with less' by reducing waste at all stages of construction as identified by the '*Rethinking*

Construction' task force in the UK (DETR, 2000). There is also a need to improve material handling by contractors as the DETR also noted that about 13 million tonnes of the estimated 70 million tonnes of construction and demolition materials comprise of materials delivered to site and thrown away unused.

1.1 The Effect of Construction Activities

Construction can be defined as the activity involving creation of physical infrastructure, superstructure, housing and other related facilities (Watuka and Aligula, 2003). The physical substance of a structure is an assembly of materials from widely scattered sources. They undergo different kinds and degrees of processing in large numbers of places, require many types of handling over periods that vary greatly in length, and use the services of a multitude of people organized into many different sorts of business entity.

The Construction industry, while contributing to overall socio-economic development of any country, is a major exploiter of natural non-renewable resources and a polluter of the environment whereby it contributes to the environmental degradation through resource depletion, energy consumption air pollution and generation of waste in the acquisition of raw materials (Watuka and Aligula, 2003).

Construction activities generate a large amount of waste compared to other industries. In EC countries, about 200 to 300 million tons of construction and demolition waste is produced annually, which translates to roughly a 400 km^2 area covered with demolition debris one meter high (Pieterson and Fraay, 1998, cited in Elias-Ozkan and Duzgunes, 2002). In the United States alone, about 136 million tonnes of construction waste is generated (US Green Building Council, 2001).

1.2 Sustainable Construction

According to Harman and Benjamin, (2004) the built environment is the heart of any economy; providing the infrastructure necessary to enhance productivity, but the manner in which it consumes natural resources makes it responsible for some of the most serious local and global environmental changes. Sustainable construction is an integrative and holistic process of construction which aims to restore harmony between the natural and the built environment (Agenda 21, 2001).

The California Integrated Waste Management Board (2003) described Sustainable Construction as a whole building approach to design and construction that saves or reduces resources in five categories: site, water, energy, materials and environmental quality. Sustainable construction, according to Watuka and Aligula (2003) can also be said to be "the set of processes by which a profitable and competitive industry delivers built assets: building structures, supporting infrastructure and their immediate surroundings which:

i. Enhance the quality of life and offer customer satisfaction
ii. Offer flexibility and the potential to cater of user changes in the future
iii. Provide and support desirable natural and social environments
iv. Maximize the efficient use of resources while minimizing wastage."

1.3 Material Waste in Construction

There are differing views held by researchers as to what constitutes Construction waste. Cheung, (1993) stated that Construction Waste can be defined as the by-product generated and removed from construction, renovation and demolition workplaces or sites of building and civil engineering structures. According to Formoso, (1999), it should be understood as any inefficiency that results in the use of equipment, materials, labour, or capital in larger quantities than those considered necessary in the production of a building. Shen et al,(2003) defined building material wastages as the difference between the value of materials delivered and accepted on site and those properly used as specified and accurately measured in the work, after deducting the cost savings of substituted materials transferred elsewhere, in which unnecessary cost and time may be incurred by material wastages.

Serpell et al, (1995), cited in Alwi et al, (2003) asserted that Construction Managers have to deal with many factors that may negatively affect the construction process, producing different types of wastes. There are several causes of material wastes which in most cases are dependent on the type of construction methods employed, the specific materials in use, and/or the stage of the construction itself. Waste can be generated by mistakes, working out of sequence, redundant activity and movement, delayed or premature inputs and products or services that do not meet customer needs (Construction Industry Board, 1998).

Construction and Demolition waste is a complex waste stream, made up of a wide variety of materials which are in the form of building debris, rubble, earth, concrete, steel, timber, and mixed site clearance materials, arising from various construction activities including land excavation or formation, civil and building construction, site clearance, demolition activities, roadwork, and building renovation. It also includes incidences of wastages in labour and energy used in construction works. However, material waste has been recognized as a major problem in the construction industry that has important implications both for the efficiency of the industry and for the environmental impact of construction projects (Formoso et al, 2002). Most construction wastes which were previously regarded as inert have been found to generate harmful leachates which have negative effects on the environment (Apotheker, 1992, cited in Lingard et al, 2000). As such, it is absolutely imperative for the construction industry to adopt ecologically sound planning and construction practices for the purpose of creating a healthy and sustainable built environment (Poon et al, 2004).

1.4 Construction Waste Management

The practice of waste management for construction activities has been promoted with the aim of protecting the environment and the recognition that wastes from construction and demolition works contribute significantly to the polluted environment (Shen et al, 2002, cited in Shen et al, 2004). This increasing awareness of environmental impacts from construction wastes has led to the development of waste management as an important function of construction project management (Shen et al 2004).

There are several approaches to construction waste management. The process of managing construction waste goes far beyond the disposal of the wastes itself. It is an all-encompassing strategy to effectively utilize construction resources, with the view to reducing the quantity of waste and also utilizing the generated waste in the most effective manner. The most common approach to management of construction waste is dumping in landfill sites. However, decreasing landfill space has led to increasing costs of landfill disposal to the contractor (BIE, 1993, cited in Lingard et al, 2000). Also, a relatively large amount of materials is being wasted because of poor material control on building sites (Poon, et al, 2004). This has prompted the need for alternatives for waste prevention and the initiatives to reduce, reuse and or recycle waste produced which are referred to as the three R's of construction waste management. A waste hierarchy has been widely adopted as a guide for construction managers, in line with the principles of sustainable construction. The Waste hierarchy suggests that:

i) The most effective environmental solution may often be to **reduce** the generation of waste.
ii) Where further reduction is not practicable, products and materials can sometimes be **re-used,** either for the same or a different purpose.
iii) Failing that, value should be recovered from waste, through **recycling**, composting or energy recovery from waste.
iv) Only if none of these solutions is appropriate should waste be **disposed** of, using the best practicable environmental option.
(Source: Department of the Environment, Transport and Regions, 2000)

According to Coventry and Guthrie, (1998), there are two fundamental reasons for reducing, reusing and recycling waste: the economic advantages, and the environmental advantages. The environmental advantages include the minimization of the risk of immediate and future environmental pollution and harm to human health while the economic advantages include lower project costs, increased business patronage, lower risk of litigation regarding wastes amongst others. In view of these advantages and the negative impact of construction wastes on successful project delivery, this paper identifies major causes of waste, the position of construction firms and professionals in the Nigerian construction industry on construction waste management and constraints to effective site waste management such as policy and legislative issues.

2. METHODOLOGY

The research work was carried out by administering a well structured questionnaire to a sample of the population for the study. The population was all professionals in the construction industry, i.e. Architects, Builders, Engineers and Quantity Surveyors who were managing construction projects at a senior cadre level in all categories of construction firms duly registered with the corporate affairs commission in Nigeria. Twenty-Seven (27) of the returned questionnaires were administered at a conference on Sustainable Construction, while the other Thirty-Five (35) were administered to professionals handling projects in large cities like Kaduna, Lagos and Abuja.

The questionnaire was designed in such a manner to elicit responses that could be easily analysed by the use of closed ended questions with suggested answers on ordinal scales. In addition, the opinions of the respondents were also sought with relevant open ended questions a view to finding suitable recommendations on the findings of the research. The questionnaire was used to gather information on the respondents' knowledge of Construction Waste Management, legislation and the respondents' company's policy of waste management.

3. FINDINGS AND DISCUSSION

A total of 120 questionnaires were administered for this survey, of which 62 were returned with valid responses. This showed a response rate of 51.6%. From the results of the analysis, it was observed that about 12.9% of the respondents were of the opinion that no attention at all was paid to construction waste management. About 77.4% felt it was fairly given as much attention as other functions of a construction manager, while only 9.7% opined that sufficient attention was paid to construction waste management.

The research also showed that a fairly high percentage of the respondents were able to identify the most appropriate description of construction waste management from a list of options. From column 3 in Table 1, it can be seen that 52.5% chose option 4 which encompassed about all aspects of construction waste management. All other options contained only some aspects of waste management. On the level of wastes encountered on site, 61.3% of the respondents regarded the level of waste generated on their sites as Moderate. Approximately twenty three percent felt it was low while 12.9% regarded it as high. The summary of these responses are presented into Table 1.

Table 1: Awareness on Construction Waste Management Issues

Understanding		**Waste Level**		**Waste Management Attention**	
Option	***%***	***Rank***	***%***	***Response***	***%***
1	0.0	Very Low	1.6	Surely	9.7
2	14.8	Low	22.6	Fairly	77.4
3	26.2	Moderate	61.3	None	12.9
4	52.5	High	12.9		
5	6.6	Very High	1.6		

Legend: 1 = Supervising workers thoroughly to reduce waste, 2 = Proper material scheduling and handling to reduce waste, 3 = Proper disposal of wastes in landfills and suitable areas, 4 = Efficient material handling and reduction, reuse, recycling and disposal of wastes, 5 = Reduction and disposal of construction wastes

Further analysis showed that the project goals of cost and quality were considered by the respondents as most important; more important than timely delivery of the project or minimizing the impact of construction on the environment as shown in Table 2.

Table 2: Level of Importance of Project Goals to Construction Professionals

Factor	**1 (%)**	**2 (%)**	**3 (%)**	**4 (%)**	**Mean**	**Std. Deviation**
Cost	0.0	0.0	19.4	80.6	3.81	0.40
Quality	0.0	0.0	19.4	80.6	3.81	0.40

Time	0.0	0.0	40.3	59.7	3.60	0.49
Impact on Environment	4.9	9.8	50.8	34.4	3.15	0.79

Legend: 1 = Indifferent, 2 = Not Important, 3 = Important, 4 = Very Important

Many of the respondents showed a poor adoption of different methods of managing construction wastes. The most widely adopted methods were reusing and sale as scrap, largely due to the high use of timber in construction and its high scrap value for uses such as firewood. This was buttressed by the observation that only 42.6% were satisfied with the methods of waste management on their sites. Roughly 20% were neutral while 32.8% expressed that they were dissatisfied with their methods.

The low level of adoption may be explained by the fact that respondents showed a poor understanding of the benefits of an effective construction waste management scheme. Majority felt lower project costs (69.4%) and cleaner environment (66.1%) were the principal benefits of construction waste management as shown in the table below. Other factors such as increased business patronage and longer lifespan of non-renewable sources of materials were not widely thought to be important (See Table 3 below).

Table 3: Benefits of Construction Waste Management

Response	Cleaner Environment	Lower Project Costs	Longer Lifespan of Materials	Increased Patronage	Other
Agreed	66.1	69.4	3.2	11.3	12.9
Neutral	33.9	30.6	96.8	88.7	87.1

Of the respondents who practised some form of waste management, 56.7% cited the reduction of the project cost reduction as the main motivation, followed by concern for the environment of which 43.3% attested to. Thirty percent cited conditions of contract, while other factors such as legislation, client requirement and government incentives had only 13.3%, 6.5% and 0% respectively. Table 4 below shows the percentages and rankings of the various factors, while Table 5 shows the percentages and ranking of some factors that hinder the practice of waste management on site.

Table 4: Factors Influencing the Practice of Construction Waste Management

Factor	Agree (%)	Neutral (%)	Rank
Project procurement cost reduction	56.7	43.3	1
Concern for the environment	43.3	56.7	2
Conditions of Contracts	30.0	70.0	3
Legislation	13.3	86.7	4
Client Requirement	6.5	93.5	5
Government incentives	0.0	100.0	6

Table 5: Factors Hindering the Practice of Construction Waste Management

Factor	Agree (%)	Neutral (%)	Rank
Lack of awareness	46.7	53.3	1
Weakness in legislation	23.3	76.7	2
Insignificant cost of handling waste	20.0	80.0	3
Waste not a problem on site	13.3	86.7	4
Other factors	10.0	90.0	5
Abundance of landfill	6.7	93.3	6

The general observation from the results of the analysis was that the practice of waste management by construction firms in Nigeria is poor. Seventy-two percent claimed they were not aware of any legislation on construction wastes, and only 48.4% said they worked in companies with policies on construction waste management. Seventy-two percent claimed to be in a position to influence policy making in their organisations but only 45.8% of them attested to have formulated one (See Table 6).

Table 6: Policy and Legislation Issues on Waste Management

Response	Waste Legislation (No = 58)	Company Waste Management Policy (No = 62)	Influence on Policy (No = 62)	Formulation of Policy (No = 48)
	%	%	%	%
Yes	27.6	48.4	72.6	45.8
No	72.4	51.6	27.4	54.2

With respect to the causes of waste on site, several factors were obtained from the work of Tam et al, (2003) and the respondents were requested to rank from 1 through to 5 (i.e. from strongly disagree to strongly agree as shown in the legend below the Table). The means for each of the factors were computed and used to rank the factors with respect to their significant contribution to waste generation. From the results which are shown in Table 7 below, Poor supervision, workmanship and storage facilities were regarded as the most common causes of waste on site, while equipment malfunction, weather and force major were the least common.

Table 7: Causes of Waste on Construction Sites

Factors	N	Min	Max	Mean	Std. Deviation	Rank
Poor Supervision	61	2	5	4.31	0.79	1
Poor Workmanship	60	1	5	4.15	0.95	2
Poor Storage Facilities	61	1	5	4.08	0.80	3
Improper Handling	60	1	5	4.07	0.82	4
Improper Storage	59	1	5	4.05	0.99	5
Design Error	59	1	5	3.98	0.84	6
Design Changes	60	1	5	3.97	0.97	7
Human Error	61	1	5	3.75	1.03	8
Material Deterioration	60	1	5	3.43	1.18	9
No Waste Management	59	1	5	3.37	1.24	10

Personnel						
Ordering Errors	58	1	5	3.36	1.00	11
Force Majeure	55	1	5	3.29	1.20	12
Weather	61	1	5	3.20	1.08	13
Equipment Malfunction	60	1	5	2.83	1.25	14

Legend: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

The research also attempted to find out factors which may impact on the effectiveness of a solid construction waste management scheme and as such, several factors adopted from the work of Lingard et al, (2000), were included in the questionnaire and they were ranked according to their perceived impact on waste management by the respondents. Table 8 shows the distribution of the responses, the means, standard deviation and rank (based on mean) for each factor.

Table 8: Factors Which May Affect the Effectiveness of Solid Construction Waste Management

Factors	N	Min	Max	Mean	Std. Deviation	Rank
Management Support for Waste Management	57	2	4	3.74	0.55	1
Staff Knowledge of Waste Management	57	2	4	3.68	0.57	2
Waste Minimization Motivation	55	2	5	3.56	0.69	3
Material Storage Practice	57	2	5	3.46	0.71	4
Estimating/Ordering Practice	55	1	4	3.25	0.75	5
Recycling Infrastructure	56	1	4	3.20	1.02	6
Design Issues	55	1	4	3.20	0.87	6
Sustainable Development Awareness	57	1	4	3.16	0.73	8
Material Supply Issues	56	1	5	3.14	0.80	9
Cost of New Materials Against Recycled	54	1	5	3.02	0.86	10
Individual Value Judgement	56	1	4	3.00	0.76	11
Waste Disposal Costs	55	1	5	2.91	0.99	12

Legend: 1 = No Impact, 2 = Minor Impact, 3 = Moderate Impact, 4 = High Impact

It can be observed from the Table that managements' support for waste management initiatives, staff knowledge on waste management and workers motivation to minimize waste were considered to have the highest impacts, while waste disposal costs, the individuals' (site worker) value judgement and the comparative cost of new materials against recycled materials were considered to have the lowest impacts of all the factors.

4. CONCLUSIONS AND RECOMMENDATIONS

The survey results show that the general practice of Solid Construction Waste Management and site waste management as a whole is very poor and has room for a lot of improvement. The construction Professionals' understanding of construction waste management was found to be deficient, and the adoption and practice further hampered by lack of sufficient legislation or Government incentives to encourage the teachings of sustainable construction. The following recommendations are made against the backdrop of the research findings:

i. Educational institutions should include the teachings of sustainable construction in the curriculum of professionals in the construction industry. Also, professional bodies should use conferences and workshops to educate practising professionals.
ii. Government should introduce specific legislation governing the handling and disposal of construction wastes and follow up with strict monitoring to ensure compliance.
iii. Incentive schemes should be set up by Government to reward firms who embrace construction waste management wholly.

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HIGH RISE AND LAND COSTS; A THEORETICAL FRAMEWORK

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Abstract: In the Netherlands, the number of realized high-rise projects is limited. Land owners and developers are searching for conditions and boundaries under which high-rise is feasible. The research started on high rise costs with literature review, and by interviewing experts working on high-rise projects and cost modelling. One of the outcomes of the descriptive model is the increase of costs with the increase of height. Land costs are equally important. As is the case for rent levels land costs depend most of all on location. Traditionally land costs are determined based upon the value of land, in which gross floor area is leading. For the developer lettable floor area and efficiency is leading. A sub model is set up for land costs in which the land owner as well as the developer can maximise their profits within reasonable limits. This model will be further developed and discussed in the field.

Keywords: High rise, Initiative design phase, Integrated building cost model, Land costs, Real estate & urban economics**.**

1. INTRODUCTION

This paper elucidates one of the items belonging to a more extensive research 'High Rise Ability' (De Jong, Oss et al. 2007, De Jong 2007). One of it's tentatively conclusions is the increase of building costs with the height in combination with the decrease of efficiency of floor plans, again with the height. Those effects lead to a limitation of the feasible building height, at least if the building costs are the main perspective. Land cost takes up another substantial part of the investment. High rise in the Netherlands is in most cases a combined action of the developer, taking the initiative and the local government providing land and setting the rules. The developer as well as the local government may have, with different arguments, reasons to reach a certain height. The developer wants to realise a certain volume for its investor or the future owner. With a given plot size, the required height is almost a mathematical result. Some developments may require the establishment of an icon or a landmark. The local government wants to create a certain density on a location in optimising land use.
The developer, confronted with the feasibility boundaries in height, may search first for an internal solution of the problem. A different subdivision is the first focal point, lowering the cost of land in favour of the building cost. This standard Dutch residual approach, in which land cost is related to the gross floor area, is no longer an option for high rise above a certain height. Alternatively, an external approach is possible. If the external economies are taken into account, the group of stakeholders and contributors can be enlarged. Further research will focus on these externalities.

2. BUILDING COSTS AND EFFICIENCY

High rise ability is a research project in order to clarify the economic boundaries in the Dutch context. Building costs have a large impact. But impact and size are different entities. The share of building costs, as a part of the construction costs, takes a humble place in the total process, because:

- Building costs are only a part of the total investment. In the feasibility study land costs and other additional costs may have a larger impact and are more negotiable.
- Value creation means more to a project then only looking at the cost side of the balance, in which the building costs or even the investment may be treated as a fixed figure, or based upon indices and the required gross floor area.
- Compared to life cycle costs building costs, as well as the total investment costs, are only a fragment, although the design itself may have a large impact on the life cycle costs,
- Looking at the turnover of the building in its life time the building costs become really modest. The impact of design and building costs on this turnover in terms of a building (not) meeting the needs of the user can be huge.

At the same time proper understanding of building costs is vital. Where market, rental revenues and land costs are hard to adjust on a given location, all participants are looking at the design, which has to provide the way out. The designer must consider the needs of the future users in order to trigger the willingness to pay. Feasibility is depending on the balance between revenues and expenditure (Fig. 1). The total investment is for a substantial part depending on building costs in its relation to the design. The building costs becomes even more crucial because other items like building site costs, fees, taxes, interest and so on are related to the building costs, at least in the early stages, where the percentage approach is very common.

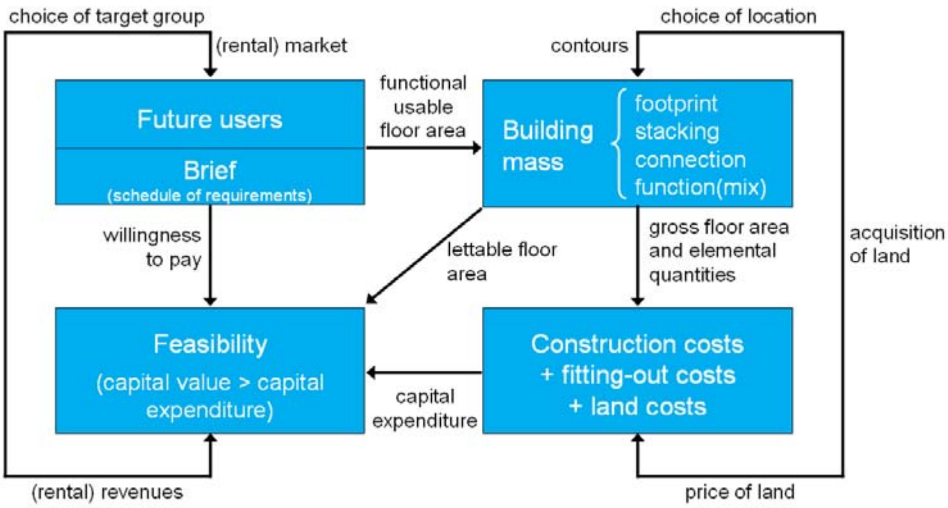

Figure 1: Development of buildings (Soeter et al. 2005)

2.1 Specific costs of high rise

There are many definitions of high rise/tall buildings buzzing around in the world. In this research the physical lower limit of 70 meter is used, due to the fact that from that height up specific regulations are required in the Netherlands.
A more appealing definition is given by the Council on Tall Buildings and Urban Habitat: "A tall building is not strictly defined by the number of stories or its height. The important criterion is whether or not the design, use, or operation of the building is influenced by some aspect of tallness." (CTBUH, 2007) Otherwise it is just a case of stacking floors. With respect to this definition high rise projects are buildings in which specific measurements with regard to that height are taken.

The definition of the Council includes specific measurements and therefore specific costs. The peculiarity of these additional costs is listed by Langdon (Langdon and Watts 2002, Watts 2002, Reus 2004):

- Increased wind loadings and heavier frames.
- Vertical transportation requirements, particularly elevator capacities, speed, zoning etc.
- Larger capacities of plant and distribution systems together with the increased pressures/hydraulic breaks required to deal with increased vertical distances.
- The effects of scale and complexity on the movement of materials and labour.
- The risks associated with the uniqueness of high rise and the fact that these risks are exacerbated by scale and the need to access a limited pool of skills and expertise
- The potential interest in including elective security and safety enhancements in response to possible risks.

One of the means given in literature to cope with these effects is the introduction of a height charge: a factor that brings the additional costs for the specific conditions into account. An elaborated example of such a height charge is given by Gossow (2000).

The research 'High rise ability' (HRA) should result in a design model for building costs and financial feasibility of high rise. Costs will be the main focus for feasibility, especially where the model will function as a decision tool. Other aspects of feasibility (revenues, value creation, sustainability, social acceptance etc.) may have a larger impact. The objective is to get a detailed estimation of building costs of high-rise office buildings in the initiative and early design phase, while limiting the number of required design parameters to those known at the initiative phase.

The research started with a state-of-the-art literature review, and by interviewing experts working on high-rise projects and cost modelling. This resulted in an integrated model, which is now being evaluated in practice. The modelling approach is based on the previous modelling approach for the initial cost estimate for office buildings, Svinsk (De Jong 2006) and the PARAP research (Bijleveld and Gerritse, 2006). The starting point for these modelling approaches is best described by Gerritse (2005).

The characteristics of high rise buildings are described and the essential parameters are defined. This interim result (Oss 2007) is represented in figure 2.

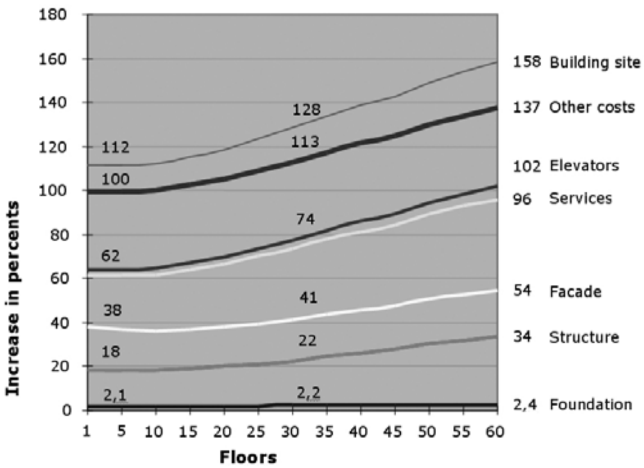

Figure 2: Increase of building costs (Oss 2007)

Where the first graph (Fig. 2) gives the stacked costs, Figure 3 gives a more clear presentation of the contribution of the single elements. Here all the results are combined in a single graph and stacked per 10 floors. It can be noted that structure, installations, elevators are the main risers (contributing to the total direct building costs with an average of respectively 16, 25 and 3 %).

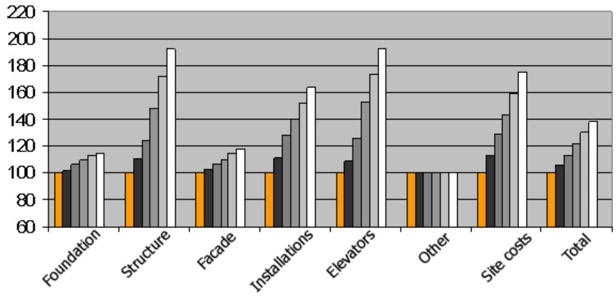

Figure 3: Increase of building costs per element (Oss 2007)

2.2 Efficiency of high rise

Where the expenditure is determined by the building costs per gross floor area (gfa), the revenues are based upon the lettable area (la). Feasibility of high rise is a matter of controlling the efficiency of the building. Efficiency is in this case defined by the ratio between lettable/leasable area and gross floor area. Not only the building process itself but also the high rise building in use may be compared to the making of a ship model in a bottle. Every piece of material has to pass the bottleneck, making the logistics, the vertical transport, exceptionally important.

Table 1: Building efficiency (Langdon 2002)

Number of floors	Efficiency (%)
2 to 4	88 – 91
5 to 9	84 – 88
10 to 19	77 – 85
20 to 29	75 – 83
30 to 39	74 – 79
40 +	72 – 77

Langdon (2002) shows that while the costs are increasing with the height, the earning capacity of the building is decreasing, in which the vertical transport with the 5 % of the gfa for the elevators takes its substantial contribution. The graph with a similar result of the HRA-model (Fig. 4) shows a similar decrease of efficiency, but here the number of floors is combined with the floor area.

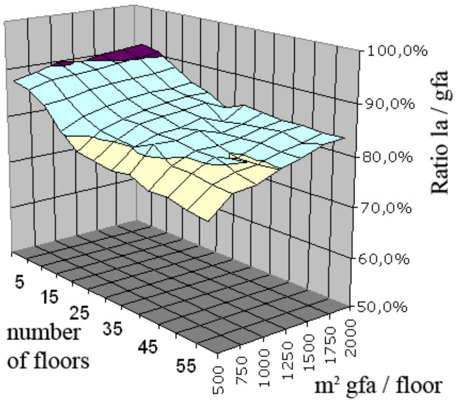

Figure 4: Ratio gross floor area and lettable area (Oss 2007)

Figure 4 shows the effect of the height on the ratio gross floor area versus lettable area. As can be seen on the gfa/floor axis the difference between small floor plans and larger floor plans can be dramatically. The worst results in the sense of efficiency and feasibility are appearing with tall buildings with small floor plans. However, Dutch regulation (daylight requirements for office workers) obstructs the application of Sears-tower like floor plans (67.5 x 67.5 m^2). Floor plans like the one of the 'Nationale Nederlanden' (the tallest office in the Netherlands until the end of this year) are more likely (22.5 x 45 m^2). The graph above could be simplified into a linear expression (average floor size of 1000 m^2) in which the efficiency is decreasing with around 0.40 % per floor.

3. LAND COST

Building costs and efficiency have a national character due to national legislation. Feasibility is much more defined by location and the market and therefore has a national as well as a local aspect. As stated by a colleague working in the Hong Kong environment: "Land costs are so dominant, it does not matter how you make high rise, as long as you make it!" Educational projects have been showing that certain high rise designs are not feasible in Rotterdam, while the same design would be feasible in Amsterdam, where the higher rent level sufficiently compensates the higher cost of land. The supply of land is an activity of the local government in The Netherlands. It is normal for the municipality to buy up land which is zoned for development in the ensuing period, if necessary using its powers of compulsory purchase to ensure compliance on the part of land owners, to provide infrastructure, and to sell the sites on to construction firms for development (Evans 2004). In this way The Netherlands are very different from Britain and the USA. The municipality interferes in the setting of land prices. They exercise a functional land-price policy. For commercial real estate prices are based on the standardized residual value approach, based on average construction costs and additional expenses assumed pro function (Van der Post 2007).

Table 2: National differences in land policy structures (Van der Post 2007)

Implemented conditions	**Amsterdam**	**Houston**	**Frankfurt**	**Stockholm**
Dominant actor	Local government	Market	Market	Local government
Public ownership	Substantial (80 % municipality)	Only open space	Only open space	Substantial (70 % municipality, 20 % state)
Land supply	Public body	Private	Private	Public body
Interference in land price setting	Yes	No	No	No
Protection private spatial property	Weak	Strong	Strong	Weak
Coordination planning system	Restrictive	Free	Free	Restrictive

This Dutch approach clarifies why development of high rise is a combined action of the developer and the municipality as stated in the introduction; it is almost impossible to neglect the local authority. In general the planning system is working well (Evans 2004). A problem for high rise occurs where a 'standardized approach' based on 'average cost' is used, where the number of high rise projects is still very limited. Combined with the fact that the functional as well as the residual value approach are based on prices per gfa, the increase of building costs and the decrease of efficiency, developers are looking at the local authorities to acknowledge the specific situation and to modify the conditions.

4. MODELLING LAND COST

The value created with a high rise project could be represented by the rent per square metre gross floor area (1). This rent will increase with the height due to the additional value of the height. It will not necessarily be a straight line. Comparable with high rise apartments where penthouses are sold easier then mid rise apartments, the highest office floors will give another status then the 20th floor in a 60-floor building. Also time will influence this line. Reaching the highest height in the city may cause a temporarily jump until another building will take over this 'top position'.

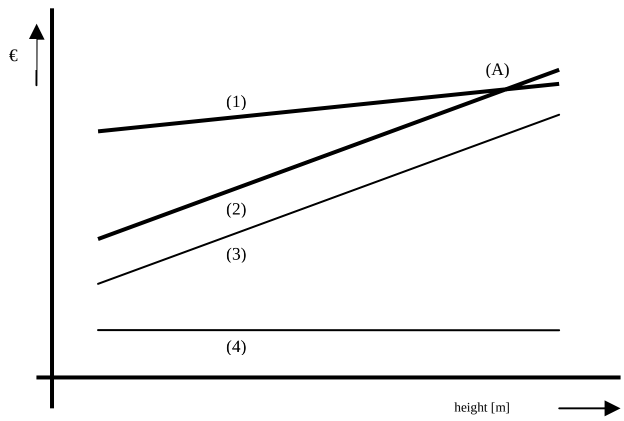

Figure 5: Value and costs related to the height

With a fixed size of the plot and a continuous floor plan, the total value of the building is represented by the area enclosed by (1) and the axis. Theoretically the positive contribution of the additional value of the height could be less then the negative contribution of the efficiency. However, this area of possible solutions should not appear due to the fact that developments will come to a standstill when these conditions are met.

(1) $f(x) = y1 + ax$

The value of y1 is most of all depending on the location and for the lesser part of the quality of the building. Further elaboration of this value is a project based activity of brokers where a more scientific approach is done by Koppels (Koppels, Remøy et al. 2007).

The second line (2) represents the investment costs. These costs are increasing by the height. The investment costs are divided in land costs, building costs and additional costs. Some elements in the additional costs may have a relation to the height, but in general it can be treated as a fixed sum per m2 gross floor area. In some cases parts of the additional costs are represented as a percentage of the building costs, where the total financial endeavour is in stake. Land costs are given by a fixed sum per m2 gross floor area.

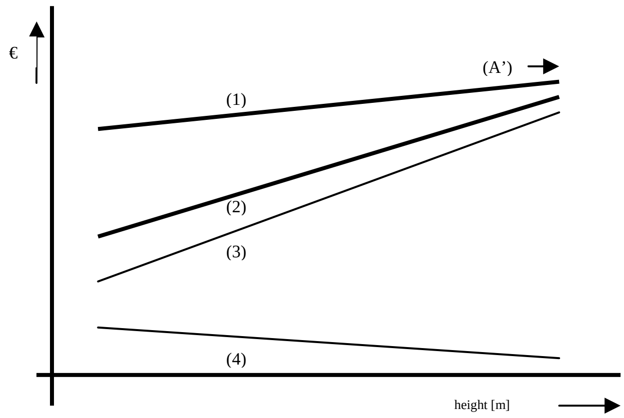

Figure 6: Adjustment of land costs

The investment costs (2) are divided into an increasing line for the sum of building costs and additional costs (3) and a horizontal line for the land costs (4).

Table 3: Input model

Input	**Values**	
length	45	m
width	22,5	m
building costs	1067	€/m^2
increase of building costs per floor	0,80	%
additional costs	40	%
land costs	500	€/m^2 gfa
decrease of land costs per floor	1,00	%
efficiency	90	%
decrease of efficiency per floor	0,40	%
rent	200	€/m^2 la
increase of rent per floor	0,25	%
rent period	15	years

As long as the investment is lower then the total value developers could be interested in this project. Point A could be presented as a breakeven point. The common interest for both the developer as the land owner is to shift point A to the right. The general idea is that if the land owner compensates some of the additional costs of the increasing height by a certain decrease per floor of the land costs still the total revenues of both parties will increase. The values of these parameters are arbitrary, and will depend on circumstances, but as shown by figure 7 and 8, the general conclusion may be that it is hardly possible to reach an internal solution in which land owners as well as developers are gaining by reducing the land costs resulting in additional floor space.

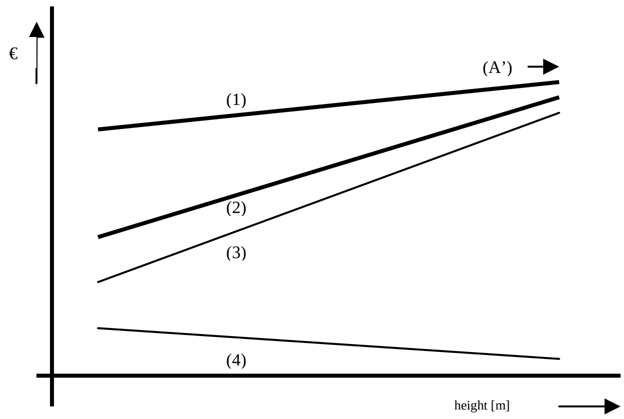

Figure 6: Adjustment of land costs

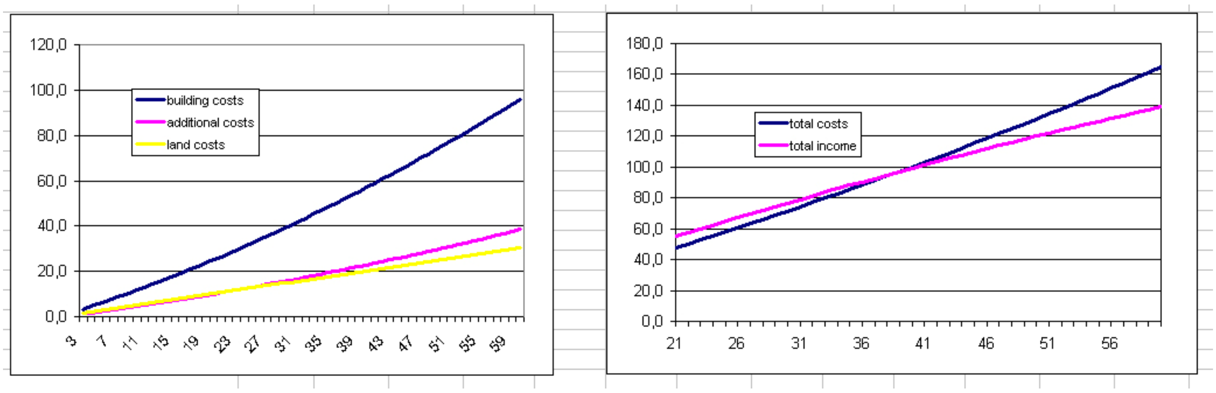

Figure 7: Total costs (building, additional and land costs) in € in relation to total income without the decrease of land costs per floor

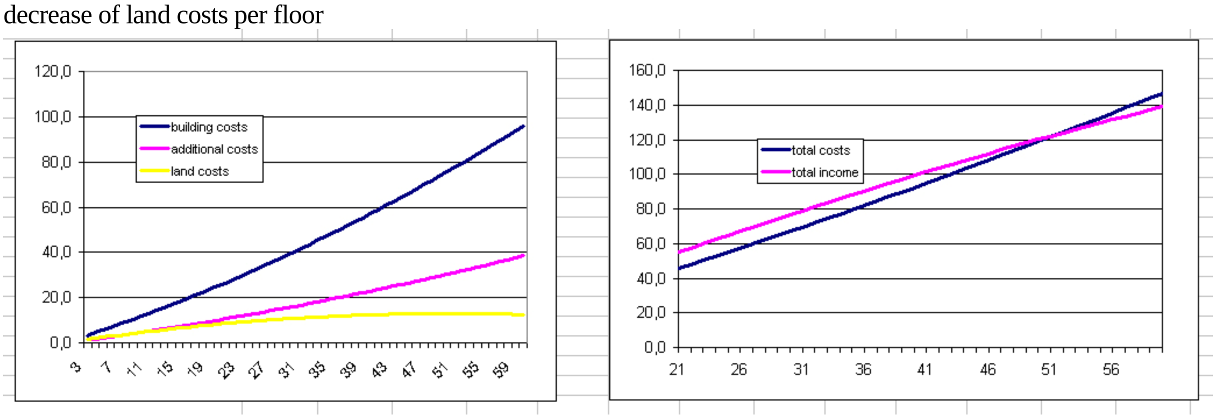

Figure 8: Total costs (building, additional and land costs) in € in relation to total income with the decrease of land costs per floor

An increase of building costs by 0.8 % per floor may not look impressive but it means that the addition of the 50th floor will cost 80 % more compared to the addition of a low rise floor (De Jong, Oss et al. 2007).

5. EXTERNAL (DIS) ECONOMIES

5.1 Economic externalities

Externalities are endemic in urban areas. Indeed external economies, positive externalities, are one of the reasons why cities exist (Evans 2004).

Land owners will point out that the logical party to contribute to the increased building costs will be the users of the high floors. If they are not willing to pay the required rent, than ‘there is no market’. Based on a sample of 105 high rise buildings, using hedonic price modelling Clapp (1980) showed some existence of relations between number of floors, density and rent. At the other hand Sabbagh (1991) illustrated the difficulties to get users in a skyscraper. Depending on the market situation the user will ask for a lower rent because of the traffic time in order to reach the desired top floors.

In case the land owner is the local government differentiation in land prices are used for planning strategies: if the municipality requires social housing they will reduce the land price for such a function. Also high rise requires these kinds of steering attributes. One of the qualities of Amsterdam is its historical inner city. The market is willing to pay high rents in this area, giving a good financial base for high rise. At the same time the inhabitants and the municipality are convinced tall buildings will destroy this historical quality. Coding and pricing prevents the establishment of high rise in the inner city. At the same time city planning is creating options for high rise in surrounding areas like the second ring and the Zuidas. Searching for the right balance between steering in the development and contributing to the cities financial situation is partly based on trial and error.

5.2 Social externalities

Skyline development by high rise zoning is appreciated by the majority of the public, while solitude tall buildings in low rise areas meet considerable resistance. Where the historical value could still be calculated in an economic model, it will require different techniques to quantify the public appreciation, the well-being of the society, touching the main objective of planning.

This well-being is even more influenced by the way high rise is contributing to a sustainable society. The huge mass of material, relatively a lot of façade and high service requirements, against enhanced land use, optimised infrastructure and better options for sophisticated measurements. Modelling of sustainability has many similarities with modelling of building costs (De Jonge 2005, Van den Dobbelsteen 2004, 2006). Both approaches break down the total building concept into its elements, and determine the contribution of the element to the total (ecological) costs or the environmental load.

6. FURTHER RESEARCH

Further research will first of all be concentrated on the elaboration of the design model. The multiple regression analysis will be used in the Dutch context for evaluating the results of the HRA-model, on the output level, and controlling the amount of user activities at the input level. However, the core will be formed by designer rules.

At the same time the demand for expanding this design model in a model for feasibility is increasing. Controlling density, ratio between residential and office floor space, zoning, as well as sustainable aspects (energy consumption, environmental load, pollution) will be incorporated into a model as ingredients for the determination of the land price on a building level, in combination with the costs for the land owner for the minimum price level. This relation between public demands and externalities will be explored in a case study. A high rise office designed as a sustainable tall building will be compared with a similar volume in a low-rise design. The research question will be the sustainability of high rise including the use of land. The result should clarify if such an approach will raise sufficient arguments in order to consider compensation of the building costs. An additional question raised by this approach is if sustainability is a sufficient driver for willingness to pay, requiring market research.

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TENDERING FOR PERSONAL COMPETENCIES – A WAY OF IMPROVEMENT?

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Abstract: It has in Denmark for years been possible to award construction companies for giving the economically most advantageous bid. But in most situations the clients still use the building cost price alone as criterion for selecting business partners. This can be seen as a hindrance for improvement of the building process because of the lack of consideration for long term consequences. This paper aims to show how to use the new possibilities for tendering in order to support an ongoing development of the building process. It becomes clear that the competencies of the people involved are an important factor for project successes. However, even though this knowledge seems obvious for the practitioners, they do not use this when selecting a project team. The discussion is supported by interviews and empirical findings from a case.

Keywords: Building process, Communication, Learning, Personal competencies, Tender.

1. INTRODUCTION

In Denmark, as in most other countries, the tendering process in publicly supported projects is based on laws with the aim of ensuring a fair and transparent competition. However, the existing tending process is eagerly discussed in the public debate. The Danish Board of Complaints on Tendering (In Danish: Klagenaevnet for udbud) reports that many cases are going to arbitration because the parties in the tendering process do not know how to handle the process in a proper way (www.klfu.dk checked 23/4-07). At the same time the parties are not satisfied with the process, because the client only assigns by use of the criterion: lowest prices. Unfortunately, the cheapest bidder has often forgotten significant costs in the calculation or is the one delivering the lowest quality. Therefore, in most cases tendering based on the criterion “lowest price” seems to inhibit development of the building industry.

To comply with this critique another tendering process has been introduced in Denmark based on the economically most advantageous bid. (First time in Denmark 1/9-2001 in the “Law of quotation”) In this case the client can define other criteria than the initial price e.g. quality and management of the process. However, the criteria are not easy to define and evaluate, and often the losers of the tendering are felling badly treated, and the parties do not understand the tendering process and the criteria according to which the winning bid has been selected.

The different parties interpret the laws on which the tendering is based differently, and in more and more situations the parties have to solve their disagreements in compulsory arbitration. The Danish Benchmark Centre for the Danish Construction Section (in Danish: Byggeriets Evalueringscenter), has made inquiries during the last years which show that there is a problem with the existing tendering process. The analysis shows that there may be a conflict between the management in the companies and the project manager. (Byggeriets produktivitet – en analyse fra BEC (14/2 2007)

In the public debate different parties from industry claim, that they acknowledge problems with the present tendering process, and some of them also point to different possible solutions. However, the step from discussion to action seems hard to take. The parties all act as usual and expect others to develop and try out new tendering processes. In this way they can wait until new methods have proven positive effects. Because everybody awaits the situation, and no fundamental, breaking ideas and methods in the area seem to be developed and effectuated.

This reaction is understandable, but it is not rational taken into use in the long run. Someone has to take the first step, but the problem is who and with which proposal, it is best to start?

In this paper focus will be on both the direction and the methods to choose for new tendering process that will support development of the building process. This will be supported by empirical findings and experience from other industries, (Møller and Bejder 2004, and Wandahl and Bejder 2007), on how to set a successful team. The objective is to initiate a qualified debate which could lead to real changes instead of the primary discussion of "someone ought to do something".

2. METHODS

This paper is based on initial work on the subject of tendering based on a case study and on interviews.

The case study was part of an ongoing Ph.D.-study concerning learning and development in the building industry[1]. The case was selected because the client had initiated a number of projects with the objective to support learning and development of the building process. The case study was monitored for more than three years with the aim of understanding the mechanisms of learning at the building site (Ebbesen et al., 2006). As a part of the case study, an extensive amount of formal and informal interviews were conducted with several representatives from the clients' organisation, from the project manager and from the skilled workers at the construction site. Furthermore, observations, participating observations and action research were carried out in order to understand and support learning activities at the site (Kristiansen and Krogstrup, 1999).

The interviews were conducted as a pilot study in connection with a Ph.D.-project concerning the tender process and the selection of the project team[2]. The respondents

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[1] PhD.-Project: Learning Processes in the Danish Building Sector, Randi Muff Ebbesen. www.leanconstruction.dk/innovation

[2] Ongoing PhD.-Project: Udvælgelses- og tildelingskriterier i byggesektoren, (Selection- and assignment criteria in the Danish building sector), Lene Faber Ussing.

were chosen to represent a broad range of roles in the building industry: the professional client (3 numbers of interviews), the architect (4), the engineer (4), and the contractor (4). 15 interviews were conducted covering both management and practitioners. The interviewed persons were all chosen as mid-level manager to get the most honest answers. The interviews were semi structured allowing the respondents to reflect on the questions and elaborate on their answers (Bogdan and Taylor, 1975). The main questions in the interviews were: How is the project team set under normal circumstances? What is the ideal way of setting a project team?

3. FOCUS ON LEARNING AND COOPERATION

In this section the case will be presented with the aim of showing how a client made a decision and took the first step to do something new with the objective of improving the building process.

The client chose a team assigned on the basis of an architect project. The aim was to initiate a strategic partnering relationship (Bennet and Jayes, 1998) with the involved companies, starting with two projects without setting the second project to tender. By using the same team, the client believed both that the team members would invest in the cooperation among the different parties and the development of the building process, and that the experience gained in connection with the first project could be reused in the subsequent project. The overall objective was to increase the effectiveness and efficiency so the client would get a better quality at a lower price, and so the team members would benefit from the projects.

The client took several initiatives in order to improve the cooperation and learning among the team members, such as the Last Planner System of Production Control (LPS) (Ballard, 2000) and such as focus on social arrangements with participation of all the involved parties. The project was also a part of a national initiative, BygSoL (Danish abbreviation for Leaning and Cooperation in the Building Industry, (Ebbesen and Olsen, 2006)). All of the above mentioned initiatives were introduced by the client because he believes in learning and cooperation as a way to improve the building process. By using the same team, the client believed that the initiatives would be a good investment and furthermore the client considered that the project would provide the building industry with some valuable experience.

At the beginning of the second project the expectations to the project were high among the skilled workers because of the development initiatives. They had heard some about the planning system in connection with the first project, and were looking forward to reliable planning and fruitful cooperation. They expected the site to be a nice and secure place to work and that all the trades would benefit.

The project manager did not show the same enthusiasm at the beginning and after a few months, he felt that he was not needed at the site as much as normally, so he stayed at his office much of the time. He also did not perceive the new planning methods as special. He planned in almost the same way as he always did and he did not feel any demands for special competencies compared to traditional planning methods. Partly because of this attitude the skilled workers began to feel that their expectations were not met. They experienced several severe misunderstandings or faults in the material logistics; misunderstandings when it came to supply of equipment; and frustrations because of differences in ambitions to the use of the new planning system. They felt that the planning went as normal with the traditional lack in communication. So instead of being enthusiastic about the new initiatives, the skilled workers became more and more frustrated, because the building process did not meet their expectations. The project manager saw this frustration as normal, and did not take any action to prevent this.

Therefore, despite the many different initiatives, the expectations about an effect of keeping the same team were not met. The workers were frustrated about the lack of improvement in the building process seen from their point of view and nobody seemed to build on former experience, such as expected by the client. Several reasons caused this. The client points to the fact that a) due to unforeseen problems from the authorities it was not possible to keep the same key persons in the project team over time; b) the competencies of the project manager have not met the client's expectations. Whereas the client until then had been focused on the competencies of the companies, the personal competencies of the key-persons were now recognised as being highly important. The next time such initiatives will be implemented, the client will require more control of which people the different companies involve in the process, and the client expects to be included if a key-person, mainly the project manager, has to be replaced.

The case showed a client with a belief, who took the first step and tried it out. The client believed that cooperation and learning were key issues in making a team work and develops over a period. However, the client chose his team according to traditional parameters such as price and technical competencies in the companies. The outcome was not as expected. It showed that the personal competencies meant a lot to the outcome of the project – perhaps even more than the initiatives taken to support learning and development in the building process. Under all circumstances the personal competencies of the involved persons were more important to the development of the process than the architect project used for assignment. The client learned that personal competencies were very important, but the client did not get any idea of how to use this knowledge in a future tender process. Therefore, it is believed that there would be no actual change in subsequent projects.

4. IN THE IDEAL WORLD I WOULD WORK WITH MY FRIENDS

To find out what the ideal way of selecting a project team could be for the parties in a building process, interviews were conducted with representatives from the building industry. The main conclusion was that if the project team does not work, the project will most likely fail. Moreover, if the respondents could choose freely they would prefer to work with people and companies, whom they know and with whom they had good experiences on earlier projects. It seems that key-persons are more important to project success than how the work is done and by which means (Jørgensen et al., 2007).

The respondents also found, that a way to obtain a good building process would be to choose people with focus on personalities in order to make the team work. In that way there is a chance to create a building project, where the team members can talk and understand each other. There is also a chance that they will have less conflicts and instead will help each other bring about a win-win situation.

When going through the interviews it looks like an easy thing to do as the respondents suggest: choose the people you know and like. But when you ask about suggestions how to choose employees on a site according to personality, there are no suggestions. The tendering has to be transparent (and when it comes to publicly financed projects they follow the law based standards) in order to be accepted by the parties. The use of personalities as criterion is very difficult to make explicit, both because of the subjective nature of the criterion and because there is no tradition for its use.

From the above it can be stated that the building sector has to do something in order to make a better and more transparent tendering process which does not inhibit development in the building process.

5. PERSONAL COMPETENCIES ARE IMPORTANT

The empirical findings indicate that personal competencies and personal relations are perceived as highly influential on the success of building projects. The case pointed to the project manager as a key person in achieving the objective set by the client. The Danish Benchmark Centre for the Danish Construction Section has just published a big research study about the efficiency in the Danish building and construction sector. The report documents among others that the project manager is very important and that management on the sites in these projects is not good enough. (Byggeriets produktivitet – en analyse fra BEC(14/2-07)). There are project managers at many levels; every involved company has its own project manager on the project.

In the case the client did not articulate any demands on the competencies of the project manager before choosing the team. As the project manager did not fulfil the implicit competencies expected by the client, the client learned to be more aware of this in future projects. Nonetheless, the client has not articulated how this will affect his future tendering processes.

The interviews showed that the representatives for the different parties in the building process all pointed to the traditional competitive tender process as a hindrance for improvement of the building process. If they could decide how to choose a project team, they would prefer to use their experience and knowledge of the potential participants' personal competencies instead of traditional tendering. But again, the respondents' answers were built on intuitive feelings of how to choose the best team, and they do not seem capable of explicitly articulating on what criterion they would base the "ideal tendering process".

There are many reasons for problems with explicitly articulating causes among other things the competitive tradition in the industry seem to block alternative use of tendering. Furthermore, personal competencies is a fuzzy concept and very difficult to measure objectively. Expressed needs on soft personal competencies such as empathy can be understood in several ways and personal competencies also alter over time. Because of these obstacles the parties of the building industry have seldom set out specific wishes for an alternative way to set the project team.

However, it is necessary to articulate the wishes for an alternative selection of team members in order to move in the direction of relying on more personal competencies and less on lowest prices. Firstly, criteria for the selection have to be explicit in order to make a competition legal (www.klfu.dk checked 23/4-07) and to avoid arbitration because of unclear awarding. Secondly, explicit criteria are necessary to allow the loosing team to improve, and thereby to ensure a healthy development of the bidding teams.

Other experience and literature also emphasise the importance of personal relations (Ng et al., 2002), and personal competencies (Doyle, 2006) in building projects. (Interview with SAM karrierecenter 23/4-07). Furthermore, continuity of the core personal is perceived as important allow to the relationship between client and contractor to be reinforced at an individual level (Bresnen and Marshall, 2002).

The above-mentioned findings showed that particularly the personal competencies of the project manager are important for the project success. Surprisingly, the literature on project success factors does not specifically mention competencies of the project manager as an important factor, which is in contrast to general management literature (Turner and Müller, 2005). Though, Turner and Müller strongly questions that this lack in the literature is due to the fact, that the project manager does not have impact on the project success. Instead they stress that there has not been much research with in the area.

In summary, both the practitioners and the general management literature point to the (project) manager as a key person for success, and both the practitioner and the literature point to the personal soft competencies of the project manager as highly influential.

6. ALTERNATIVE PROCEDURES FOR SELECTING THE PROJECT MANAGERS

As stated above, personal competencies are very important for the success of building projects. So, for what can this information be used? In this section we turn to the case again to see, what the client might have done instead of focusing on the architect competition in order to support learning and development of the building process. It is not the objective to give *the final* answer just now. Instead we hope to inspire to more in-depth research and perhaps even develop new tender processes. Furthermore, the ongoing PhD.-project investigates alternative tender processes.

First of all, the focus should not merely be on building cost, up keep cost, the product or the concept – but it should also include the process and the people involved. In the following we will focus on how to make an explicit evaluation of the bidding team – and especially on the project manager. Today, the client has no restriction on what personnel the winning companies assign to the task, even though the client would be working very closely with the project team – at least in the design phase. So in order to have some control of the composition of the project team, he should state some guidelines for the bidding companies in the invitation to tender and the final contract. He could e.g. demand CV's from the people expected to participate in the project and make a clause on how the companies can replace the assigned personnel, for instance he can demand specific personal skills.

By doing this, the client from the case could have avoided a situation where the project manager from the first project was replaced on the second project, without the client knowing it. Circumstances can of cause occur that make a substitution of a person necessary, however the team and the client can by making a clause ensure that they are involved in the process of finding a substitute with similar skills.

In order to make explicit evaluation of the bidders, the client could use a selection committee which on behalf of the criteria from the client should choose the best fitted person for the job. These criteria could also include criteria for personal competencies of the persons to be involved in the project. This, however, demands a firm preliminary work by the client in order to make the demands to the competencies of the team explicit, in order for the client to trust the decision of the committee.

E.g. in the case described earlier, the client had an ambition to support learning and development. In order to reach this, the project manager had to understand the ambitions of the client and also contribute to reaching the objective. The client's ambitions also outlined demands for the competencies of the project manager. He is the one most important person who should carry out the ambition in practice. He should implement the new planning methods; he should support the skilled workers and help evaluating the final result. So the client or the committee should ensure that the project manager has the skills, or determine what support the manager would need to carry through this job task.

In order to make the selection explicit, the committee could use different assessment methods, e.g. various tests that could assess the project manager either as an individual or as part of a team.

One of many tests to support the selection of the project manager could be use of the Meyers-Briggs Type Indicator (MBTI) ®. The MBTI has been evolved since 1943, and is not really a test but a physiological instrument to see and understand different types of people. The test mainly gives an indication of an individual's thinking style and temperament in a team (Turner and Müller, 2005), and it is frequently used to test people's personal competencies against different types of jobs. Another way could be by measuring both the bidding and the client teams' soft competencies for the award of major contracts (Doyle, 2006). With this method the consultants measure and visualise the fit of the two teams.

7. CONCLUSION

The traditional tender process has been criticised for solely focusing on lowest prices. According to the criticism this inhibits development of the building process. When the practitioners are asked about this they agree, and they state that the personal competencies as e.g. ability to co-operation, to general view, not getting stressed and to be patient in the project team are overseen factors that correlate very much with the success of the project.

The case also pointed to the fact, that when focusing on development of the building processes it is necessary to be aware of the competencies of key persons in the project team, and in this case particularly the project manager.

Other industries have in many years incorporated the competencies of people to be involved, when selecting their partners. It could be interesting to investigate these experiences and try out some of the tools used for decades in the building industry. (Wandahl and Bejder 2007).

However, this is not an easy task. The tradition in the building sector is to focus mainly on competition; therefore the alternative tendering has to be explicit and perceived as fair in order to succeed. A way to go further can be a project in which focus is on new ways co-operation and selecting parts in a building team. Some projects in that direction are the two above-mentioned ongoing PhD.-projects.

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ASSESSING THE RELATIONSHIP BETWEEN PROCUREMENT SYSTEMS AND WASTE GENERATION IN CONSTRUCTION

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Abstract: The construction industry has a major impact on the environment, both in terms of resource consumption and raising waste production. The current research in the field of construction waste management and minimisation focuses mainly on onsite waste quantification and management; and stakeholders' source identification. Although recent studies argue that a significant amount of construction waste originates throughout different stages of the construction procurement process, very few attempts have been made to examine the influence of procurement on construction waste generation. Hence, this research, part of a doctoral study, has been undertaken to explore the relationship between different construction procurement systems and construction waste generation. The paper covers: construction waste source evaluation; current procurement practices in the UK construction industry; and the relationship between waste and procurement systems. The conclusions capture knowledge on the relationship between procurement systems and construction waste generation; and pave the way for the development of a construction waste minimisation framework for procurement methods.

Keywords: construction procurement, UK, waste generation, waste minimisation.

1. INTRODUCTION

Construction and demolition activities generate a considerable amount of waste. Recent figures published by the UK Government reveal that construction and demolition activities produce 109 million tonnes of waste every year (DEFRA, 2007a). Furthermore, construction waste accounts for more than 50% of all landfill waste in the UK (Fergunson *et al.*, 1995). As such, the newly published waste strategy for England 2007 (DEFRA, 2007b) has identified the construction industry is a major source of waste in England. There is a consensus in the literature that reduction is the best and most efficient method for minimising the generation of waste and eliminating many of waste disposal problems (Formoso *et al.*, 2002; Esin and Cosgun, 2007; Osmani *et al.*, 2007).

The current and ongoing research in the field of construction waste management and minimisation focuses mainly on onsite waste quantification and source evaluation (Ekanayake and Ofori, 2000; Bossink and Brouwers, 1996; McDonald and Smithers, 1998). Several studies have focussed on waste minimisation from various angles such as implementing waste management plans during construction phase (McDonald and Smithers, 1998), waste minimisation through design (Keys *et al.*, 2000; Osmani *et al.*, 2007), waste source evaluation (Ekanayake and Ofori, 2000; Bossink and Brouwers, 1996) and onsite waste auditing and assessment (Chen *et al.*, 2002). However, findings reveal that construction waste is accepted as a by-product of the construction process, including procurement. Only a few studies point out that procurement system could have an influence on waste generation, but some argue that a significant amount of construction waste originates throughout different stages of the construction procurement process (McDonald and Smithers, 1998; Ekanayake and Ofori, 2000; Jaques, 1998), very few attempts have been made to examine the influence of procurement on construction waste generation. Hence, this research, part of a doctoral study, has been undertaken to explore the relationship between different construction procurement systems and construction waste generation. It reviews adopted definitions; examines construction waste origins; and, explores the relationship between waste and procurement systems in construction.

2. DEFINITIONS

2.1 Construction Waste

Various interpretations and definitions of waste can be found in the construction waste related literature. The definition of waste by the European Council Directive 91/156/EEC is "any substance or object which the holder discards or intends or is required to discard"(Directive 91/156/EEC [2], Article 1, Letter a). This definition applies to all waste irrespective of whether or not it is destined for disposal or recovery operations (Osmani *et al*., 2005). However, Ekanayake and Ofori (2000) defined construction waste as "any material, apart from earth materials, which needs to be transported elsewhere from the construction site or used within the construction site itself for the purpose of land filling, incineration, recycling, reusing or composting, other than the intended specific purpose of the project due to material damage, excess, non-use, or non compliance with the specifications or being a by-product of the construction process." The adopted definition of construction waste for this research is a material which need to be transported elsewhere from purpose of project due to damage, excess, or non use or which cannot be used specific due to non compliance with the specifications, or which is a by product of the construction process (Skoyles and Skoyles, 1987).

2.2 Construction Procurement

CIB W92 (1997) [cited in Masterman, 2002] defined a procurement process as "a strategy to satisfy clients development and/or operational needs with respect to the provision of constructed facilities for a discrete life cycle." This sought to emphasise that the procurement strategy must cover the whole lifespan of the project. However, the strategy, which is most appropriate method of procuring the project, is known as a procurement system (Masterman, 2002). Thus the term procurement system is defined as "the organisation structure adopted by the client for the management of the design and construction of a building project" (Masterman, 1992), and "the organisational structure adopted by the client for the implementation, and at times eventual operation, of a project" (Masterman, 2002). Similarly, Love *et al.* (1998) defined procurement system as "An organisational structure that arranges specific responsibilities and authorities to participants and defined the relationship of the various elements in the construction projects", which expresses key attributes of the system and will be taken on for the purpose of this study.

2.3 Procurement Method or Contract Strategy?

The belief that a procurement system is defined by a simple contract strategy is misleading (Rowlinson and McDermott, 1999). However, Rowlinson and McDermott (1999) suggest a contract strategy is a key component of a procurement system and should be considered within the whole procurement system, encompassing the political, social and economic factors, which impinge upon any project. Further, they highlighted the acquisition of resources such as consultants, contractors, sub contractors, suppliers and client's own resources are essential in order to realisation of construction project. Acquisition of resources or the process of combining necessary resources together is part of the procurement system and this could be termed as contract strategy. In order to clearly and adequately define contract strategy, the following variables should be considered: organisational form, payment method, overlap of project phases, selection process, source of project finance, contract documents, leadership and authority and responsibility (Rowlinson and McDermott, 1999).

3. CONSTRUCTION WASTE SOURCE EVALUATION AND MINIMISATION

3.1 Waste Origins and Causes

Gavilan and Bernold (1994) identified waste sources in construction as design, procurement, material handling, operation, residual and other. Bossink and Brouwers (1996) adopted a similar approach to extend the list of sources and respective causes. For the latter, it is important to note that 'procurement' represents 'material procurement' and not a 'contract strategy'. Similarly Pinto (1989), Soibelman *et al.* (1994), and Pinto and Agopayan (1994) [cited in Bossink and Brouwers,1996] related construction waste to material types such as steel, cement, concrete, sand, mortar, ceramic block, brick, timber, hydrated lime, wall ceramic lime, wall ceramic tile and floor ceramic tiles.

On the other hand, Keys *et al.* (2000) classified waste origins under the headings of manufacture, procurement, supplier, designer, logistics, client, contractor and site management. However, Ekanayake and Ofori (2000) categorised construction waste causes under four main categories as design, operational, material handling and procurement (material), whereas Osmani *et al.* (2007) adopted a life cycle approach to construction waste origins from inception to completion. These sources demonstrate that waste origins are attached to different elements of a procurement system such as: design related origins to design element, contractual origins attach to the contact strategy, procurement, transportation, on site management and planning, material handling and storage, and site operations attached to construction.

3.2 Waste Minimisation in Construction

There are two principal ways in which construction waste could be minimised: through source reduction techniques both on site and during the design and procurement phases of a building project, and through improvement of onsite waste management strategies (McDonald and Smithers, 1998). Economic, social and political pressures are likely to continue to drive up the costs of waste disposal over the next few years, which will increase importance of waste minimisation strategies in the UK (Turner and Powell, 1991). Indeed, the increase in the Landfill Tax in the UK from £24 a tonne in 2007 to £32 a tonne in 2008, will act an economic incentive to reduce waste at source and increase the recycling of construction waste. Osmani *et al*. (2006) went further to categorise construction waste minimisation drivers as: environmental, economic, industry concerns, and government policies, and regulations. Thus, it is apparent that there is an emerging requirement for waste minimisation in construction. However, literature revealed that many studies attempt to cater for this emerging need in different ways. In 2007, Osmani *et al*. revealed the current and ongoing research in the field of construction waste management and minimisation in eleven clusters (such as Construction waste quantification and source evaluation and On-site construction waste sorting methods and techniques) and so broadened waste minimisation research studies by exploring waste minimisation through design.

However, there appears to be little research related to assessing the impact of procurement systems on construction waste generation/minimisation. An attempt to explore the relationship between waste generation and procurement systems in construction is discussed in the next section.

4. RELATIONSHIP BETWEEN WASTE AND PROCUREMENT SYSTEMS IN CONSTRUCTION

4.1 Procurement Systems and Trends in the UK Construction Industry

Procurement systems have different organisational structures and arrangements that can affect not only the design and construction stages of a project but also cultural, managerial, environmental and political issues (Masterman, 2002). Sharif and Morledge (1994) [cited in Rowlinson and McDermott, 1999] who have drawn attention to the inadequacy of the common classification criteria for procurement systems in enabling useful global comparisons. In a review of procurement and contractual agreements in the UK, Latham (1994:5) [cited in Rowlinson and McDermott, 1999] noted the difficulty of drawing conclusions from existing studies, and stated that ‘‘some international comparisons reflect differences of culture or of legislative structures which cannot easily be transplanted to the UK.” Furthermore, Masterman (2002) reported that it is difficult to quantify accurately the past or present level of use of all, or any of available procurement systems, due to lack of truly comparative figures for the individual methods over a set period of time from a sufficiently wide range of reliable sources. However, he mentioned that the RICS (Royal Institution of Charted Surveyors) surveys come nearest to achieving accurate and truly comparative figures as a reliable source. Masterman (2002) adopted a four fold categorisation of procurement methods in the UK: 'Separated' (the conventional system), 'Integrated' (Design and Build, variants of Design and Build), 'Management Oriented' (Management Contracting, Construction Management, Design and Manage) and 'Discretionary' (British Property Federation system, Partnering). This categorisation was based on the way in which the interaction between the design and construction, and sometimes the funding and operation, of the project is managed.

4.2 Assessing the Relationship between Waste and Procurement Systems in Construction

There is a small but growing body of literature that attempted to explore the affect of procurement methods on construction waste generation and minimisation. As such, McDonald and Smithers (1998) emphasised the need of minimising the amount of waste generated during the design and procurement phase of a building contract and suggested that the future work should involve assessing the ways in which differing procurement methods affect the generation of waste on site as a result of the different interrelationships involved in alternative procurement processes. Additionally, Ekanayaka and Ofori (2000,5) stated it is necessary to 'promote appropriate clients procurement systems' where contractors' experience in methods and sequence of construction can help in the decision-making process during the design stage to avoid unnecessary extra work during construction which cause time delay and material wastage. Begum *et al.* (2007) argued that waste minimisation should be integrated into the construction process, and planned at the design and tender stages.

Jaques (2000) enquired, whether alternative methods of procurement offer improved opportunities for waste minimisation strategies to be adopted. In response 20% of architects and 15% quantity surveyors thought that alternative procurement methods would improve waste strategies. However, 43% of architects and 50% of quantity surveyors were agreeing that is sometimes true. Further, quantity surveyors stated 'there has to be a cost incentive to reduce waste. The only incentive at the present - the more waste the less margin on all procurement methods other than cost reimbursable contracts. The more competitive the procurement method the least margin, therefore minimal waste/more profit. Fixed sum procurement strategy is generally the more competitive method for this purpose'. The same study concluded that alternative procurement routes did not have any significant advantages over the traditional route in terms of waste minimisation. However, the fixed sum form of procurement was suggested as an alternative method of procurement to offer improved opportunities for waste management strategies. This is contrary to a study carried out by McDonald and Smithers (1996), where respondents thought that fixed sum offered few opportunities in terms of waste minimisation and there was no clear relationship between different procurement methods and waste minimisation. In summary, the literature presents no clear evaluation of the impact of procurement methods on construction waste generation.

4.3 Relationship between Waste Generation and Procurement Systems

Separated systems or more common term conventional methods of procurement have been criticised for their sequential approach to project delivery, as they have contributed to the so called 'procurement gap' where by design and construction process are separated from one another (Love *et al.,* 1998). This leads to a lengthy design and construction process, poor communication, undermined relationships and finally resulted in problems of buildability. Ngowi (1998) reported a number of apparent problems related to traditional procurement system such as: difficulties in phasing and sequencing of functions; lack of coordination between participants and trades; adversarial contract conditions; and unsatisfactory competitive tendering. Hence, the method does not sufficiently make use of the contribution that organisational and individual team members' knowledge can make to a project's design, waste and under utilisation of resources are inherent within the different stages of design and construction. Additionally, tenders are obtained on the basis of an incomplete design and facilitate to respond to late demands for changes, known as variations, which result in rework leading to inevitable waste production (Masterman, 2002). However, when a design is fully developed and uncertainties eliminated before tenders are invited, tendering costs are minimised and proper competition is ensured. This allows contractors to provide competitive bid value (by eliminating unnecessary costs) and can be a preset driver for minimising the costs associated with waste production.

In an integrated procurement system, design and construction responsibility lies with contractor, hence this could result a buildable design (since contractor's experience absorbed to the design) and improved constructability. The absence of a bill of quantities makes the valuation of variations extremely difficult and restricts the freedom of clients to make changes to the design of the project during the post contract period (Masterman, 2002). However, Keys *et al.* (2000) reported that overlapping of design and construction complicates the management of the design process and moves waste minimisation to the bottom of the priority list.

A 'management oriented' system is carried out by an organisation working with the designer and other consultants to produce the design and manage the physical operations that are carried out by workers, or packages, contractors (Masterman, 2002). As result of employing separate management organisation early start and shorter duration by acceleration of the project is possible. Early stage advice ,obtained from the contractor to improve design, buildability, programming and materials and material availability together with general construction expertise (Masterman, 2002), provides an effective opportunity to minimise waste generation. The system offers a good opportunity to adopt value management in the early stages and employ specialised trade contractors in the latter stages of the project providing an incentive to minimise waste. Involvement of the client is highly encouraged by the 'Management Oriented' system, however, this could result in both positive (able to force construction team to adopt waste minimisation strategy) and negative (last minute decisions and changes) impacts on waste generation.

Discretionary is an administrative and cultural framework in which any procurement system (s) can be incorporated, thus allowing the client to carry out the project by imposing a very specific management style or company culture, while at enabling the use of the most suitable procurement methods (Masterman, 2002). The RICS survey (2004) reported that 'Partnering', which is an innovative, multi-party, two-stage contract where client, consultants, contractors, and specialists sign it at an early stage and then work towards an agreed maximum price and a commencement of agreement, has been identified as the emerging arrangement in recent years, Literature indicates that the use of 'Partnering' arrangement enhances the communication between parties, efficient working, greater productivity, allowed innovative thinking, research and development, shorten construction period and quality of final product. Effective utilisation of personal resources is key feature of Partnering, which enhances flexibility and responsiveness in terms of added skills and resources available from other parties (Bower, 2003) providing good incentive to minimise waste. Furthermore Partnering allows contractor's involvement with design team in early stage and continue relationship for future projects developments as well, so that it optimise design team time, enhances buildable design, improved opportunities for adaptation of new methods leading to waste minimisation strategies. Bower (2003) stated that manufactures and suppliers stand to gain through partnering include approval of their product recommendation, a voice in the design intent, involvement in the coordination with other projects trades and the possibly of report business. Thus, this could prevent many waste causes related to material procurement, handling and onsite waste origins.

Literature reveals common waste driving variables of procurement systems. Further, each procurement systems could have different relation to those waste driving variables due to unique characters of those systems. Similarly, procurement systems with different relationship with waste driving variables influence on waste origins and respective causes in different capacities. This results a varying amount of waste generation in construction according to the use of different procurement systems. In conclusions, the common waste driving variables of procurement systems in construction are:

- Arrangement of organisation structure (organisational form)
- Management (including leadership, authority and responsibility)
- Communication
- Process duration
- Relationships between parties
- Client involvement
- Tendering process
- Payment method
- Innovative thinking opportunities (i.e. value management , advanced construction technologies)
- Contract type and documents

Identification of waste origins and causes with respect to different phases of procurement process is vital in terms of waste minimisation. The use of different procurement systems may affect only certain phases in the procurement process. For instance, Osmani *et al.* (2007), through a survey with architects, investigated design waste generation and found that the majority of responding architects believed that waste is predominantly produced during onsite activities and rarely generated during design stages.

5. CONCLUSIONS

This paper has given an account of and the reasons for the need of assessing the relationship of construction waste and procurement systems in construction by considering past literature, waste origins and waste minimisation. One of the most significant findings emerge from this study is that very limited number of studies were conducted within the area of procurement systems and construction waste. Additionally, literature emphasised the need of research in this field. Further, the paper attempted to identify the possible waste generation drivers from different procurement systems and relationship between different procurement systems and waste origins. Hence, very few attempts have been made to examine the influence of procurement on construction waste generation. As a result, the forthcoming research will set out to develop a construction waste minimisation framework for procurement methods. The next stages of this study will focus on identifying waste production driving variables by generating procurement systems versus waste production scenarios; attempts will be made to identify the common waste driving variables of procurement systems in practice other than the theory, to identify the extent of influence of waste-driving variables specific to the different procurement systems, to assess the extent of impact of waste driving variable of procurement systems towards waste origins and waste causes and identify relevant waste causes and origins in to respective phases of different procurement systems.

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IDENTIFYING THE SUCCESSFUL INNOVATION AND ADVANCED BUSINESS PRACTISES IN THE CONSTRUCTION INDUSTRY

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Abstract: The construction industry has been characterised as slow to adopt technological innovation and advanced business practices, which has contributed to low productivity and poor performance. A survey was undertaken to identify successful innovation and research practices within the construction industry. Innovation activities and levels were measured based on technological and advanced business practices. The results of the survey showed that innovation in UK construction is comparable to the UK as a whole, with around two thirds of construction companies in the UK being 'innovation-active'. The main constraint on innovation was found to be there being insufficient benefit from innovating, followed by the cost of an initiative and the presence of conservative stakeholders. This paper concludes with recommendations regarding the development of innovative strategies and best practice guidelines to enhance the competitiveness of the construction industry as a whole.

Keywords: Business, Construction industry, Innovation, Research and development, Technology,

1. INTRODUCTION

Through the Latham (1994) and the Egan reports (1998), the UK Government has supported major reviews of the way in which UK Construction performs and some ambitious targets were set for performance improvement. R&D in construction has a relatively low profile compared to other industries like aerospace, automotive and pharmaceutical industries (Winch, 2003). The amount of investment funding available for construction research has been declining steadily in recent years. Since the publication of the Egan report ‘Rethinking Construction’(1998), it has been accepted that for future growth within the construction industry to be sustainable it will become increasingly reliant on its R&D capabilities and it is very important that a better mechanism be developed for defining the industry’s long term R&D investment needs (Fairclough, 2002). The UK innovation survey in 2005 show that 62% of companies in the UK were innovation active (Robson and Ortmans, 2006)

This study investigated innovation activity, business practices and strategy in the UK construction companies. What constitutes innovation, types of innovation whether technologies or advanced business practices, factors that drives or stops innovation within the construction industry. The study reviewed the successful innovation models, best practice and lessons learned within the construction industry.

1.1 Overview of Innovation

The UK Government, via the Department and Trade and Industry states that 'innovation as a successful exploitation of new ideas' (DTI, 2003). It is widely accepted in policy, business and academic circles that innovation is the main source of economic improvement for industries (OECD, 2000). Indeed, experience in OECD countries also clearly shows that innovation has a positive impact on profitability at the firm level (Guellec and Pattinson, 2001)

Many research projects have attempted to characterise technological innovation and explain how it works. For example, by categorising innovations via type e.g. incremental, radical or system innovations or process e.g. whether the innovation is radical or incremental, is continuous or discontinuous, is sustaining or disruptive. This has produced an array of many competing models, varying in their integrity and applicability (Gesey et al, 2005). Developing the basic definition described above, Slaughter (1998) characterised innovation according to whether it is incremental, architectural, modular, system or radical.

2. RESEARCH METHODOLOGY

This survey is a part of an ongoing research project for which aim is to explore ways of promoting a culture of innovation and research within the construction industry. The findings of this survey will be used as one of the sources to developing strategies and best practice guidelines to enhance the industry's competitiveness through the implementation of technological innovation and advanced business practices.

The specific objectives of the project include to:

- investigate the drivers, enablers and barriers to the development of a culture of innovation
- review theoretical and industrial models of innovation and research in the construction industry
- explore methods for assessing innovation capabilities and develop a prototype ' Self-Assessment Tool' for construction companies.
- evaluate the usability of the self-assessment tool

A review of recent literature was used to develop an initial set of hypothesis and six page questionnaire to test them against. The hypothesis in this research is that UK Construction cannot deliver these improvements without an effective innovation and research (IR) culture.

The survey was distributed by post, to a random of 98 construction companies encompassing various construction disciplines. A pilot study for the survey questionnaire was conducted to ensure that the questions were appropriate and made sense to the target group. It covered innovation rates, types, e.g. whether its technology or advanced business practices, drivers, strategies etc. It was refined through a number of prominent academics and industry professionals on the design and content of the survey.

The pilot study improved the clarity and structure of the survey questions. The survey was then sent to people with job roles such as business development manager or those with responsibility for innovation, research and technology within their companies. To improve the response rate, companies that had not responded received written reminders with additional copies of the questionnaire.

From the 98 participants a total of 25 usable, but detailed responses were received. This can be considered reasonable for a voluntary postal survey. Saunders et al (2000) suggested that response rates for postal surveys can be as low as 15 - 20% and Ruikar et al, (2002) carried out a similar survey in the construction industry and the response rate achieved was 22%. Akintoye and Fitzgerald (2000) confirmed that the construction industry response norm is 20 – 30%. It is possible that the low response rate can be explained by the fact that responsibility for innovation within construction companies is not necessarily clearly delineated. The findings presented in this paper are based on an overall response rate of 25.5%.

3. RESULTS AND ANALYSIS

This section examines the overall responses to the survey and reports on significant cross-tabulations between survey questions. Of the 25 respondents, almost half 48% were Small to Medium-sized Enterprises (SME)[1]. Creswell (1994) highlights that there is no one right way to analyse data and therefore the method that is most suited to the response data has been chosen, for example the results were analysed statistically.

3.1 Company Size and Activities

This section considers the background information about the survey questionnaire. The company size varied widely, from large to SMEs. Based on the survey results around two thirds of the respondents have in-house resources dedicated to innovation and were innovation active. These figures do indicate similar trends to the UK innovation survey in 2001 (Robson & Ortmans, 2006) in which 62 percent of enterprises in the UK were innovation active.

R&D plays a major role acting as a main driver for innovation (Fairclough, 2002) and when asked what mechanisms they use for investing in R&D, most responded that top slicing of profits and/or R&D tax credits were used for investing in R&D to support innovation. For example, respondents stated that they used the following:

- "Tax credits, to match leverage with partners"
- "A business improvement initiative scheme is linked to our capturing and rewarding innovation scheme, then gives employees the opportunity to get resources secured to implement good ideas."
- "An annual budget set based on planned areas of R&D"
- "Investment in projects through staff time, members time plus limited cash"

[1] To be classed as an SME, an enterprise has to satisfy the criteria for the number of employees (i.e. $10 \leq 50 \leq 250$) and one of the two financial criteria, i.e. either the turnover total or the balance sheet total. http://europa.eu.int/ISPO/ecommerce/sme/definition.html

3.2 Innovation Activities

Tatum (1991) points out that construction companies need to innovate to win projects and to improve the financial results of these projects. Most stakeholders expect innovation to offer benefits in one or more of following areas; capital and operational expenditure, quality, performance, market share, competitiveness, customer service and value etc (Barrett and Sexton, 1998).

When asked what constitutes innovation, there was no common opinion about what constitutes innovation. However, within the literature there has been a noticeable convergence as to its principal characteristics and in the context of this survey this point can be illustrated by a sample of general definitions by the respondents.

- "Innovation covers an organisational ability to encourage/create a climate for innovation and an individual innate ability to innovate. Innovation covers internal business processes & external client offerings"
- "Good Ideas and forward thinking- combined"
- "Identification of new ways of doing business that leads to one or more of customer satisfaction, competitiveness, productivity, profit and efficiency. Innovation should be market driven and add value."
- "Practical implementation of a new idea"
- "Something new of benefit to the industry/society/the firm that adds value"
- "An innovation is a new way of doing something or an application of an old way in a new field that yields greater efficiency and/or effectiveness of process"
- "The introduction of a new approach or technique to improve the service we offer, or new technology that improves the way to do something"
- "Change in process, change in method, more efficient products"
- "Providing new solutions/approaches"

The construction industry needs to innovate more to boost its competitiveness so it can meet the ever increasing client demands of both national and international marketplace (Larsson, 2003).

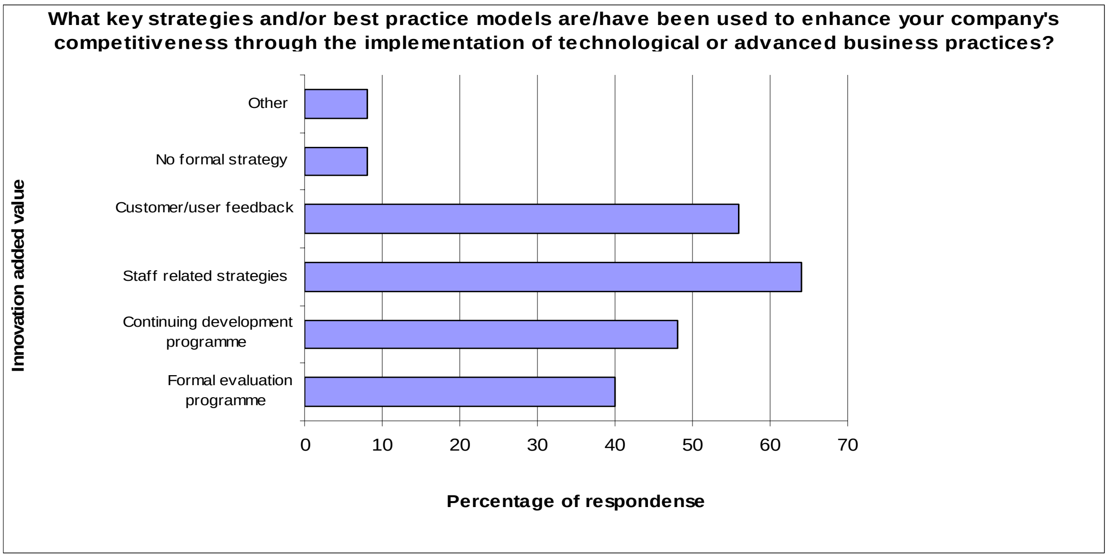

Figure 1: Strategies used to ensure that Innovation adds Value.

Respondents were asked what strategy used to ensure that innovation adds values. Figure 1 plots the percentage of respondents for the key strategies adopted to ensure innovation added maximum value to their business. There were staff related strategies, continuing development programme, customer/user feedback and formal evaluation programme. These again are promising results, as the innovation literature stresses the importance of formal evaluation strategies for innovation success (Barrett et al 2001)

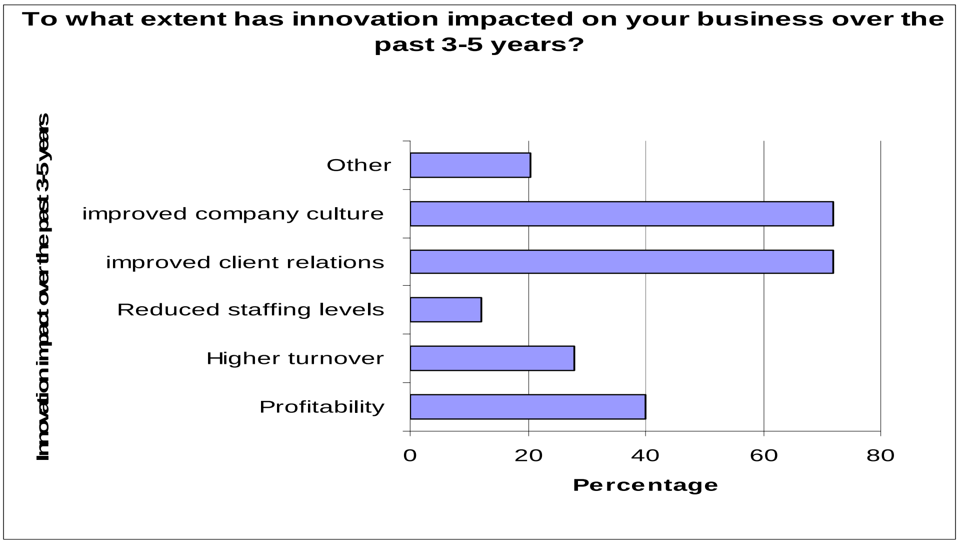

Figure 2. Innovation Impact

Respondents were asked to what extent has innovation impacted on their business over the past 3-5 years Figure 2 plots the percentage of respondents for innovation impact over the past 3-5 years. This indicates that the most important components were improved client and company culture, followed by profitability and higher turnover. It is widely accepted that innovation has a positive impact on profitability at the firm level (Guellec and Pattinson, 2001)

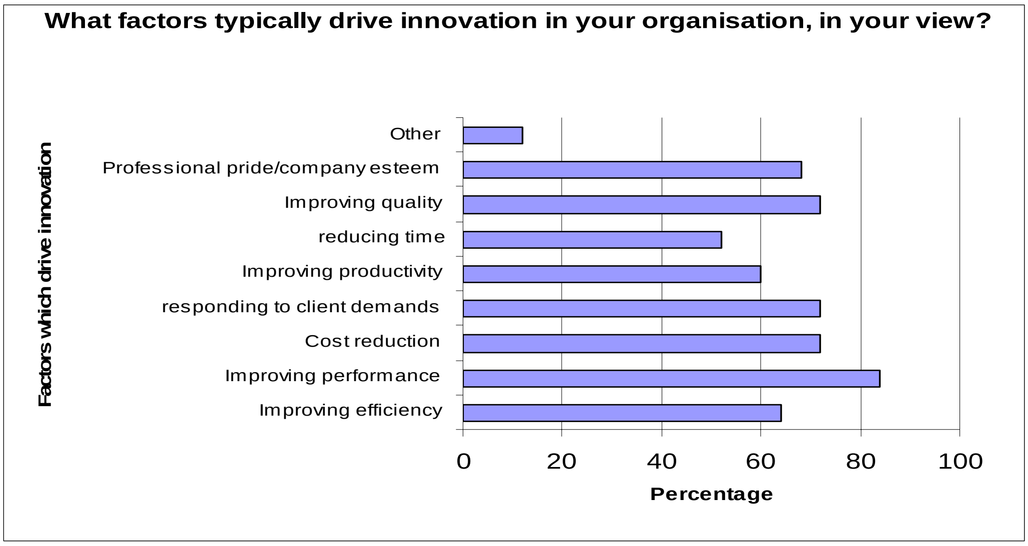

Figure 3: Factors that Drive Innovation

Respondents were asked what factors that drive innovation in their organisation. Figure 3 describes typical factors that drive innovation, namely improving performance, cost reduction, responding to client demands improving efficiency etc. Of the surveyed organisations it can be seen that the main factors that drive innovation was improving performance, nominated by 84% of respondents. Cost reduction, responding to client demands and improving quality were the second most important drivers, each nominated by 72% respondents. This is an important finding, confirming the pivotal role clients can play in promoting innovation along the supply-chain by demanding ever more innovative output (Manley, 2005).

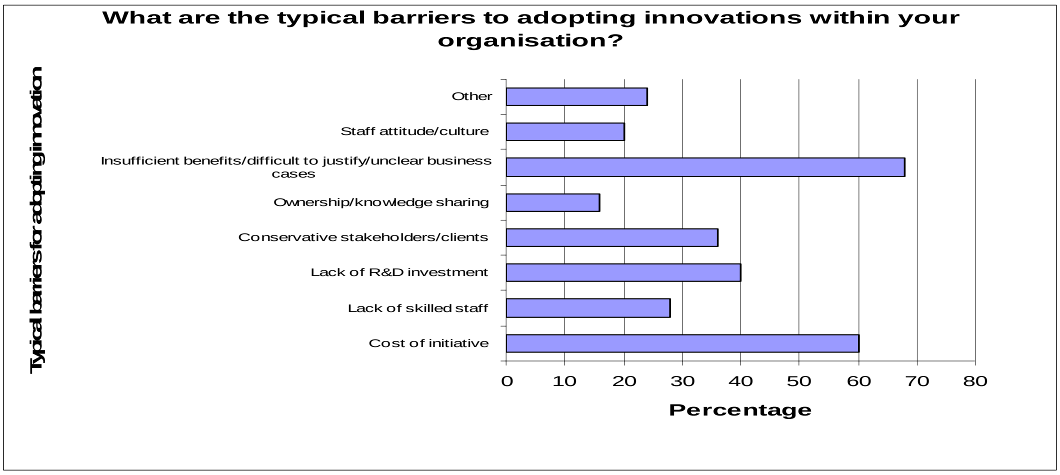

Figure 4: Perceived Barriers to Innovation.

As shown in Figure 4, the most common barrier to adopting innovation was insufficient benefits/difficult to justify/unclear business cases, nominated by 68% of respondents. Cost of initiate, lack of R&D investment, conservative stakeholders/clients were the second most important typical innovation barriers, nominated by 60%, and 40% respondents respectively. These can be obstacles that the construction companies encounters while carrying out innovation activities as well as factors preventing innovation (Stockdale, 2001).

Table 1: Key Sources of Ideas

Respondent	Response rate (%)
In-house staff	92
Professional or trade associations	64
Previous projects	60
Conferences/workshops	60
Internet/intranet/extranet	48
Clients/customers	44
Consultants	40
Technical support providers	36
Research Institutions	36
Journals/magazines	32
Trade contractors	28
Competitors	20
Other	16

Respondents were asked to select the key sources of ideas/information about new technologies or advanced practices they adopted from the table above. 92% of the respondents surveyed indicated the key source of ideas/information about new technologies or advanced practices was in-house staff, followed by professional or trade associations, previous projects and conference/workshops. Regional bodies, government, general contractor and overseas sources attracted the fewest scores. These finding are consistent with other similar innovation survey. Indeed, the BRITE Innovation Survey (2005) also found that In-house are a key of innovation ideas and underlining the importance for companies of maintaining strong internal skills-sets and attracting creative employees.

Table 2: Business Practices

Respondent	Response rate (%)
Written strategic plan	100
Staff training budget	92
Long-term collaboration arrangements with other businesses	92
Computerised project management	76
Computerised asset analysis	40
Written evaluation of new ideas in order to develop options for your business	36

Respondents were asked to nominate which technology and advanced practices they had successfully adopted. The responses were allocated into broad categories of business practices as shown in Table 2. A written strategic plan was the most commonly cited, nominated by 100% of respondents. Long-term collaboration arrangements with other businesses and staff training budgets were the following most important successful adoptions, both nominated by 92% of the respondents. These strategies are considered in the literature to be drivers of innovation (Anderson and Schaan, 2001).

Table 3: Business Strategies

Respondent	Response rate (%)
Building relationships with existing clients	88
Actively encouraging your employees to seek out improvements and share ideas	84
Enhancing your business's technical capabilities	72
Delivering products/services which reduce clients' costs	72
Increasing your market share	68
Attracting new clients	68
Providing a broader range of services to clients	64
Recruiting experienced employees	52
Introducing new technologies	48
Protecting your business's intellectual property	40
Investment in research and development (R&D)	36

Respondents were asked which business strategies they consider are highly important to the success of their business. Table 3 shows the percentage of respondents for the most important business strategy. This indicates that the most important components are building relationships with existing clients, followed by Actively encouraging employees to seek out improvements and share ideas, delivering products/services which reduce clients' costs and attracting new clients. and protecting your business's intellectual property were the least likely strategy to be cited. The results show that knowledge and human resource strategies are the key importance to the construction industry (Manley, 2005)

Table 4: Business Statements

Respondent	Response rate (%)
We have robust relationships with key organisations in the industry.	76
We have a formal system for transferring project learning into our continuous business processes.	68
We have a formal system to encourage staff to share ideas.	52
We actively monitor international best practice in our field.	36
We actively monitor advances in related industries that might be applicable to our business.	32
We reward staff for maintaining networking linkages with strategically useful industry participants.	28
When we make changes, we measure how well the changes have worked.	20

Respondents were asked which are the most important components of a successful commercialisation capability. Table 4 shows the percentage of respondents for the most important components of a successful commercialisation capability. According to Love et al (2004) improved business performance relies on having formal robust policies in place such business statements.

4. CONCLUSIONS

This study has shown that innovation rates in the UK construction industry are comparable, to the those found in the UK Innovation Survey covering the whole of the UK. Findings from the survey indicate 66% of construction companies in the UK were innovative active. The evidence which has been presented in this paper shows the importance of innovation to business success, Innovation leads to customer satisfaction, competitiveness, productivity, profit and efficiency. Although there are obstacles to maximising innovation performance e.g. the lack of recognition of a number of key determinants of innovation in construction industry, such as; investment, strategic vision, mechanisms for change and research base structure. The industry want to improve the innovation performance by adopting procedures to evaluate their innovation capabilities.

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

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iCON: A WEB-BASED INNOVATION ASSESSMENT TOOL FOR CONSTRUCTION ORGANISATIONS

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Abstract: Many studies have shown that construction companies are not able to deliver on their potential to innovate. In response to the increasing concern over the lack of innovativeness for the construction organisations. An innovation assessment tool called "iCon" was developed to provide a rapid online assessment of innovative practices and competencies in construction companies. The paper describes the development of the tool for the construction industry and reviews existing innovation assessment tools and models, from within and outside of the industry. It outlines the development of a Self- Assessment Model and Prototype Application for the construction companies. The iCon is built around the assumption that, in order to be innovative, an organisation requires to excel in six categories: leadership to drive policies and strategies; management that believes in innovation; people who have the adequate skills and who believe that innovation is the successful exploitation of new ideas; processes that enable and support innovation; IR Investment, one of the key determinates of innovation or technology in any industry; and technology tools and the necessary infrastructure to support business functions. The content will be of interest to both academics and practitioners.

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

1. INTRODUCTION

The UK construction industry is a vital part of UK's economy, but it has inherent problems due to its structure and fragmentation. There is widespread agreement that the fragmented nature of the industry is not conducive to efficiency (Accelerating Change, 2002; Sorrell, 2003; Be and CIRIA, 2003). The construction industry is slow in the adoption of technological innovations and new ways of working (Winch, 2003). Construction poor performance has been challenged by its client base and it has been forced to seek ways to deliver improved performance (Beatham, 2003). Latham (1994) and Egan (1998) reports called for improvements in the construction project delivery process to improve efficiency, productivity and ensure value for money for the construction industry's clients.

The paper describes the development of an innovation assessment tool (iCon) for construction organisations and reviews existing innovation assessment tools and models, from within and outside of the industry. It outlines the development of a Self-Assessment Model and Prototype Application for construction organisations

2. REVIEW OF BUSINESS IMPROVEMENT MODELS AND TOOLS

Over recent years there has been increasing recognition that a more holistic approach to performance is required, such as the European Foundation of Quality Management (EFQM) Excellence Model EFQM (1999); the Malcolm Baldrige Model; ISO 9001, and the Balanced Scorecard (Kaplan and Norton,1996); an assessment system such as Key Performance Indicators (KPIs) and benchmarking (Construction Excellence, 2005). These business improvement models and assessment tools have been used for the last few years to self-assess organisations' performance and capabilities. see Table 1.1 Business Improvement models .

Table 1.1: Business Improvement Models

EFQM Excellence model	**The Malcolm Baldrige Model**	**ISO 9001**
▪ Leadership ▪ Policy and strategy ▪ People ▪ Partnerships and resources ▪ Processes ▪ Customer results ▪ People results ▪ Society results ▪ Key performance results	▪ Leadership ▪ Strategic planning ▪ Customer and market focus ▪ Measurement, analysis and KM ▪ Human resources focus ▪ Process management ▪ Business result	▪ Quality management system ▪ Management responsibility ▪ Resource management ▪ Product realisation ▪ Measurement, analysis and improvement
Total Quality Management (TQM)	**Balanced scorecard**	**Key Performance Indicators (KPI)**
▪ Culture ▪ Communication ▪ Commitment ▪ Planning ▪ People ▪ Process ▪ Performance	▪ Learning and Growth Perspective ▪ Business Process Perspective ▪ Customer Perspective ▪ Financial Perspective	▪ Client Satisfaction – Product ▪ Client Satisfaction – Service ▪ Defects ▪ Predictability – Cost ▪ Predictability – Time ▪ Profitability ▪ Productivity ▪ Safety ▪ Construction Cost ▪ Construction Time

The table above shows the business improvement models which have originated from manufacturing and service industry, it has been argued they are not necessarily appropriate for construction (Thompson, 2005). The business improvement models and approaches are useful in themselves, but innovation that appears to be present in them is in an unclear, unstructured manner. Several assessment tools were reviewed; These are briefly described below.

Table 1.2: Comparison of Assessment Tools

Criteria / Tools /Models	**Aspect**	**Status of Model /Tool**	**Software Availability**	**Usability**	**Survey Method**	**Suitability for Construction**
ISDT **www.innovation.gov.uk**	business process	Development ongoing	Yes, web based	Yes, but its very basic	Questionnaire	No

GIS www.goinnovative.com	people, process, structure and technology	Commercial	None	It seems very complicated	Interview	No
OAT www.innonet.org	organizational strengths	Commercial	Yes, web based	Yes, but its very basic	Questionnaire	No
RAT (Burgess & Shaw, 2005)	business, technical managers	Development ongoing	None	Pencil & paper	Interview	No
SPICE (SPICE, 1998)	project management	Research prototype	None	Yes	Questionnaire	No
RACE (Wognum et al, 1996)	process & technology	Commercial	Only for specialists	Yes	Questionnaire/ interview	No
VERDICT (Ruikar, 2006)	People, process, management and technology	Research prototype	Yes, web based	Yes	Questionnaire	Yes, but it requires some modifications, as it designed e-readiness not innovation assessment

Of these assessment tools, most conceive organisational improvements in general as supporting innovation, some of them are under development and some are being used on a commercial basis. However, the assessment tool that is most relevant to this study after appropriate modification is Verdict (Verify End-user e-Readiness Using a Diagnostic Tool) (Ruikar, 2006). Verdict is an internet based e-readiness application that assesses the overall e-readiness of end-user construction firms for using e-commerce technology. It comprises of a series of statements that fall into four categories, namely, people, process, management and technology. On their own, Verdict's four parameters may not be sufficient for an assessment whether it is e-readiness or innovation assessment in the construction industry or indeed for any other industry sector. This would require leadership in order to drive policies and strategies and to successfully implement it. The other parameter missing from Verdict is R&D investment which is one of the key determinants of innovation in any industry. Having looked at strengths, weaknesses, it becomes clear that innovation is missing in most of them as well as differences between the business improvement models and approaches, there is a need to develop a web-based innovation assessment tool specifically for construction companies, which addresses innovation management in the construction industry.

3. DEVELOPMENT OF ICON MODEL & PROTOTYPE APPLICATION

This section describes the development and evaluation of the innovation assessment model and prototype application. The acronym iCon is derived from the overarching goal of the software (Innovation Assessment Tool for Construction Organisations). The Prototype Application is a self-assessment tool, which aims to provide a rapid online assessment of innovative practices and competencies in construction companies. The following sections present the development and evaluation of the self-assessment model and web-based prototype application.

3.1 Methodology for the iCon Application

The methodology adopted in the development of the Self Assessment tool for construction organisations is presented below. The development of the self-Assessment Model involve both qualitative and quantitative methods. This type of research methodology can also be referred to as triangulation method. Figure 1.1 illustrates the development of the Model.

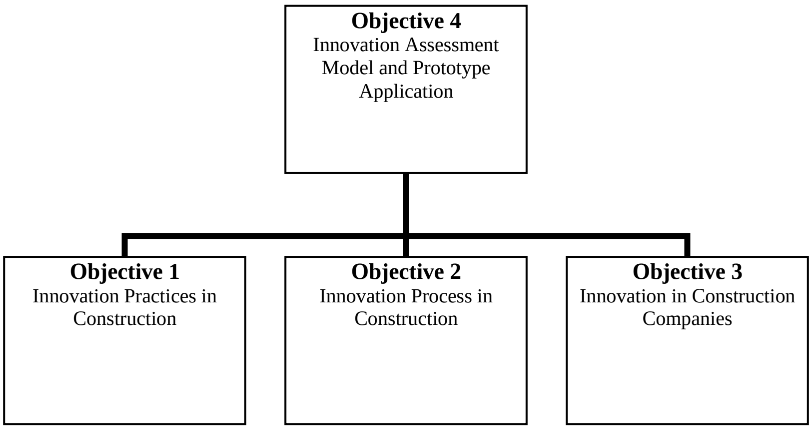

Figure 1.1: Data Input for the Development

The triangulation methodology is adopted for the development of the iCon model that assesses innovation performance for the construction industry. A triangulation method involves the use of both qualitative and quantitative approaches. Using this method, theories can be developed qualitatively and tested quantitatively (Khalfan, 2001). Triangulation increases the validity and reliability of the data, since the strengths of one approach can compensate for the weaknesses of another (Ruikar, 2006). A systematic two-stage approach was adopted for assessing innovation performance in the construction industry. The first stage involved the development of an assessment model for gauging the construction industry innovation performance. Using a qualitative approach, a review of existing literature on the subject matter (i.e. innovation assessment models and tools) was carried out. The best suited models in the context of this research study were then adapted to develop a model that assesses the construction industry innovation performance. The outcome of this led to the development of a set of questions that assess the overall innovation performances. Further, a quantitative approach was adopted to analyse end-user responses and presenting the findings graphically. The second stage involved development and evaluation of a prototype application. The development of the application was an iterative process based on the Rapid Application Development (RAD) methodology of software development (Maner, 1997). The prototype was evaluated using a number of methods including self-evaluation and peer reviews during the development phase and then through industry validation of the final prototype application. Evaluation was based on the functionality of the prototype application, its user-friendliness, errors, and its relevance to its target audience i.e. construction companies.

The Tool provides a rapid online assessment of innovative practices and competencies in construction companies. It allows construction companies to: assess their innovative performance; help them to focus on the areas where they want to make progress; integrate innovation related strategies/best practice guidelines into overall competitive strategies; and benchmark their innovation performance with peers and within the construction industry.

3.2 The iCon Model

The iCon Model comprises of six main categories with four maturity levels namely: poor, average, good and excellent as depicted in Figure 1.2. and translates these into an effective tool to assess innovation end-users such as SMEs or large construction companies. Such a tool also helps to organise company performance data and can be easily retrieved via intranet/internet and database technology.

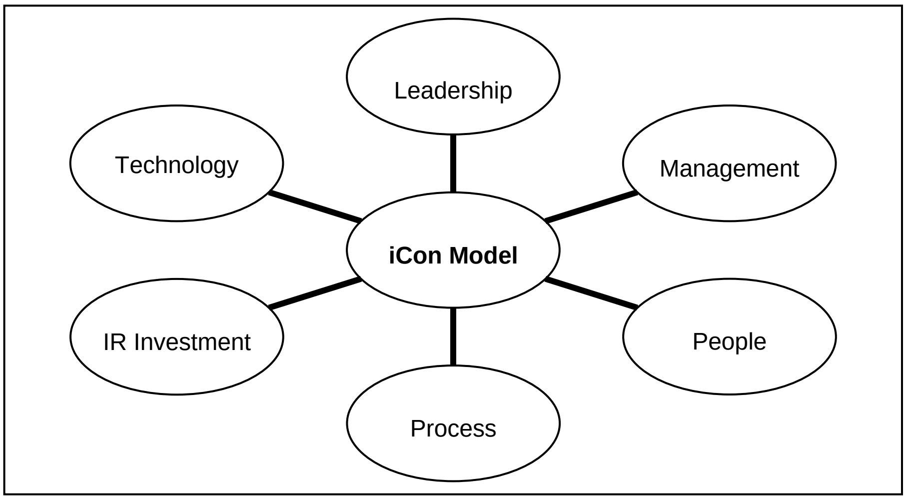

Figure 1.2: A Model for Innovative Construction (iCon)

The Tool adopts a similar methodology to Verdict (Ruikar, 2006), wherein companies will be required to respond to the statements and on completion the construction companies whether they are SMEs or large companies will be presented with an innovation performance report, which includes a summary of their responses and best practice guidelines on areas for improvement.
According to Cheung et al, (2003), effective performance assessment depends on well-structured assessment categories, which in turn are subject to the following questions what kind of data can be used and how to collect and interpret the data in a way that end-users can understand. To derive a reliable set of innovation performance categories, the researcher covered the work of Goolsby, (2001) and others (Larkin, 2003; Emmett, 2002), which indicate processes, people and technology are the three key aspects the need to be considered for successful implementation of technological innovation. Emmett (2002) stated that “people, processes and technology need a leader” just as “an orchestra needs a conductor”. Based on these, six innovation performance categories , the iCon Model is built around the assumption that in order to be innovative, an organisation requires leadership to drive policies and strategies with a belief in innovative practices. This includes people who have adequate skills with an understanding and belief of innovation, to successfully exploit new ideas with processes and technology tools that enable and support. Also IR investment being a key determinant in any industry.

3.3. iCon Application

The iCon Application comprises of a series of statements with which respondents may or may not agree to varying degrees. Statement indicators are words and sentences that describe a state of behaviour or practice, which are employed to measure practices of a particular process (Sherif, 2002). The iCon consists of ninety statements and the purpose of these are to establish the existence or non-existence of a good innovation process.

Interpretation of results is based on the overall mean score of each of the six categories of the assessment (leadership, management, people, process, IR investment and technology), which involves four levels: e.g. poor, average, good, and excellence. The scores are averaged, and depending on the average score, the respondents are presented with colour key indicators.

3.4 iCon System Design and Development

The development of the application was an iterative process based on Rapid Application Development (RAD) methodology of software development (Maner, 1997). RAD is a concept that facilitates the faster development of application software.

A typical questionnaire page as shown in (Figure 1.3), consists of a series of statements relevant to each critical factor and the corresponding category. The users rate their organisation performance on each statement on a five-point Likert scale.

Please tick the appropriate box to indicate your response							
Leadership		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Don't know
1	Senior management is fully supportive of the development of our innovations	o	o	o	o	o	o
2	Our leaders are aware of the potential rewards and risks of innovation practices	o	o	o	o	o	o
3	We recognise the benefits of being an innovative organisation	o	o	o	o	o	o
4	Our organisation has a director/manager at board level with overall responsibility for innovation and research (IR) issues	o	o	o	o	o	o
5	Our company has a vision and/or mission statement, which sets the organisation's direction in relation to innovation	o	o	o	o	o	o
6	Our company has a definition of innovation in construction for internal and external use	o	o	o	o	o	o
7	Our organisation has a detailed map for managing its key innovation issues with associated level of priority, actions, impacts and outcomes	o	o	o	o	o	o
8	Our organisation has short, medium and long term action plans to deliver its innovation policy with defined objectives, targets, performance indicators and list of personnel responsible for delivery action plans	o	o	o	o	o	o
9	Our leaders promote innovation as a competitive edge for the company	o	o	o	o	o	o
10	Our leaders are directly involved in the development of an innovation culture in order to bring about continuous innovation improvement	o	o	o	o	o	o

Figure 1.3: Typical Assessment Questionnaires

Even though the system allows users the freedom to navigate forward and backward after completing all the questions on each page, it does ensure that all questions are completed before the report can be generated. Therefore, on clicking the 'Get Report' link, the system checks the database and generates the total of the number of questions for each category. Once completion of the assessment the system calculates the mean score of each category and users are automatically presented with a report of their performance and interpretation of their results.

3.5 Mean Scores of each Category with Colour Coding

This part of the report collates the mean scores of the user on each category (i.e. leadership, management, people, process, IR investment and technology) and the total mean score with interpretation of scores as illustrated in Figure 1.4. It benchmarks each category mean scores of individual organisations with peers of similar business types (e.g. clients), group types in terms of turnover as well as the industry as a whole.

Your performance matrix score

Category Name	Mean Score		
	Your Company	Peers	Construction Industry
Leadership	2.5	2.8	3.2
Management	2.3	2.9	3.2
People	2.0	2.9	3.2
Process	2.5	2.9	3.2
IR Investment	2.5	2.9	3.3
Technology	2.1	2.9	3.2

Figure 1.4: Benchmarking of Performance

3.6 Radar Diagram of Performance Benchmarking

This part presents the graphical illustration of the benchmarking. The mean scores are plotted on a Radar diagram as depicted in Figure 1.5. The Radar diagram is based on the performance score interpretation scale.

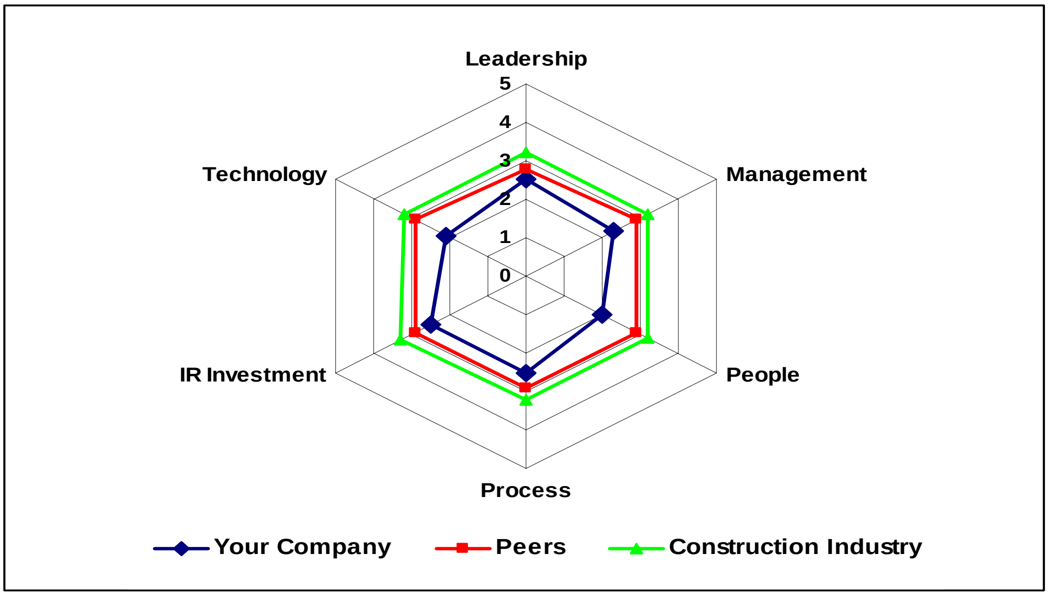

Figure 1.5: Rader Diagram of Performance Benchmark

4. EVALUATE THE USABILITY OF THE SELF-ASSESSMENT TOOL (ICON)

The iCon model was evaluated using an independent panel of reviewers including academic researchers and industry practitioners who are aware of and supporting innovations in the construction industry. Evaluators were given a standard evaluation questionnaire and were encouraged to make any additional suggestions in each category. A total of 22 samples evaluated the iCon Model, these include 17 managerial staff from different construction companies and five academic researchers. The outcome of the evaluation is depicted in Figure 1.6. The evaluation questions includes (i) the effectiveness of the questions in capturing the overall innovation issues; (ii) the formulation and easy to understand each aspect of the questions; (iii) the extent to which the different categories capture overall essence of innovation issue; and (iv) the usefulness of the model to aid organisation innovation implementation process within the construction Industry.

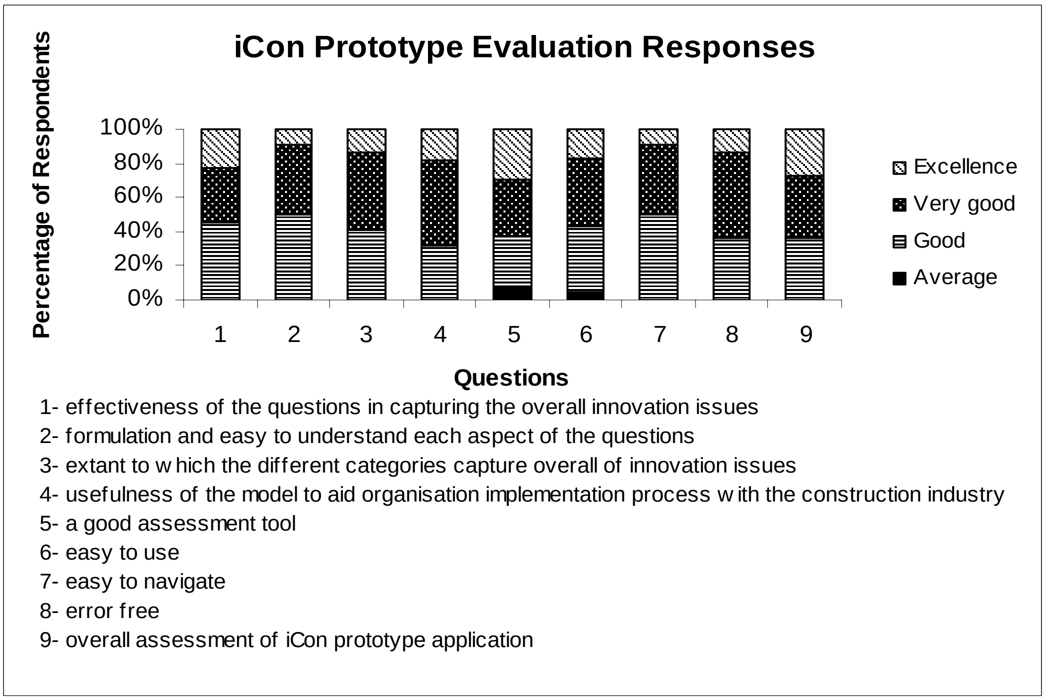

Figure 1.6: iCon Model Evaluation Responses

Overall evaluation results show that the model is an effective and useful tool, which provides a means for construction companies to assess their innovation practices and competences.

For the iCon prototype, evaluators were also asked to make comments how the iCon prototype application could be improved. Evaluation was based on the functionality of the prototype application, its user-friendliness, presence of any errors in content or links, and its overall relevance to construction industry. They were impressed with the iCon prototype application, the feedback from evaluators has been positive, to quote some of the reviewers' various comments are as follows.

- 'A novel way to review innovation in organisations and to stimulate improvements. Could also be a benchmark process e.g. do again in 6 months and check for (hopefully positive) changes'.
- 'It helps companies pinpoint the areas where they can improve innovation'.
- 'Fast, effective and easy to use'.
- 'Not time consuming… results are informative and reflects /highlights differences'.
- 'Gives you an idea of how good your company is for innovation'.

In general, the evaluation findings highlighted that the model addresses all aspects that construction organisations need to become an innovative organisation and to stimulate improvement.

5. CONCLUSIONS

This paper described the development and evaluation of the innovation assessment model and prototype application. It discussed, methodology used, the development of iCon assessment model, the design, development and implementation of iCon prototype application; a web based self-assessment tool for construction companies.

A number of assessment tools/models have been discussed and an innovation assessment model iCon is developed. The model is to initiate a process leading to the effective implementation of a strategy/best practice guidelines and allow construction companies to: assess their innovative performance; help them to focus on the areas where they want to make progress; integrate innovation related strategies into overall competitive strategies; and benchmark their innovation performance with peers and within the construction industry etc.

This paper has demonstrated the iCon can help to sharpen companies' innovative performance through adopting procedures to evaluate their innovation capabilities. It enables managers to integrate innovation-related strategies/best practice guidelines into their business activities. It also allows managers to benchmark their performance with peers and within the construction industry. The resultant report can then be used as the basis for innovation enhancements.

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THE ALIGNMENT OF CONTINUING PROFESSIONAL DEVELOPMENT WITH KNOWLEDGE MANAGEMENT IN CONSTRUCTION ORGANISATIONS

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Abstract: There has been a growing interest in continuing professional development (CPD) and lifelong learning as a means of improving the skills of staff and the delivery of construction projects. CPD can be both formal and informal, on-the-job experience, training courses and involvement in professional bodies all contribute to learning and skills acquisition. Knowledge management (KM) is recognised for its potential to bring considerable gains to construction organisations, their projects and individual workers. This requires the effective learning and sharing of knowledge through both technology and social interaction. Based on a continuing doctoral study, this paper presents the findings of empirical research conducted with a number of the leading Irish construction organisations. This includes interviews with senior management from ten organisations, an in-depth case study of one organisation and an interview with the CPD accreditation manager of Engineers Ireland, the country's leading professional body. The findings indicate that construction organisations recognise the need to promote learning and sharing of knowledge within their organisations. Individual employees value CPD quite highly and recognise the need to learn from the experience of others. Recommendations are made for the alignment of organisational KM objectives with individual CPD requirements.

Keywords: continuing professional development, knowledge management, professional bodies.

1 INTRODUCTION

It is recognised that construction organisations face many challenges in a highly competitive, fragmented industry. The requirement for contractors to learn from past experience and share knowledge throughout the organisation is vital in terms of continuously improving project, and ultimately organisational performance. Knowledge Management (KM) has been promoted as a means of harnessing and utilising intellectual resources to address these challenges, improving innovation, business performance and client satisfaction, although there is uncertainty about how to devise and implement a viable and cost effective KM initiative (Kamara et al. 2002). Central to learning and knowledge sharing are the organisation's employees, who can learn from direct experience, through interaction with colleagues and from formal training and development practices. Indeed, a focus on the continuing development of staff through both formal and informal means has been well recognised in recent years. The demands placed on construction professionals such as engineers, quantity surveyors and construction managers in terms of their time and experiences are considerable particularly due to the nature and intensity of work in construction (Wall and Ahmed, 2005). Therefore any opportunities for learning and knowledge sharing should be minimal in terms of disruption to their work. The potential alignment of continuing professional development (CPD) for construction professionals with an organisational KM programme could potentially maximise the benefits for both individual and organisation. Reporting upon an ongoing doctoral study of KM in the leading Irish construction organisations, the objectives of this paper are as follows:

1. To identify common areas between CPD activities and KM practices
2. To ascertain current approaches to both CPD and KM within the leading Irish construction organisations
3. To make recommendations for the alignment of CPD with KM in construction organisations

These objectives shall be achieved through a review of CPD and KM literature and the presentation of findings from primary research conducted with a number of the leading Irish construction organisations.

2 CONTINUING PROFESSIONAL DEVELOPMENT

Increased profitability, improved project delivery and client satisfaction can be achieved by construction organisations that employ highly skilled staff (Ellis and Thorpe, 2004). The development of technical knowledge in the specialist subject area; personal transferable skills and attributes such as team working and problem solving; and general managerial skills are identified as the main areas of learning for professionals (Roscoe, 2002). In order to develop these skills, CPD is important and is defined as: *"the planned acquisition of knowledge, experience and skills and the development of personal qualities necessary for the execution of professional and technical duties throughout a construction professional's life (Wall and Ahmed 2005: 1290)."* Three of the main stakeholders in CPD are the individual member, the professional body to which they belong and employers of professional staff who are concerned with maintaining the competence of their staff (Roscoe, 2002). It is important that employers afford their employees the opportunity to reflect on their practice, learn from mistakes and seek guidance in a supportive organisational environment (McDougall and Beattie, 1998). While much informal learning occurs through on-the-job experience, there are a number of activities which can account for formal CPD, such as completion of training courses and post-graduate academic studies. Other activities which can contribute to formal CPD and are recognised by professional bodies are included in Table 1 (CIOB, 2007; Engineers Ireland, 2007; SCS, 1996).

Table 1: Formal CPD Activities

Conferences and lectures	Workshops and seminars
Private study and reading	Involvement with professional body
Tutoring and mentoring	Teaching and examining
Tours & site visits	Membership of working groups
Open distance learning	Research publications & presentations

Many professional bodies CPD schemes treat formal training as the primary source of CPD, but Roscoe (2002) questions whether such courses are the best way to develop technical, personal and management skills. A case study of learning within an organisation found that informal learning between staff occurred in areas such as technical and market knowledge; coping with change; management and intra-organisational communications (McDougall and Beattie, 1998). Roscoe (2002) contends that individuals undertake CPD, not only to satisfy their professional bodies requirements, but to ensure credibility with colleagues and employers, improve current job performance, widen and deepen the capacity to perform in the current role and develop future capacity to enable promotion and progression.

3 KNOWLEDGE MANAGEMENT

It is recognised that construction firms have been managing knowledge informally for years, but the challenges facing the industry *"mean that most organisations now need a more structured, coherent approach to KM (Hari et al. 2004: 848)."* Jashapara (2004: 12) defines KM as: *"the effective learning processes associated with exploration, exploitation and sharing of human knowledge (tacit and explicit) that use appropriate technology and cultural environments to enhance an organisation's intellectual capital and performance."* However, there is little evidence of effective KM in practice due to a lack of understanding of both knowledge and its subsequent management within the industry (Robinson et al. 2005). One of the key KM processes is a reliance on the accumulation of individual knowledge and the dissemination of it through face to face interactions (Kamara et al., 2002). This dissemination can be supported by numerous organisational knowledge sharing practices, such as those presented in Table 2 (Dainty et al., 2005; Kamara et al., 2002).

Table 2: Organisational Knowledge-Sharing Practices

Knowledge exchange seminars	Recruitment and training
Departmental meetings	Site visit programmes
Rotation of staff in various roles	Post-project reviews
Coaching & mentoring	Brainstorming
Intranet and databases	Communities of practice

Within construction organisations, the project-based, short-term and task-oriented nature of construction work inhibits learning on a continuous basis (Egbu and Botterill, 2002). In a survey of large UK construction organisations, it was found that a requirement to share tacit knowledge and disseminate best practice were key drivers of KM and a lack of time and standard work processes within organisations as the main barriers to KM (Carrillo et al., 2004). Other identified barriers to KM include lack of management support, employee resistance to sharing knowledge, poor ICT infrastructure, lack of dedicated resources, poor organisational culture, poorly articulated strategy, and difficulty in evaluating benefits (Robinson et al., 2005; Dainty et al., 2005). According to Kurul et al. (2004), knowledge is personal and based on experience and reflection, socially constructed and disseminated, and context-specific. Therefore, any research into the management of knowledge within organisations requires consideration of existing informal processes.

4 CONTINUING PROFESSIONAL DEVELOPMENT & KNOWLEDGE MANAGEMENT

Motivating individuals to learn and share knowledge can be particularly difficult in pressurised environments such as construction where time for reflection is limited (Jashapara, 2004). The relationship between individual and organisational learning is discussed by McDougall and Beattie (1998) who view individuals at the core of learning within organisations. The link between knowledge and learning is discussed by Gourlay (2001) who cites the need for the involvement of human resource (HR) specialists in KM projects, if they are to be successful. Indeed, Gourlay (2001) identifies the design and delivery of formal training as being complimentary with the dissemination of explicit knowledge within organisations. Storey (2005) discusses the management of knowledge workers in the context of training, empowering, and rewarding them, and more specifically the role of HR in facilitating the use of available knowledge and encouraging people to learn. Training and development is considered an important aspect of KM by Olomolaiye and Egbu (2004) who cite the need to equip employees with the skills to manage their own learning and development. They also propose that awareness of KM can be improved by using training as a vehicle to focus on achieving quality, creativity, leadership and problem solving. McDougall and Beattie (1998) suggest that there is a role for training and development professionals in increasing awareness of informal learning strategies within organisations, which can lead to effective knowledge transfer and organisational learning. Participation in continuing education, conferences and similar CPD activities can allow employees the opportunity to *"reflect upon their work, trade stories and ideas with co-workers, or catch up on professional theory and practice (Grisham and Walker, 2005: 554)."*

There is considerable overlap between the CPD and KM activities identified in tables 1 and 2 such as mentoring, training courses, site visits and seminars. This view is further reinforced by the fact that Ireland's largest professional body Engineers Ireland (EI) have introduced a CPD accreditation scheme for employers of engineers across a spectrum of industries, including construction. Specifically defined criteria have been established, against which accreditation of companies is considered, including the development and implementation of a KM system (Engineers Ireland, 2007). It is reasonable to suggest therefore that CPD has an important role to play in KM within construction, at individual, project and organisational levels, and that there are opportunities for the alignment of both CPD and KM.

5 RESEARCH METHODOLOGY

Having commenced the wider doctoral study with a survey of the leading twenty contracting organisations (based on 2004 turnover), ten of these were selected to participate in further research of an emergent nature. Due to the complex nature of investigating knowledge and its management, a predominantly qualitative approach was adopted as it is deemed to best suit such research (Kurul et al., 2004). The primary research reported in this paper comprises three phases:

1. **Interviews with Senior Management:** In order to get an overview of current approaches to managing knowledge and CPD from both strategic and operational perspectives, senior managers from ten of the leading Irish construction organisations were then interviewed. Based on literature reviewed, a number of key themes formed the basis for the interview questions at individual, project and organisational levels.
2. **Case Study of a Leading Irish Construction Organisation:** Based on findings from phase 1, the case study organisation was selected as it was the first construction organisation to be accredited by Engineers Ireland for its CPD practices. A multi-method approach to data collection was employed, comprising a self-administered questionnaire for staff and semi-structured interviews with a full project team. Such an approach was chosen as it seeks a range of different kinds of evidence in a case setting, which when abstracted and collated has the potential to provide the best possible range of answers.
3. **Interview with Engineers Ireland CPD Accreditation Manager:** Having identified the important role which CPD accreditation has played in KM within the case study organisation, it was decided to approach Engineers Ireland. An unstructured interview was arranged and conducted with the CPD Accreditation Manager in July 2006, to discuss KM in relation to construction organisations.

5.1 Research Challenges

Whilst obtaining a representative sample is a major concern for many studies, the opportunity to explore the basic properties or dynamics of the organisations upon which to build further research was the primary concern in the present study. A key challenge in phase 1 was the identification of appropriate interviewees within the organisations in order to get both strategic and operational perspectives of current approaches to managing knowledge. Through consultation with the author's colleague who has extensive industry contacts and knowledge, gained from over 20 years of placing undergraduate students with these organisations, appropriate interviewees were identified and contacted regarding participation. The good relationship enjoyed between the author's institute and the organisations throughout the years ensured that agreement to participate in the interviews was not a problem. During one of the senior management interviews, the opportunity arose to conduct further research within a single organisation. With the support of this organisation's director, access to staff for both a survey and interviews proved relatively easy, obtaining a satisfactory response to the survey however, was problematic. The survey was administered via email by the company's HR Manager, who in consultation with the researchers identified 180 appropriate respondents comprising a variety of professional, technical and management staff. An additional two email reminders were sent to all relevant staff in order to maximise responses, with a 36% response rate being achieved. One of the most difficult challenges encountered throughout the research has been the scepticism of industry towards academic research. Many senior managers questioned the value of such research to their organisations, which is perhaps symptomatic of the reported low levels of research and innovation in the Irish construction industry. With regard to the case study organisation, the authors made a presentation to the director who was interviewed in phase 1, the HR Manager and the administrator of the company's lessons learned database, making a number of recommendations. These three individuals all commented on the relevance of the research and are currently addressing some of the problems identified with both the KM and CPD practices.

6 RESEARCH FINDINGS

6.1 Interviews with Senior Management

The senior managers were queried on a number of issues relating to managing knowledge and CPD within their organisations, Table 3 shows the activities employed by the ten organisations.

Table 3: CPD and Knowledge-Sharing Practices

Organisation	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
CPD Activities										
CPD Policy		X			X	X	X	X		
Appraisal		X	X		X	X	X	X		X
Mentoring		X	X		X	X	X			X
Post-Graduate Studies	X	X	X		X	X	X			X
Knowledge-Sharing Activities										
Post-Project Review	X	X	X	X	X	X	X	X	X	X
Lessons Learned					X	X				
Site Visits	X	X	X	X	X	X	X	X	X	X
Workshops & Seminars	X	X	X	X	X	X	X	X	X	
Departmental Meetings	X	X	X	X	X	X	X	X	X	
Intranet		X			X	X	X		X	

With five organisations having a CPD policy, all respondents emphasised that the onus for CPD was on the individual to manage their own learning. The CPD practices of both F and G are accredited by Engineers Ireland, while B, C, D, E and H are signed up to the scheme, but have yet to be audited. Seven of the organisations undertake annual appraisals to help employees identify training needs for the year ahead. Organisation E, appraise their staff under the following headings: *"job knowledge, problem solving ability, quantity/quality of work, task management, training requirements, communication skills, adaptability, business knowledge and achievement of goals set previously."* Despite all organisations conducting post-project reviews, only two (E and F) document the findings of the review in lessons learned for dissemination to the wider organisational audience. Most admitted that staff are willing to share their knowledge with co-workers, *"the difficulty is in finding time, because everybody is busy trying to get their own work done."* Many of the respondents indicated that the promotion of face-to-face interaction through a variety of methods such as mentoring, meetings, social activities, training courses and seminars worked well. Apart from financial incentives, the opportunity for career progression was cited as a motivating factor for staff performance, whilst recognition from directors and a sense of ownership of the company also ranked quite highly. Site visits are employed by all organisations, albeit on an ad-hoc, informal basis, the benefits of these were recognised by everyone. All respondents acknowledged the need for their organisation to improve their KM practices and consider a more formal approach.

6.2 Case Study of a Leading Irish Construction Organisation

The survey was sent to a range of professional, management and technical staff including quantity surveyors, engineers and project managers within organisation F's Dublin office. The interviewees comprised a senior contracts manager, a project manager, three quantity surveyors, three engineers, four foremen and a safety officer all based on a €70 million commercial development project. Of the 65 survey respondents, 63.1% are members of a professional institution, with 18.5% holding membership to more than one professional institution. Over a quarter of respondents (28%) are members of Engineers Ireland, followed by the CIOB with 23% and the SCS with 15%. The overwhelming consensus among interviewees was that organisation F are excellent in their provision of CPD, with one individual commenting, *"I think they're good, they've a good attitude to staff, they support training and career development, so I think that overall, they're a good company to work with."* All respondents to the survey cited that a good training and development programme was either very important or important in motivating them in their work, while senior management support of CPD was recognised as being *"proactive and supportive."* An annual appraisal is conducted with a director to review performance and identify areas where training is required. One interviewee commented *"I think it's good to hear what other people think of you in your work."*

The company have a lessons learned database (LLDB) containing lessons from post-project reviews which are sorted according to subcontract packages, and posted on the company intranet. They also run regular lessons learned seminars in head office covering a wide range of topics, *"particularly technical, we find it's actually quite hard to get good technical courses, so we do a lot of that in-house, with our own senior managers."* The main reason for attending such seminars was cited as helping individuals to improve in their own work (79.2%) by learning from other peoples experiences. *"The seminars are effective if they get people at similar levels together, when they wouldn't normally get together and they give people a chance to learn from the experience of others."* With 49% of survey respondents having visited another site, it emerged during the interviews that a number of participants had *"visited a site to look at pods and a twin wall system…we got to know how they worked, how to go about setting out for them, it's helped shorten the learning curve."* Apart from financial incentive, being given the responsibility to work on their own initiative was seen as the most important motivational factor by 73.8% of survey respondents. A good training and development programme and being part of a team also ranked quite highly, while personal contact with directors was ranked as least important.

6.3 Interview with Engineers Ireland CPD Accreditation Manager

Despite a number of the leading Irish construction organisations being involved in the CPD accreditation scheme, it was acknowledged that the construction sector is not as advanced as other sectors such as ICT and pharmaceuticals in their CPD practices. These construction firms are becoming involved with the scheme to develop in order to improve the retention of staff in what is a highly competitive employment market at present, "*the companies are trying to get some strategy so that they can attract, recruit and retain people.*" The construction organisations, she felt struggled with the concept of knowledge and its management because they "*are so practically focussed.*" Organisation F were the first construction organisation to become accredited, which she believes is down to the efforts of the company director who is "*very clued in, more than most.*" The prospect of developing guidance documentation and training resources aimed specifically at construction organisations was discussed as a means of raising awareness and understanding of KM, and ultimately improving its implementation. Such resources would have to be "*very practical and not theoretical and include a lot of ideas and solutions.*"

7 DISCUSSION

7.1 Current Approaches to CPD and KM

The interviews with senior managers found that CPD practices vary between the ten organisations, although those who have a CPD policy appear to have good range of practices in place. In particular, organisations B, E, F and G exhibit high levels of both CPD and KM activities, all of whom are involved in Engineers Ireland's CPD scheme. The range of activities offered by organisation F appear to indicate that a supportive organisational environment is in place, which is acknowledged by employees (McDougall and Beattie, 1998). With almost two-thirds of the survey respondents claiming membership of a professional institution, the provision of learning opportunities are highly regarded by staff. The provision of formal learning comprises activities such as training courses, lessons learned seminars and mentoring, with informal learning occurs through, amongst others, regular meetings and informal site visits. The alignment of LL seminars with CPD, addressing the organisation's KM objectives while affording employees the opportunity to undertake CPD, appears to be mutually beneficial. While KM is not a term that is specifically used, a number of the leading Irish construction organisations recognise the need for sharing knowledge. While some of these organisations have taken their first steps in KM, their awareness and understanding of both knowledge and KM requires improvement.

7.2 Potential for Aligning CPD with KM

It would appear that the provision of a range of learning opportunities has a positive effect on an organisation's learning environment; specifically there are a number of areas where CPD and KM could be aligned.

- **Training:** could be provided at two levels; KM training and guidance for senior management who are leading a KM initiative; and for all employees to improve their awareness of the need to share knowledge and learn. Lessons learned within the organisation could be packaged into formal training courses to help improve technical knowledge and managerial skills of employees.
- **Appraisals:** a comprehensive appraisal system could aid the identification of expertise and knowledge gaps within the organisation, allowing action to be taken.
- **Site Visits:** the development of a site visit programme within the organisation, with regular opportunities for staff to share knowledge and experience.
- **Mentoring:** this practice should be utilised as much as possible throughout organisations with both the mentor and mentee engaging in CPD activity.

The nature of construction projects and the industry in general imposes constraints on the amount of time which individuals and organisations can afford to dedicate to CPD and KM. The alignment of these through activities such as training, appraisals, site visits and mentoring can potentially bring benefits to both the organisation and the individual.

8 CONCLUSIONS

The CPD and KM practices of a number of the leading Irish construction organisation have been identified and evaluated, with a view to making recommendations for the alignment of CPD with KM. Based on this investigation and the identified objectives, the following conclusions can be made:

1. Both CPD activities and KM practices are concerned with individuals acquisition of knowledge, experience and skills; the former of primary benefit to the individual, the latter benefiting the organisation.
2. Current approaches to both CPD and KM within the leading Irish construction organisations vary, although it appears that those organisations, who exhibit good levels of CPD activities, also provide ample opportunities for KM activities. The main thrust of these activities include training and development; annual appraisals; mentoring; post-project reviews and lessons learned; site visits; workshops and seminars; departmental meetings and the use of an intranet.
3. To optimise the technical knowledge and personal and managerial skills of employees, whilst improving project and organisational performance, construction organisations should seek to align CPD with KM through the integration of training, appraisals, site visits and mentoring.

The importance of the HR professional in the development of CPD and KM practices is well recognised. The next phase of this research will investigate this aspect further through interviews with HR managers from a number of construction and non-construction organisations involved in Engineers Ireland's CPD accreditation scheme in order to identify best practice. Of particular interest will be the potential for aligning CPD and KM practice and the development of KM training resources.

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COMMUNICATION FLOW IN MERGERS AND ACQUISITIONS

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Abstract: Over the last ten years mergers and acquisitions (M&As) have become a worldwide growth industry. Although the opportunity to merge or acquire is presented to shareholders as a strategy for wealth creation, statistics show that the number of acquisitions actually achieving 'success' is relatively low. Many M&As fail to recognise the importance of communicating clearly with existing employees. Knowledge and feelings of employees, together with implementation of other recognised integration techniques can impact upon the overall success of M&As. The literature suggests that post-acquisition integration of M&As is the phase where expectations are fulfilled or broken and where there is potential for employee motivation to reduce dramatically. The paper is based on a case study, whereby a locally based contractor is acquired by a national company. The methodology included a literature review and a structured questionnaire seeking data from sixty-four employees. The variables are pre and post-acquisition knowledge, employee feelings, communication and success of the acquisition. Inferential statistics are used in the analysis. The validity of the study is asserted. Strong relationships are found between level of employee knowledge, communication and success. It is concluded that acquisition strategies should consider communication with employees a key priority at all stages of the process.

Keywords: Acquisitions, communication, employees, mergers, success.

1. INTRODUCTION

Weston *et al* (1998) believe that mergers and acquisitions (M&As) and industrial restructuring activities have raised important issues both for business decisions and for public policy formulation. No firm is regarded safe from a takeover possibility. M&As are critical to the healthy expansion of business firms as they evolve through successive stages of growth and development into new product areas and geographical markets. Whilst the aims of M&As could be achieved by organic means, acquisition is quicker and easier – provided the rules are obeyed (Heller, 2006a). Although the opportunity to merge or acquire is presented to shareholders as a strategy for wealth creation, it is estimated that more than half of all M&As prove financially unsuccessful (Cartwright and Cooper, 1992). Statistics taken from IBM (2000), show that only 37% of acquisitions are considered to be 'very successful', in the eyes of the companies undergoing the process; this suggests that reality often falls short of the ideal. Bruner (2004) says that some writers portray M&As as the kind of losing proposition that compulsive gamblers face in Las Vegas; you can't win; you can't break even; and you can't get out of the game. This is unduly pessimistic. Though M&As are a very compulsive business activity, it is possible to succeed. Beyond all the statistics and optimistic press announcements, real organisations are being disrupted, real executives are being displaced, and real shareholders are being disappointed – not for lack of effort, but largely for lack of effective planning and integration (Galpin and Herndon, 2000).

Research and experience indicate that integration is a critical management process that must be taken and managed seriously within M&As. Integration is not just a few random activities that can be handled after the event, but a series of well-orchestrated activities that begin long before and continue long after acquisition (Schweiger, 2002). IBM (2000) suggests that the announcement of any acquisition will hit most people in a way that they will not have experienced before. Reactions will be complex; some people will thrive and others will suffer badly. Paying attention to the 'people agenda' and integration makes sense because people are often ignored or dismissed as being soft or mushy issues. People have come to be labelled as the 'forgotten or hidden factor of M&As', nobody comes through the experience unscathed or without a tale to tell. As one manager speaking on the basis of experience suggests, those who underestimate or ignore the human factor do so at their peril (Cartwright and Cooper, 1992).

Pritchett (2006) states that acquired companies should be prepared for a cloud of uncertainty to settle over them. Employees start wondering about the future of firms, what their role is likely to be in months ahead and how they will be affected. There are far more questions than answers and this can result in information / communication vacuums in organisations. Failure in communication demoralises everyone involved in acquisition processes and the grapevine takes over. Often the 'truth' is a moving target. Decisions are made, announced, and then promptly changed – some people can accept this while others find it extremely upsetting. Brad Cooper (Mook, 2000) a management consultant believes that over-communicating in a merger or acquisition is good. If a communication gap occurs between top management and employees, the vacuum will be filled with rumours. Wall (2005) states; the message to communicate should begin on the day the acquisition is announced and continue throughout the integration period and beyond. Maintaining continuous communication between people is imperative (Mumm and Beuerlein, 2004).

The context for this study is the acquisition by company A of company B in May 2005. Company A is a national concern, that is striving to become the 'Nations Local Builder', by continual expansion across the UK. It is currently working on a five year business plan, which aims to increase the number of its companies across the UK to more than 100 and increase annual turnover to over £1BN in 2007. Company B is a medium-size contractor based in North West England. The acquisition was seen as a first for company A, as company B boasted a healthy turnover, full order book and substantial profits. However this resulted in integration problems (don't fix it if it isn't broke), which meant that standard acquisition procedures used to integrate other businesses were placed on hold. To date the post-acquisition integration has stuttered and the company is still not fully accepted as part of company A's Group. The information /communications received by employees of company B were insufficient, creating lots of uncertainty. Due to the expansion plan of company A's group and the level of ongoing M&A activity, there may be considerable scope to improve the acquisition processes currently adopted. The acquisition of company B has displayed many of the problems highlighted in the literature above. Company B retains its old identity within its new group, and operates semi-autonomously.

Data for the study is collected from company B. The research measures three independent variables (IVs). These are pre and post acquisition knowledge (IV 1), employee feelings (IV 2), and communication (IV 3). The dependent variable (DV) in the research is success of the acquisition. Tests are undertaken to determine whether relationships exist between each of the IVs and the DV.

2. THE LITERATURE

2.1 Mergers and Acquisitions

Since the middle 1920s a wave of M&As, historically unprecedented in scope and effects, have swept through British industry (Singh, 1971). During this time, millions of pounds in deals have been struck and tens of millions of people have been affected by M&A activity (Schweiger, 2002). M&A activity in the UK has been grouped into periods of time or 'waves', the first of which occurred in the 1920s. Further waves appeared in the 1960s and early 1970s and also in the 1980s, indicating that the level of M&A activity in the UK increased substantially in the period 1920-1980, both in terms of size and frequency (Cartwright and Cooper, 1992). From 1992 through to 2000 there were eight straight record years of M&A activity. The 1990s will go down in history as the time of the biggest M&A wave of the century (Grundy, 2003).

More and more businesses have discovered there is a need to adjust to massive changes in their environments to find effective routes to growth (Weston et al, 1998). The corporate mind-set is often one of striving for continual growth, rather than for selective growth (Grundy, 2003); this means businesses must investigate all available routes. Cookson (2004) stated that it is a fact of business that companies will continue to pursue acquisitions to achieve growth. However, this merely represents an intermediate objective. M&As are also undertaken by companies to achieve certain strategic and financial objectives and involve the bringing together of two organisations with often disparate corporate personalities, cultures and value systems (Sudarsanam, 1995). Stallworthy and Kharbanda (1988) state M&As are a cheap and fast method of entering a new market. Bruner (2004) believes that the motives for M&As are creation of market value, financial stability, improved strategic position, organisational strength, enhanced brand, observance of the letter and spirit of economic norm and laws and the possibility of improved processes. Stallworthy and Kharbanda (1988) agree that there are a multitude of motives, although one or two may predominate in a specific situation. Decisions taken are often based on inconsistent and even incomplete information. With a particular M&A, some of the motives may even be conflicting and incompatible and lead to difficulties later in the process.

One of the basic difficulties that complicate our understanding of M&A related dynamics and outcomes is the range of possibilities / processes by which M&As can be undertaken. There are a variety of combination types, which raise a number of different issues for employees and pose problems for planning and integration (Risberg, 2003). Angear and Dewhurst (1989) believe that, given the risks involved, acquisitions require meticulous planning and a sound strategic underpinning. At present, the process by which companies are bought or sold can prove difficult, slow and expensive. Grundy (2003) says that many M&As do not succeed because they either have an average (and not cunning plan), or perhaps a very incomplete plan. He suggests that this is partly due to the many types of acquisition processes available, but also because each M&A has its own sets of issues and sets of risks. Unless companies are embarking on a series of similar M&As, they will all vary considerably in the demands placed during the process. All M&As become unique projects and therefore require small variations in the processes used to make them work.

It is no secret that plenty of M&As do not work. Kreitl and Oberndorfer (2004) suggest that many studies across industry have discovered that M&As show a high failure rate, which confirms that as an instrument of corporate development, it is rather risky. Those who advocate mergers will argue they will cut costs or boost revenues by more than enough to justify the price premium. Fortunately, various studies have validated core elements that demonstrate successful results in M&A activity. Hodge (1998) suggests that an effective planning policy, good management of the post-merger integration, a compelling vision that is understood by all personnel involved in M&As, effective alignment and fast and focused transition, and good communication policies will help to lead companies involved through the uncertainty (Gaplin & Herndon, 2000). Success in M&As is uncertain; research and practice suggests there are several contributing factors such as; executive leadership, integration planning, effective implementation, structuring, staffing, communication, cultural issues, change management, people issues, measurement etc. Bringing about success in M&As is not easy, as each has different requirements (Bruner, 2004).

2.2 Integration Issues

Integration is emphasised as highly important in M&A research. Integration is the key to making M&As work. Not until the two firms come together and begin to work toward a common purpose can value be created. The primary objective of the integration is to make more effective use of existing capabilities. The combining firms can take advantage of economies of scale by reducing unit costs in production, integrating similar department, sharing sale forces etc. Hence, integration is very important in getting full value from M&As (Risberg, 2003). M&A integration encompasses a wide spectrum of activities ranging from business policies and procedures to information technology and financial reporting. The challenge involved in effectively integrating business systems between the purchaser and the acquired company are often underestimated (Johnson, 2002). Basically integration deals with both the ‘hard’ and ‘soft’ issues involved in M&A processes and commences when first assessing a potential acquisition (pre acquisition knowledge), and running until newly acquired firms become part of the overall organisation (post acquisition knowledge).

Organisations are by definition complex, made of many parts and many people. Management has been ingenious at creating systems to fit people and processes together (Robbins & Finley, 1998). However many M&As are frequently undertaken with an emphasis on getting the deal done. Therefore the integration issues that arise are crucial to making acquisitions worthwhile (Johnson, 2002). Every M&A deal presents different challenges, and requires customised adaptations of generic processes. When a structured integration process is well managed, significant results can be achieved (Galpin and Herndon, 2000). It is well known that any M&A will also create an expectancy of change within an organisation (Cartwright and Cooper, 2001). Change is omnipresent. Societies change, technologies change, markets change, competition changes. If others change and you do not, your relative position alters. So you change – or worse, are changed (Heller, 2006b). Kotter (2002) emphasises the importance of dealing with pre acquisition strategies, restructuring, new strategies, cultural transformation, globalisation etc in the entire organisation, an office, a department, or a work group. He suggests that, when the situation is handled relatively well, you win, but handle it poorly, and it can drive you crazy, cost a great deal of money, and cause a lot of pain. Good knowledge can help to create a successful acquisition.

Change management means uncertainty, which often creates discomfort among those who are subjected to it (Johnson, 2002). However as stated by Burke and Cooper (2000), if organisations did not change they would stagnate and decline. Hardy (1999) says that; resistance to change is based on fear. Fear comes from the uncertainty or lack of knowledge created by M&As. It may or may not be well founded but, to those experiencing fear, it is very real indeed. Eccles (1996) believes that in order to combat this fear, newly acquired businesses should make the mode of running their acquisitions immediately, clearly and decisively obvious (pre and post acquisition knowledge). Changing the way in which organisations conduct their businesses – their managerial style, systems, procedures and the symbols of identity – also means changing people and their organisational culture. Although cultural compatibility and the way in which M&A integration processes are managed are to some extent related, cultural compatibility of fit alone is no guarantee of M&A success (Cartwright and Cooper, 2001). The culture of organisations grows out of the behaviour of the people within them, and in turn it influences how they behave (Heller, 2006c). Acquired companies must aim to guide the development of organisational culture by various means so that they support changes resulting from integration. In most successful acquisitions, the corporate cultures of the purchaser and vendor are compatible (Johnson, 2002). Understanding corporate culture is crucial when planning for change. The long-term aims of organisations can be achieved only if staff are in sympathy with them and with each other (Heller, 2006a). Ankrah and Langford (2005) agree that organisational culture influences the success of M&As; integration of new technologies, meetings, communications and relationships, helps to explain why some companies are more successful than others. Industry needs to look at culture, but also how people in organisations behave and ultimately what bonds organisations together.

2.3 Pre acquisition Knowledge Issues

A large part of what makes deals successful after completion is what is done before completion (Grundy, 2003). Efficiently and quickly gathering and analysing useful information about a target as early as possible is essential. In particular learning about similarities and differences between the acquirer and a target and their implications is pivotal. Therefore, an organised, systematic process for doing so must be created, due diligence (Schweiger, 2002). Fealy and Kompare (2003) say that larger organisations cannot complete M&As without carrying out proper due diligence. It is critical to have a clear understanding of the legal obligations and perform all necessary due diligence to uncover any unexpected liabilities. It should begin during the earliest possible stages of locating the target company, and it should continue through negotiations and into integration planning.

Garnett (1984) says that if success is to be achieved, there is a need to harness the ideas, views and experiences of people actually carrying out jobs (pre acquisition knowledge). Cartwright and Cooper (2001) agree that people involved in the process are best placed to carry out development or planning in the integration period. They state that monitoring the success of any integration involves maintaining the momentum for change, the assessment of the cultures, the identification of employee concerns and expectations etc by utilising extensive management development programmes or integration plans. Integration plans are very important and should enable; major activities to be completed, timeframes and milestones for the completion of major activities, specific responsibilities, resources required to carry out the integration (people, financial), budgetary information (revenues, costs, capital investments), potential roadblocks, monitoring and managing the integration and any contingency plans which may impact upon employees, customers or stakeholders (Schweiger, 2002). Hardy (1999) states that major changes such as M&As are seldom detailed; bland statements, qualified only by an indication that further information will be issued later, are normally circulated to reduce the level of uncertainly, which ultimately leads to limited pre acquisition knowledge.

2.4 Post Acquisition Knowledge Issues

Once the M&A deal has been finalised the integration stage moves on from planning and implementation to people, processes, systems and technology or the post-acquisition integration (Gaplin and Herndon, 2000). Post-acquisition integration is where expectations are fulfilled or broken and where employee knowledge increases dramatically. Burner (2004) suggests that M&A transaction terms set the stage for this crucial phase of the deal. Failing to recognise integration issues at the bargaining table or in the analytic phase of the work can create enormous problems later on. More importantly, knowing what to do after the definitive agreement is signed is vital to the success of the deal. Grundy (2003) agrees that this is the most important period as the acquirer has most opportunity to learn from the M&A. How difficult and speedily did we integrate the acquisition relative to our expectations, is a central question. It is also considered to be the all important determinant of the success of the acquisition creating value (Sudarsanam, 1995).

Post-acquisition key success factors include: establishing strong leadership, improving knowledge levels, establishing a plan for managing the post-acquisition integration, developing an effective communication plan, developing a strategy for cultural integration and ensuring that management addresses human resources issues (Mickleson and Worley, 2003). Therefore the ability to manage post-acquisition integration processes is crucial to transforming the shareholder value. But this begs the question: if the integration phase is so important for the success of the acquisition process why is it that acquirers do not seem able to improve the odds of success by focusing on developing integration capabilities? (Maurizio, 1999).

If organisations emphasise either the task or the human aspects of integration, but do not give adequate attention to both, negative results may occur. An overemphasis on the task side of the integration is likely to lead to dissatisfied employees and a lack of common identity. On the other hand, too much emphasis on the human side of the integration is likely to diminish the level of operational synergies achieved (Swee, 2001).

2.5 Employee Feeling Issues

Due to the fact that financial and strategic factors dominate M&A select decisions, the diagnosis and analysis for failure has traditionally tended to adopt a similar focus. M&As are considered to fail for rational economic reasons, the strategic fit was poor or ill-matched, or there were unexpected changes in market conditions or exhausted rates. It is true that M&As do fail for these reasons, but making successful M&As, is more than just a matter of 'getting the sums right'. Managers that have already experienced the trauma of M&A activity are likely to be well aware of the multitude of 'people problems' and issues which inevitably arise (Cartwright and Cooper, 2001). Rather than concentrating on integrating two cultures (knowledge, understanding, communication etc), post-acquisition integration efforts are generally geared towards combining the tangible assets – finances, IT systems, real estate etc. to achieve maximum cost reductions. What goes unrecognised is the way the so called 'soft' issues are managed; these can have a dramatic impact on the success of acquisitions.

Most human failures could be stemmed if management invested in people issues rather than ignoring them. Not investing in people is foolhardy, and it is arrogant and disrespectful to shareholders. What looks promising on paper often fails in practice for one reason; people. People are messy. That may be the only certainty to materialise from the flurry of M&A in which successful integration of differing cultures has been anything but a sure thing (Krell, 2001). Employees often feel a strong sense of loss. Employees are usually not well prepared for the changes these kinds of losses make in their everyday lives. They may feel psychologically jolted. M&As create a great deal of stress for people (Pritchett, 2006). Some of these stressors may be relatively temporary, for example vulnerability to redundancy. Others may be of a more enduring nature, such as ambiguity and cultural change. Reactions will be complex; some people will thrive and others will suffer badly. Paying attention to the 'people agenda' makes sense (IBM, 2000).

2.6 Communication Issues

Communication is one of the most frequently discussed dynamics in the entire field of organisational behaviour, but it is seldom clearly understood. In practice, effective communication is a basic prerequisite for the attainment of organisational goals, but it has remained one of the biggest problems facing modern management (Luthans, 1989). Garnett (1984) suggests that employees will only give of their best to their work if they fully understand the decisions that affect them and the reasons behind those decisions. People need to understand what they have to do, how and why. Peter Drucker says that the great majority do not know what to say, when to say it, how to say it, nor whom to say it. Ludlow and Panton (1992) go a step further, and point out that the weakest link in communication processes is listening. If no-one listens, any attempt at communication collapses. Communication leads to greater effectiveness, keeps people in the picture, gets people involved with organisations, increases motivation, increases commitment, creates better relationships and more importantly in M&A activity, helps people to understand the need for change

While the basic communication process may appear relatively straightforward, few organisations lack communication problems. Perceptual and attribution biases, interpersonal relationships, top managements' role, gender differences, physical distance and organisational structures can create barriers to communication (Gordon, 1999). The way of reducing the effects of these barriers is to check continuously during the communication process what the message really is (Ludlow and Panton, 1992). The importance of communication can not be overemphasised, not least during M&As (Phoenix, 2006). Fisher (2004) said that one of the key lessons learned from M&As is establishing clear communication lines upwards, and positive control downwards, immediately. Guirdham (1999) agrees that managers of all types, business executives, members of the professions and people at work generally need to be able to communicate with other successfully in M&As. However they must now learn to communicate in a new world of diverse colleagues, clients and customers and of international operations. Modern societies and organisations are composed of people who differ widely in terms of nationality, ethnicity, gender, sexual orientation, age, education, social class or level of disability – in other words in terms of their demographic profile or social background. At work, therefore, individuals are now likely to interact with a highly diverse range of people.

Yazdifar *et al*, 2006 agrees that organisations undoubtedly realise the importance of good communications for successful implementation of the entire M&A process, but they often find it hard to make this communication both constant and lucid. Berk's (1996) views differ. He believes that communicating the facts in M&As to all affected parties is a process that can be reduced to its components and managed effectively. It is important, however, to allow enough time to do the job right. However Wall (2005) suggested that what may be obvious in the boardroom may simply not be getting to employees (Wall, 2005). Harwood and Ashleigh (2005) suggest that recent research has linked the mishandling of people/or communication aspects to the poor performance of M&As. It is therefore imperative that communication in M&As equip employees with knowledge and tools to help them deal productively with the concept of constant change. To that end, true business transformation means equipping employees with actionable knowledge and skills to achieve business results (Henry, 2002 as quoted in Yazdifar *et al,* 2006). Bruner (2004) suggest that companies which gave priority to communication were 13% more likely than average to have successful deals.

3. METHODOLGY

The data collection technique selected was a survey questionnaire, which collected quantitative data. The population comprised employees at company B who were employed prior to the acquisition in 2005. The population of 200 employees was considered too large to survey and therefore a sample of 100 was selected. 60 replies were received. The questionnaire was constructed using the lead author's knowledge of the company / acquisition, information gathered in the literature review and scales from Naoum (2001). The questions used were adapted from questionpro (2006), an online research centre specialising in company questionnaires. The author used questionpro questionnaires relating to success, acquisitions, communications and employee feelings and adapted them by removing all questions which did not measure the variables highlighted in the study. Using this authoritative source ensured that correct measurement scales were used, loaded questions were reduced and questions had already been rigorously tested.

The questionnaire was divided into five main sections. Each section contained a basket of closed questions which were designed to gather ordinal data. Section one collected information about the respondent and other subject variables, section two information on pre and post acquisition knowledge and section three concentrated on employee feelings. Sections four and five were related to communication and success. All the data was transformed into numerical data using a five point scale (each answer given a number 0-4, with the higher value reflecting a positive response to the level of knowledge etc.). The scores collected were added together in the relevant variable section, to provide a total score for each variable. A quantitative analysis is undertaken, using inferential statistical techniques. Tests are undertaken to determine that the data collected are at the parametric level. Internal reliability is tested using correlation coefficients between individual questions and the totals of those questions for each variable. Validity of the study is enhanced by tests of data homogeneity, which are executed to determine whether subject variables influence success. Confidence intervals are also calculated. The alpha level is set at $p \leq 0.05$. Qualitative data was collected in an interview with a former director of company B. This data was used to inform the research conclusions.

4. ANALYSIS, RESULTS AND FINDINGS

The underlying concept in this piece of research is to assess if there are relationships between pre and post acquisition knowledge (IV 1), employee feelings (IV 2), communication (IV 3) and success of the acquisition of company B (DV). It is suggested that ordinal data takes account of the differences between ranked scores and is classed as non-parametric, but Bryman and Cramer (1997) suggest that there is a compelling argument to treat the totals in a multiple scale (basket of questions) as interval data (parametric). Due to the sample size and method of data collection used, the data can be assumed to be interval and parametric.

Tests of internal reliability gave significant correlation coefficients of ≥0.50 for forty six out of fifty questions. Mean scores for variables were: pre and post acquisition knowledge 28.6%, employee feelings 30.5%, communication 49.8% and success 52.9%. Confidence interval results (at 95% confidence) showed the ± ratio in all cases was below 5.5%. It is argued that this demonstrates reliability and validity in the study. Tests on the main research hypotheses are shown in table 4.1. A positive correlation was found between knowledge (IV1) and success (DV1), that is the better the knowledge of employees about the acquisition process the higher the success. A negative correlation was found between employee feelings (IV2) and success (DV1), that is the lower the feelings of employees during the acquisition process the higher the success. The correlation coefficient in this case, although significant, is not strong, and it is surprising that it is in the negative direction. More work is therefore needed to validate this result. A positive correlation was found between communication (IV3) and success (DV1), that is the better communication about the acquisition process the higher the success.

Table 4.1: Main hypotheses results

Independent and dependent variables	P value	Correlation coefficient	Cannot reject or reject the null hypothesis
Pre & Post Know (IV1) v Success (DV1)	0.01	0.557	Reject
Employee Feeling (IV2) v Success (DV1)	0.05	-0.282	Reject
Communication (IV3) v Success (DV1)	0.01	0.729	Reject

Statistical tests were also performed on subject variables to test for data homogeneity. Gender, age, role, length of employment and area of work were tested. In most cases p was $\geq$0.05 so the null hypothesis was not rejected and it was found that subject variables did not influence the results.

5. CONCLUSIONS

The literature suggests that M&As are complex and require a large amount of planning and communication. Whilst there are many models and strategies available, each company is different, therefore every acquisition is different. A large amount of emphasis can be place on the financial implications of deals, but the softer issues (people, feelings, communication) are also very important. Due to the fact that there is no defined procedure for M&As, literature suggests that organisations must in all cases assess the needs of companies before undertaking M&As. Bruner (2004) stated that success in M&As is uncertain, and there are many contributing factors which need to be addressed. A best practice approach will benefit anyone undertaking M&As.

The mean score of 28.6% for pre and post acquisition knowledge suggests that employees were not provided with an acceptable level of information about the acquisition. A mean score of 30.5% for employee feelings suggests that many employees experienced a high level of discomfort. The mean score for communication of 49.8% suggests that employees felt the level/standard of communication received during the acquisition process was poor. The mean score for success of the acquisition of company B of 52.9% is considered to be ‘modest’. The authors conclude that data collected in this study suggests that there are significant improvements to be made to ensure that the acquisition of other companies by company A do not become part of M&A failure statistics. An important point raised in the qualitative interview with a former director of company B was that in two years time, the level of success achieved may increase, and that high levels of success during integration periods are unlikely. Recommendations for further study include data collection and analysis of other M&As within company A to provide a greater insight into M&A success in the whole company. It suggested that additional research should be undertaken on integration, people, communication and planning methods involved in M&As and that company A must establish a method of measurement for success on all future M&As. This will enable the company to benchmark its success and establish areas where current M&A strategies succeed or fail.

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SUSTAINABLE DEVELOPMENT AND TQM IMPLEMENTATION IN LIBYA: A STUDY OF THE ELECTRICAL GENERATION INDUSTRY

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Abstract: In developing economies, reliable and consistent power supplies are considered an essential component underpinning the development of urban centres and industries. Consequently, in Libya, increasing urbanisation and industrialisation are placing significant strains on the power generation industry. Total Quality Management (TQM) is widely considered as an essential element in the creation of world class industrial development and performance. There would be an apparent elegance in marrying the concepts of TQM implementation, with the development of economic sustainability through power generation. However, in a developing economy such as Libya, this is not as straightforward as it may appear. TQM is still a new issue for Libyan organisations; these organisations need to establish a new strategy towards quality management. This paper presents the results of a survey designed to measure approaches and attitudes to the implementation of TQM in Libyan electrical power generation industry. The survey secured 306 respondents (61% response rate) from the industry, measuring 10 dimensions of TQM using factor analysis. The analysis of the survey indicates that ten TQM dimensions, comprising only 11 of the original items, account for most of the scale variance. The authors utilise these results to begin to develop the future needs of the Libyan power generation industry in order to deliver sustainable economic and urban development for the future.

Keywords: Electrical Power Generation Industry, Libya, Total Quality Management.

1. INTRODUCTION

Energy is the crucial foundation of any human society and the driving force for economic growth. The importance of energy stems from its contribution to daily life quality and industrial development; while its shortage is associated with periods of international crises. This implies the imperative need for the wiser management of the existing sources of energy in the first place; and the exploration of new/alternative sources. In developing economies, reliable power supplies are considered a cornerstone for sustainable social and economic development. Primarily, the efficient provision of electricity contributes both directly and indirectly to poverty reduction. The direct contribution coming from the fact that electricity contributes to the basic requirements of health and education. Indirectly the provision of electricity enhances economic growth and therefore increased employment. Increased employment reduces poverty. It can be seen therefore that the degree to which any economy has access to electrical power is strongly correlated to the wealth of that nation. Alternatively, it could be stated that the access to electrical power is inversely proportional to poverty. Particularly in Libya, electric power demand has grown rapidly over the past few decades in line with the country's development. Therefore, there is a necessity to explore potential methods for removing significant strains placed on the power generation industry from increasing urbanisation and industrialisation. Total Quality Management (TQM) has been internationally applied in diverse economic sectors and is widely considered as an essential element in the creation of world class industrial development and performance. The usefulness of TQM emanates from the structural, attitudinal, and process improvements it creates (Oakland, 2003) and therefore, its implementation could be considered as a potential solution in achieving sustainable economic growth in Libya through power generation.

This paper presents the findings of a research project which aims to establish a framework for the implementation of TQM philosophy in the electrical power generation industry in Libya. Specifically, it demonstrates the results of a survey designed to measure the current understanding of TQM as the primary task in developing the future needs of the industry. The paper is structured around 3 main issues. Initially, the current situation of the Libyan economy is discussed with an emphasis on the electricity sector. Then, TQM is introduced as a platform which has the potential to support the further development of the industry and contribute to sustainable economic growth. Finally, the responses of 306 participants are analysed providing the basis upon which conclusions are drawn regarding approaches and attitudes to TQM implementation in the Libyan electrical power generation industry.

2. THE LIBYAN ECONOMY

2.1 Economic reform

The Libyan economy is largely based on oil exports which contribute circa 95% of export earnings - equivalent to approximately 30% of the GDP (World report, 2004). Financial sanctions on Libya were lifted on 12 September 2003 after more than 10 years, resulting in the country reappearing back in the mainstream world stage. Mainly due to rising oil prices, exports have doubled over the last 5 years, underpinning substantial economic growth of 4.6% in 2004 (World report, 2004) . Libya has still to face the challenge of modernising its governance structures and expanding its vital infrastructure. These factors combined are a precondition for promoting growth of the non-oil sector and attracting significant foreign investments. The need for vast reform of the public sector has been acknowledged by Libyan policy makers. Currently, substantial reforms are underway to decentralise and privatise industry. The restoration of trade and investment links with the world economy has been accompanied by the privatisation of 360 state-owned enterprises scheduled to be privatised by 2008 (World Report, 2004). The reform agenda includes a £18bn programme, incorporated in the National Development Plan for upgrading existing infrastructure.

2.2 Electricity sector

The Energy sector has a crucial role to play in order for Libya to achieve its ambitious infrastructure and economic development plans (Project Libya, 2006). Libya's demand for power is growing geometrically at 8%pa, with an anticipated demand expected to reach 5.8GW by 2010. Indeed, according to United World (2006), the per capita consumption in KWh increased approximately 9 times between 1970 –2005. Consequently, the current power generation capacity of 4.7GW falls far short of anticipated requirements. To meet this shortfall the General Electricity Company (GECOL) plans to spend US$3.5 billion over the next 4 years building 8 new combined cycle and steam cycle power plants. Furthermore, GECOL has a US$1 billion program to upgrade and expand the country's power transmission grid (Project Libya, 2006). Therefore, the future challenge for the power generation industry consists of 2 mutually crucial objectives; the satisfaction of the increased future needs and the support of the country's economic development. However, it is anticipated that the immense expansion of the power generation capacity will be accompanied by higher requirements for management. Consequently, appraisal of current operational and organisational issues is imperative for ensuring any required changes will take place smoothly and contribute to the sustainable development of the industry.

3. REQUIREMENTS FOR FUTURE DEVELOPMENT

The need for a cultural change in the electrical power generation industry in Libya is recognised by the Chairman of GECOL who underlines that GECOL's short to midterm planned main priorities consist of (United world 2006):

- Upgrading and developing the human resources
- Upgrading technological standards
- Improving management systems
- Introducing modern management techniques

These recommendations indicate lead to the conclusion that substantial efforts will be required to improve industry performance for sustainable future economic development. TQM is widely considered as an opportunity for bringing about the necessary changes and restructuring for modern management (Youssef and Zairi, 1995). Indeed, organizations implementing TQM stand to gain tangible and intangible benefits in many different ways. Overall, successful TQM enhances a company's competitive position in domestic and global markets. Reported TQM benefits include:

- Better quality;
- Faster organizational learning;
- Promoting continuous improvement;
- Increasing organisation flexibility;
- Enhancing organisation responsiveness.

To advance current TQM research, we present 3 main arguments. Firstly, these benefits may not be realized immediately. It takes time for the TQM philosophy to be appreciated by everyone in an organization. TQM benefits do not happen overnight. Secondly, TQM in and by itself cannot succeed unless it is integrated with time-based philosophies such as just-in-time (JIT). Finally, we argue that a holistic view of TQM must prevail throughout the organization and that a major part of the organization must have been converted to using TQM tools and activities. 3 variables, therefore, are essential for TQM success. These are time, organizational transformation to TQM culture and the integration of TQM with these time-based technologies.

4. LITERATURE REVIEW

4.1 TQM definition

There have been many definitions of TQM. See, for example, Crosby, (1979); Ishikawa, (1985); Deming (1986); Juran, (1989); Feigenbaum's (1991); Jablonski

(1992); (1993); Flynn et al. (1994); Powell's (1995); Vuppalapati et al. (1995); Ahire (1996); Oakland and (2003). Some of these definitions are examined below.

Jablonski (1992) defines TQM as: "Both labour and management to continually improve quality and productivity using teams." This definition emphasizes 3 pillars for successful implementation of TQM: participative management, continuous process improvements and the use of teams. However, the definition does not explicitly mention the role that suppliers and customers play in the success of TQM.

Zairi *et al.* (1994) define TQM as: "A positive attempt by the organizations concerned to improve structural, attitudinal, behavioural, and methodological ways of delivering to the end customer, with emphasis on consistency improvements in quality, competitive enhancements, all with the aim of satisfying or delighting the end customer." This definition views TQM from a wider perspective. According to Zairi *et al.* (1994), the definition is meant to include a wide range of critical factors, such as *leadership and hard and soft elements. Leadership elements including mission/vision statement, quality policy, direction, goals, communication process, measurement, quality decisions, strategic planning and deployment, and customer and market focus. Hard elements include tools and techniques, measurement, systems, procedures, specifications and standards. Finally, soft elements include problem-solving approach, teamwork, innovation and creativity, continuous improvement philosophy, empowerment, incentives and process-based approach.*

Oakland (2003) defines TQM as: "An approach to improving the effectiveness and flexibility of business as a whole. It is an essential way of organizing and involving the whole organization, every department, every activity, every single person at every level." This definition explains the term `total' from functional and organizational hierarchy perspectives. It is the closest to our comprehensive definition, in which we argue that `total' can even go beyond the internal boundaries of the organization.

4.2 TQM Practice

Due to the holistic character of TQM different parameters are examined when considering the implementation of TQM. Saraph et al. (1989) argue that there are 8 critical success factors for TQM implementation including: top management leadership, role of the quality department, training, product design, supplier quality management, process management, quality data reporting, and employee relations. Meanwhile, Black and Porter (1996) place emphasis on the customer-oriented nature of TQM revealing ten major TQM practices: people and customer management, supplier partnerships, communication of improvement information, customer satisfaction orientation, external interface management, and teamwork structures for improvement, operational quality planning, quality improvement measurement systems, and corporate quality culture. A more holistic approach is followed by Brah et al. (2000) who, in their study on TQM and business performance in Singapore service sector, come out with 11 constructs of TQM implementation, which are top management support, customer focus, employee involvement, employee training, employee empowerment, supplier quality management, process improvement, service design, quality improvement rewards, benchmarking, and cleanliness and organization. Sureshchandar et al. (2002) expanded the practices even further and came out with 12 major practices comprising of top management commitment and visionary leadership, human resource management, technical system, information and analysis system, benchmarking, continuous improvement, customer focus, employee satisfaction, union intervention, social responsibility, services capes, and service culture. Based on the literature above, the researchers have selected the following list of ten main practices of TQM implementation for this study. All practices are selected due to their usefulness and relevance to the service organization. These elements are listed below:

• Employee Participation	• Customer Satisfaction
• Education and Training	• Quality Policy
• Scientific Approaches to Decision-Making	• Planning
• Quality Management System	• Responsibility, Authority, Communication
• Management Commitment	• Measurement Analysis and Improvement

5. RESEARCH METHODOLOGY

The sample used for this research comprised a number of employees from GECOL. The target respondents were employed staff, such as senior manager, managers, executives, officers and supervisors (middle management). About 500 questionnaires were sent out to target respondents. Accordingly, there was a net useable response of 306 (i.e. 61.2%). This response rate was considered to be good and acceptable given that Saunders et al., (2007) indicates that postal surveys may generally drop to below 40%. The TQM construct measures the extent of TQM practiced in the organization. According to Zikmund (2003), a good questionnaire design is fundamental to obtaining reliable survey results and giving a high response rate. The researcher was conscious that there were several advantages associated with the use of a questionnaire (Sarantakos, 2005). The basic procedures employed in developing the scale for measuring TQM impacts for the purposes of this study followed the procedures recommended by Churchill (1979). There is some steps were taken in developing the instrument. The TQM variables were derived from 2 sources: firstly, a general TQM literature review; secondly, a review of questionnaires studies relating to TQM implementation. The survey questionnaire developed consisted of 3 parts.

Part A, was developed to elicit demographic information; parts B & C consisted of 43 questions adapted from the work of Saraph et al. (1989), Ahire et al. (1996), Sureshchandar et al. (2002) and Brah et al. (2000). These questions incorporating a 5-point Likert scale to measure respondents' level of agreement or disagreement with various statements about TQM implementation in the Libyan electrical power generation. The questionnaire was piloted using a sample of research students and academic staff in the author's institution. This was to ensure the robustness of the questionnaire and whether it could be completed within a reasonable period of time.; Following the piloting of the survey instrument, it was further modified on the basis of comments and suggestions made by the subjects. Thereafter the questionnaire was despatched to the selected sample of subjects in Libya.

6. FACTOR ANALYSIS

Factor analysis is a technique to allow a large number of variables to be distilled into a small number of related factors that could explain most variables that generate the phenomena being studied (Norusis 1990; Hedderson 1991; Pallant 2001). This approach reduces many variables into a few factors best explaining the phenomenon (Pallant 2001). Three main purposes of using the factor analysis include (Bryman & Cramer, 2004):-

- To assess the degree to which items are tapping the same concept.
- To determine the degree to which factors can be reduced to a smaller set.
- To study the factors defined.

Furthermore, factor analysis can address correlations between each variable. Hedderson (1991) suggests that a correlation matrix of variables should be constructed as a preliminary test. It should exclude variables that have correlation values with other variables below 0.4 (Hedderson, 1991) or 0.3 (Norusis, 1990) in absolute terms

6.1 Correlation

Most multivariate procedures analyze patterns of correlation or covariance among variables prior to testing research models (Hair et al. 1998; Tabachnick & Fidell 2001). Correlation coefficient provides the basis of association between 2 variables, which further permits the specification of unique variance shared between variables (Schumacker & Lomax 2004). In this study, Pearson correlation was used to test the bivariate relationships between measured. The Spearman ρ-coefficient is used to test interrelationships between demographic (non-parametric) variables (Pallant 2001).

6.2 Validity and Reliability

The reliability of the questionnaire was tested using Cronbach Coefficient Alpha measurements. The reliability coefficient (α) for the ten elements of TQM practices range between 70% and 81% (Respectable and Very Good), the reliability of the whole 43 TQM elements was recorded at $\alpha = 0.914$. Accordingly, the instrument developed for measuring TQM elements was judged to be reliable and an acceptable instrument through this test, since if correlation coefficients equal or exceed 0.70, it is considered that the test-retest reliability is good (Nunnally and Bernstein 1994; Litwin, 1995). The reliability coefficient (α) of each element of TQM is shown in Table 1. Content Validity was tested through the review of the questionnaire by academics and research stuff. This was done prior to sending out the questionnaire in order to examine 'the extent to which the instrument measures what it is supposed to measure' (Easterby-Smith et al., 2003). Construct validity of each key practice could be evaluated with factor analysis. Factor analysis validates a scale by showing that its constituents (reliability tasks) load the same common factor. If all the tasks listed under a key practice load on a single factor, they measure the same trait. Factor analysis and construct validity have long been associated with each other, and construct validity is also sometimes called "factorial validity" (Cronbach, & Meehl 1955; Thompson & Daniel 1996).

Table 1: Result of data reliability coefficient (α) of each element of TQM

Scales	Label	N of Items	Items for deletion	Cronbach's Alpha (α)
Employee Participation	EP	8 (Q8, 9, 10, 11, 12, 13, 14, 15)	None	.725
Education and Training	E&T	4 (Q16, 17, 18, 19)	None	.753
Approaches to Decision Making	SADM	4 (Q20, 21, 22, 23)	None	.748
Quality Management System	QMS	3 (Q24, 25, 26)	None	.734
Management Commitment	MC	5 (Q27, 28, 29, 30, 31)	None	.790
Customer Satisfaction	CS	4 (Q32, 33, 34, 35)	None	.814
Quality Policy	QP	4 (Q36, 37, 38, 39)	None	.738
Planning	PL	3 (Q40, 41, 41, 42)	None	.704
Responsibility, Authority and Communication	RAC	4 (Q43, 44, 45, 46)	None	.703
Measurement Analysis / Improvement	MAI	4 (Q47, 48, 49, 50)	None	.791

For this study, construct validity was assessed by identifying underlying TQM concept scores on this scale. To determine if the scale had a meaningful component structure, it was factor analyzed. Factor scores were derived on the identified components part B & C of the survey questionnaire. All 43 scale items were included in an exploratory factor analysis. The initial components solution was rotated using the Varimax procedure, with an Eigenvalue > 1.0 used as the criterion for factor retention. As depicted in Table 2, after 8 iterations and using a minimum factor loading of 0.40 (Nunnally and Bernstein, 1994), a meaningful 8-factor solution emerged. In combination, the 8 factors accounted for 53.95% of the TQM scale variance.

Table 2: Rotated Component Matrix

	FACTORS (Component)							
Questions	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**
Q17	**.743**							
Q18	**.738**							
Q19	**.720**							
Q20	**.708**							
Q23	**.679**							
Q21	**.664**							
Q22	**.500**							
Q16	**.435**							
Q34		**.744**						
Q33		**.694**						
Q32		**.640**						
Q31		**.516**						
Q30		**.432**						
Q48			**.771**					
Q49			**.757**					
Q47			**.626**					
Q50			**.602**					
Q13				**.638**				
Q9				**.615**				
Q14				**.589**				
Q8				**.559**				
Q11				**.522**				
Q10				**.496**				
Q12				**.419**				
Q27					**.685**			
Q28					**.626**			
Q29					**.604**			
Q15					**.557**			
Q37						**.806**		
Q38						**.740**		
Q36						**.717**		
Q39						**.502**		
Q40							**.715**	
Q42							**.664**	
Q41							**.648**	
Q43							**.415**	
Q24								**.756**
Q26								**.748**
Q25								**.743**
Eiganvalue	**8.23**	**3.54**	**2.29**	**1.78**	**1.63**	**1.48**	**1.38**	**1.25**
% of Variance	**20.58**	**8.84**	**5.73**	**4.46**	**4.10**	**3.69**	**3.46**	**3.13**
% Cumulative	**20.58**	**29.42**	**35.15**	**39.60**	**43.67**	**47.36**	**50.82**	**53.95**
Cronbach α	**0.84**	**0.80**	**0.79**	**0.71**	**0.72**	**0.74**	**0.70**	**0.73**

Extraction Method: Principal Component Analysis, Rotation Method: Varimax with Kaiser Normalization, a Rotation converged in 8 iterations.

7. FACTOR ANALYSIS RESULTS

43 questionnaire items were correlated and subjected to exploratory factor analysis (EFA) by principal component analysis (PCA) with Varimax (orthogonal) rotation using SPSS 14.0 to detect the factor structure in the variables. Prior to PCA the suitability of data for factor analysis was assessed. The correlation matrix revealed the presence of coefficients of > 0.3; Kaiser-Meyer-Oklin (KMO) Measure of Sampling Adequacy value was 0.848, exceeding the required threshold of 0.6 (Kinnear & Gray, 2006; Field, 2005). Bartlett's Test of Sphericity (Bartlett, 1954) reached statistical significance, supporting the factorability of the correlation matrix (Chi-Square = 4174.390 with 903 degree of freedom, at $p < 0.001$), indicating that the correlation matrix was not an identity matrix. These results provide an excellent justification for

the factor analysis (Kline, 1998). Factor analysis of the scale items was therefore deemed appropriate.

7.1 Factor rotation

Factor analysis with PCA was performed on the 43 management practice items to determine the number of factors. From the EFA and by using the scree plot as a guide, eleven factors comprised of 43 items were extracted using the KMO method (eigenvalue greater than 1), accounting for 60.789% of the total item variance. Explaining 20.69%, 8.27%, 6.04%, 4.16%, 3.79%, 3.45%, 3.41%, 3.3%, 2.8%, 2.53% and 2.36% of the variance respectively. The scree plot revealed a clear break after the eighth component. Catell's (1966) scree test, was used to determine that 8 components be retained for further investigation. Varimax rotation was used to aid interpretation of the 8 components. Q35, Q45 and Q46 were excluded from this rotation because they were shared other factors; Q44 was also removed since its loading was <0.4. Factor analysis on the remaining 39 items of the scale produced 8 factors (Table 3).

Table 3: Total variance explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.231	20.577	20.577	4.084	10.209	10.209
2	3.536	8.839	29.416	2.885	7.213	17.422
3	2.292	5.729	35.145	2.740	6.850	24.271
4	1.782	4.456	39.601	2.489	6.223	30.494
5	1.626	4.065	43.666	2.472	6.179	36.673
6	1.478	3.696	47.362	2.429	6.071	42.744
7	1.384	3.460	50.822	2.268	5.670	48.414
8	1.252	3.130	53.952	2.215	5.538	53.952

Extraction Method: Principal Component Analysis

The 8 factor solution explained a total of 53.95 per cent of the variance, with component 1 giving 10.21%, component 2 giving 7.21%, component 3 giving 6.85%, component 4 giving 6.22 %, component 5 giving 6.18%, component 6 giving 6.1%, component 7 giving 5.7% and component 8 giving 5.54%. The interpretation of the 8 factors as shown in Table (3) might be presented as follows:

Factor 1: consists of 8 questions (16-23). *Education and Training (E&T)* factor covers training programs, providing employees with sufficient training, developing the training plans and qualifications, scientific approach to finding, solving, and decision making to preventing problems. The Cronbach α score for factor 1 is 0.84.

Factor 2: consists of 5 questions (30-34). *Customer satisfaction (CS)* factor covers investigation of customer complaints, customer needs and expectations, data from customers to improve services, improvement in quality and services, and confidence. The Cronbach α score for factor 2 is 0.80.

Factor 3: consists of 4 questions (47-50). *Measurement Analysis and Improvement (MAI)* factor covers product conformity, promoting the use of statistical tools to measure customer satisfaction, and collects and analyse appropriate data to evaluate where continual improvement of the effectiveness of TQM System. The Cronbach α score for factor 3 is 0.79.

Factor 4: consists of 7 questions (8-14). *Employee Participation (EP)* factor covers participation of all employees in TQM activities, implementation of quality improvement leaders, teams, and teamwork structures. The Cronbach α score for factor 4 is 0.71.

Factor 5: consists of 4 questions (15, 27-29). *Management Commitment (MC)* factor includes top management establishment of quality policy, quality objectives and communication to organisation, ensuring resource availability, and regular review of quality policies and objectives. The Cronbach α score for factor 5 is 0.72.

Factor 6: consists of 4 questions (36-39). *Quality Policy* (QP) factor includes Quality policy commitment to continuous improvement, policy communication within the organisation, policy is reviewed periodically for continuing suitability. The Cronbach α score for factor 6 is 0.74.

Factor 7: consists of 4 questions (40-43). *Planning (PL)* factor includes measurable quality objectives, quality documentation, resourcing for achieving quality objectives and clear responsibilities and authorities. The Cronbach α score for factor 7 is 0.70.

Factor 8: consists of 3 questions (24-26). *Quality Management System* (QMS) factor includes maintenance of a quality manuals, policy and documentation also conducting internal audits of the quality system. The Cronbach α score for factor 8 is 0.73.

7.2 Factor correlation matrix

The interrelationships between the 8 factors, shown by factor correlation is depicted in Table 4. This table represents the positive and statistically significant correlations between the TQM elements described above. From that table also we can see there is no correlation significant between quality management system, education and training and employee participation

Table 4: Correlation Matrix

Factor Label	Factor	F1	F2	F3	F4	F5	F6	F7	F8
E&T	F1	1.000							
CS	F2	.375**	1.000						
MAI	F3	.292**	.528**	1.000					
EP	F4	.478**	.357	.263**	1.000				
MC	F5	.310**	.499**	.319**	.411**	1.000			
QP	F6	.220**	.352	.271**	.237	.396**	1.000		
PL	F7	.229**	.424**	.341**	.257**	.477**	.415**	1.000	
QMS	F8	.017	.305**	.157**	.080	.328**	.294**	.331**	1.000

Note: N= 306, Correlation is significant at 0.01 levels (2-tailed)

8. DISCUSSION

The findings show that successful TQM implementation can be affected by E&T, CS, MAI, EP, MC, QP, PL and QMS factors. In more detail, the results of the factor analysis indicated that E&T was positively related to electrical power generation and had the greatest impact on TQM as compared to the other nine practices. CS was also positively related to the electrical power generation (EPG) industry. This was an expected outcome since customer satisfaction is at the nexus of any successful TQM system. Indeed, this reinforces the observations of Patel (1995), who focuses on customer needs in delivering better quality. Similarly for MAI, it was found to be positively related to electrical power generation which in translates into better quality. Employee participation (EP) was also a significant factor in explaining the variations in electrical power generation supporting further the literature findings. The positive relationship supports the argument by Geralis and Terziovski (2003), as well as study made by Gilbert and Parhizgari (2000), in which they found that effective TQM practices improve quality. As mentioned by Dean and Helms (1996), both employees and managers must be committed enough and trust must be developed among them in order for the TQM implementation to succeed. This result also highlighted that the Management commitment (MC) in TQM development was important and that a lot of effort had to be put in for the implementation of quality. Top management support and participation are imperative for any organization that claims quality (Daily, 1992). In the same time the QP, PL and QMS elements were found to be to a greater of lesser degree positively related to electrical power generation. The correlation analysis shows that there was nature interrelationships between these 8 factors, there was significant correlation between most of these elements in TQM implementation success (see Table 4).

The factors extracted in this study exhibit an acceptable degree of reliability, internal consistency and cronbach alpha test results. The factor structure is robust to Varimax (orthogonal) rotation methods. All factors tested for content validity, and in light of rational considerations by both an academic research student and expert, were considered valid. This is supported by the evidence of the item analysis derived from suggestions by Nunnally and Bernstein, (1994). Unifactorial tests provide evidence of the construct validity of all factors. The goals of the research design, namely to identify some management approaches to total quality management (TQM) within this sector, based scale of item scores and to identify the critical factors of TQM, were consequently met. From a theoretical perspective, this study demonstrates the importance of TQM practices in this sector of industry. In addition, it contributes to the understanding of TQM applied to electrical power generation. Indeed, it is vital to be aware of the particular TQM practice encouraging quality orientation in these organizations. Managers of the organization may then work on changing the TQM practices that fosters the quality orientation in their organization.

9. CONCLUSIONS

The paper presented the results of a study on TQM carried out in the Libyan electrical power generation industry. A total of 8 factors, consisting of 39 variables, were considered in the questionnaire. From the analysis of the correlation matrix, it was found that most of the factors are inter-correlated in the electrical power generation industry. Besides, from the analysis of the prioritization of ranking data, it was found that education and training is the most influential factor for TQM implementation. The least important factor was found to be the quality management system. The results of critical success factors in order of importance are arranged in the following manner.

Rank	**Factor**	**Rank**	**Factor**
1	Education and Training	5	Management Commitment
2	Customer Satisfaction	6	Quality Policy
3	Measurement Analysis & Improvement	7	Planning
4	Employee Participation	8	Quality Management System

Therefore, it can be seen that the adoption of TQM is rather an internal issue of GECOL's future development plan in the first place; and additionally a matter of public policy in delivering public services and infrastructure support. The steady and balanced expansion of the organisation can be ensured by focusing on human resources training and development. It would appear that the primary observation that can be made from the findings of this study is to inform the implementation of TQM in the Libyan power generation industry. E&T issues would seem to be of pre-eminent importance to the industry since they are ranked first in the factor analysis. Similarly, CS, MAI and EP are also ranked as the principle factors for successful TQM implementation. These issues are all relatively low level, operational issues within companies concerned oriented towards lower levels in the hierarchy of the organisation. Conversely the lesser factors for successful TQM implementation are MC, QP, PL and QMS issues. This is significant in that the lesser factors are all more strategic in their nature, oriented around senior management and senior employees.

These are significant results overall since they imply two distinct possibilities. Firstly; they may imply that the current emphases of TQM implementation at a higher level in these organisations to drive the process into the lower levels of the organisation are misplaced in the Libyan context. This would further imply that in order to effectively implement TQM, low level employee focussed training and indoctrination is the most appropriate way ahead for the power generation industry. Conversely, a further contention would be that the differential in the factors could be traced to a misplaced understanding of where the responsibility for TQM implementation lies; i.e. the respondents did not understand the need for senior management leadership in TQM implementation. These seemingly opposed observations are actually two sides of the same coin, although they will require further investigation in order to resolve the paradox. Once further detail is put in place, GECOL will be in a substantially better position to address TQM implementation in the power generation industry by creating an implementation strategy better suited to the particular needs of the Libyan industry. Ultimately, this will increase the performance of the industry, better deliver customer satisfaction, and support sustainable development of Libya's economy in the future.

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THE INTEGRATION OF CONDITION BASED MONITORING TECHNIQUES AND METERING DATA WITH BUILDING ENERGY MANAGEMENT SYSTEMS FOR IMPROVED MAINTENANCE STRATEGIES AND ENERGY PERFORMANCE

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Abstract: Regulations for England and Wales have made it compulsory for building operators to use metering to account for at least 90% of energy usage. Effective sub - metering is a valuable tool for measuring the energy consumption within different zones of a building.

However, simply increasing the amount of metering alone will not improve the energy efficiency of a building. Current Building Energy Management Systems are capable of measuring energy consumption, but their ability to synthesise metering data and compare results to benchmark energy consumption data is limited. Furthermore, data is not collected and analysed in such a way as to identify the reasons why benchmarks are not being met and hence initiate targeted remediation.

Within other sectors of industry, for example railways and power generation, extensive use has been made of condition based monitoring techniques to provide a means of effective, timely and cost effective maintenance strategies. The use of such techniques within buildings has hitherto been minimal, but their use would have clear advantages. The integration of energy consumption monitoring and targeting with condition based monitoring would be a major step forward.

This paper describes a methodology by which this integration could be achieved, and highlights some of the key technical and operational issues that need to be taken into account. Of these issues, it is clear that the most significant is that of ensuring efficient handling and processing of the large amounts of data that would be collected, and this means that use will have to be made of data mining techniques.

Keywords*:* Maintenance, Condition Based Monitoring, Building Energy Management System, Metering, Data mining.

1. INTRODUCTION

The last several decades have seen buildings evolve into larger, more complex entities and in doing so have seen the level of the energy required to meet the needs of the occupants increase. Fears over climate change and limited sources of fossil fuels for energy generation have added to the drive for cleaner and improved performance of buildings. Within the UK 30% of carbon emissions can be attributed to the building sector [1], in addition to this, the steadily increasing cost of utilities have meant that both the state and building owners alike, now wish to improve on the energy efficiency within buildings. As a result the government has sanctioned radical amendments to Approved Document L (Part L) of the building regulations concerning the conservation of fuel and power. Part L now requires building operators to account for 90% of energy consumed via metering/sub-metering [2].

In the past metering strategies simply reflected the need of the occupants to determine their energy consumption namely for billing purposes. This provided little information on how much energy was being consumed by each end-use and whether the system concerned was operating economically/efficiently. As a result comparison of metering data with benchmarked performance figures was difficult to achieve. Furthermore, this led to the state, where buildings would be continually performing inadequately in the long term due to problem areas going unnoticed.

The first step in understanding just how much energy is being consumed by a building is to measure the quantity of energy being used for each end-use. To accomplish this it is necessary to sub-divide each end-service and sub meter it, this cannot be achieved via a single incoming utility meter.

2. CURRENT RESTRICTIONS

As mentioned previously, metering strategies were mainly used for billing purposes. Effective sub-metering is essential in achieving improved energy management, in essence it allows for the segregation of various end-uses (lighting, ventilation, office equipment). A sufficient metering strategy has the potential to enable owners or occupiers to measure their actual energy consumption via energy meters/sub-meters [3]. It should be noted that metering alone will not improve the energy efficiency of a building. To fully benefit from the metering strategy, data from each meter must provide adequate information which can be easily monitored and logged for use by the building owner. However, providing vast arrays of numerical data to the end-user is ineffective, the lack of interpretation leads to a state where the information being supplied is continually ignored. To simplify the process, Building Energy Management System (BEMS) were utilised for monitoring and logging data; however, very few systems provided the critical stage of interpreting the data. Fewer still have integrated benchmark figures (target emission rate) to inform the building owner of how well the building is performing in comparison to the benchmark.

Presently, few systems utilise metering data for reasons other than measuring consumption rates. Comparison of data with benchmarks is essential for determining of how well a building is performing. In circumstances where a building is failing to perform adequately the cause of failure is not given. Although there are several monitoring and targeting software packages available to manage energy consumption, these will prove to be ineffective unless they provide appropriate data/commands to the end-user [4]. Current systems have the distinct inability to inform the end user of where the problem lies and what corrective action is required to improve the building efficiency. Identification and location of the problem is essential for optimal performance, reasons for failure to comply and remedial action must be given to the end-user in order for them to effectively combat the problem. This in itself shall only be effective if the outputs given by the BEMS provides the end user with potential reasons for the malfunctioning system and locates the source of the problem, currently BEMS at their best simply highlight that there is a problem in building and little more with no indications of the source problem and no remedial actions.

This in effect leads to a situation where benchmarks are not met and building operators are unable to determine the causes of failure for compliance. As a result facilities management teams are under prepared to tackle maintenance issues which may drive up the energy consumption leading to failure to comply with Part L. Condition Based monitoring (CBM) has successfully been utilised for fault detection in other industries, however, within the building industry very little work has been done to integrate CBM with BEMS. This is a necessary step in order to provide an active targeting system that has the distinct feature of identifying problems and providing remedial action. The following section describes the methodology involved in synthesising metering data for improving energy performance and maintenance within buildings.

3. CBM METHODOLGY

The changes in Part L have provided the opportunity to use the increased levels of metering data for improved energy performance as well as providing evidence of compliance via the BEMS and Condition Based Monitoring techniques. The BEMS can be utilised in a proactive manner in which shall actively monitor specific end-uses and provide appropriate information to the building owner. To achieve this it is required that the BEMS is able to take data from meters and other sources (such as sensors) to provide the building owner with information on building performance in comparison to the benchmark. The main step in achieving this is to programme the BEMS to ‘handle’ the incoming data and to process it effectively. To further this aim, CBM techniques should be employed to deliver in-depth analysis of building performance, maintenance requirements and remedial action.

Condition based monitoring is the technique of analysing data from a system to predict the operational state of that system and when/if the system will fail. Currently CBM has largely been applied to other industries such as the rail industry and has been considered more widely within the aerospace industry. The data given to the BEMS from meters, sensors and feedback signals can be utilised for fault detection. CBM techniques can be used to determine which area of the building services is not performing adequately but far more importantly if the service is performing in compliance with Part L and the point at which corrective action is imperative.

The methodology involved in achieving this, firstly requires an appropriate metering strategy. The minimal level of metering should at least cover the building services equipment. Other sources of energy consumption such as office equipment that has a relatively predictable/stable consumption rate may be estimated or use indirect methods of metering.

Take the case of a 3 storey building, a typical electrical metering schematic is shown in figure 1.

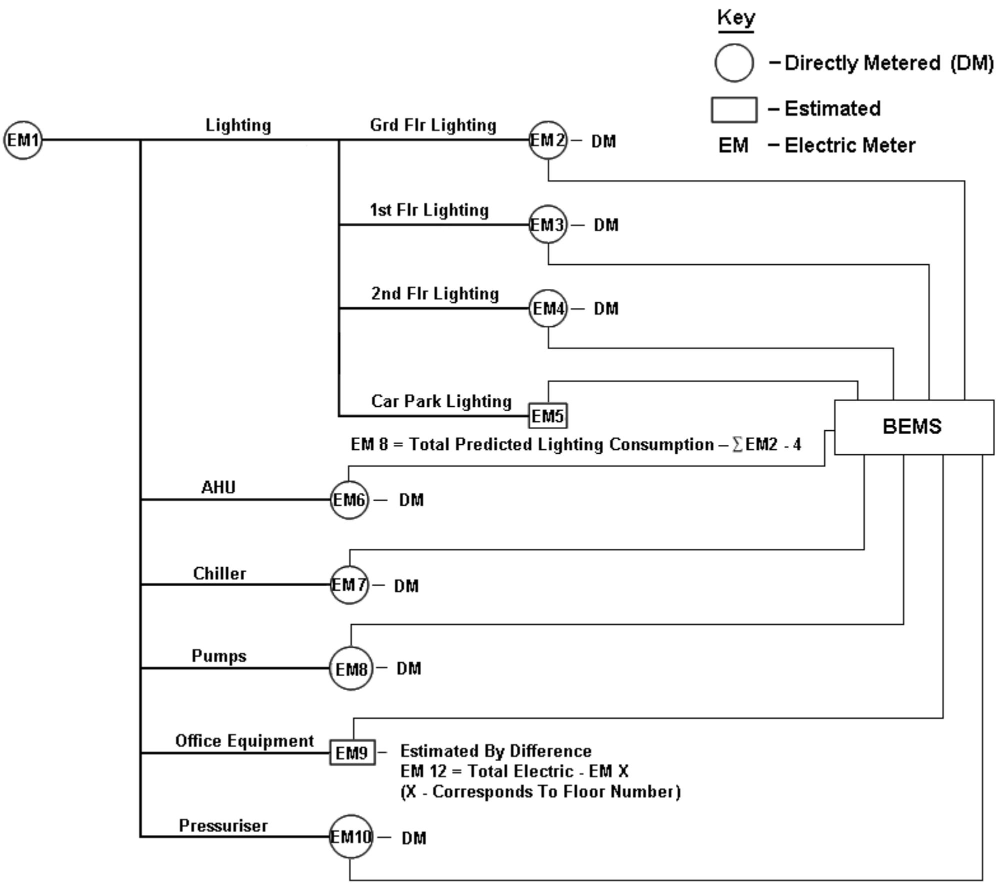

Figure 1: Typical metering strategy applied to a 3 storey building

Each meter feeds data into the BEMS, the estimated consumption is also programmed into the BEMS. The data can then be utilised to provide an accurate figure for energy consumption of electricity that can then be compared to the benchmark figures. The new strategy should aim to keep track of end-uses such as power consumed by lighting, ventilation systems and other services and provide indication of any significant deviations from the predicted benchmark.

The metering information can be fed into the BEMS to form part of a network, the overall CBM technique operates under a network of sensors, feedback signals, and control mechanisms all of which is connected with the BEMS. Figure 2 gives an overview for the of the CBM network.

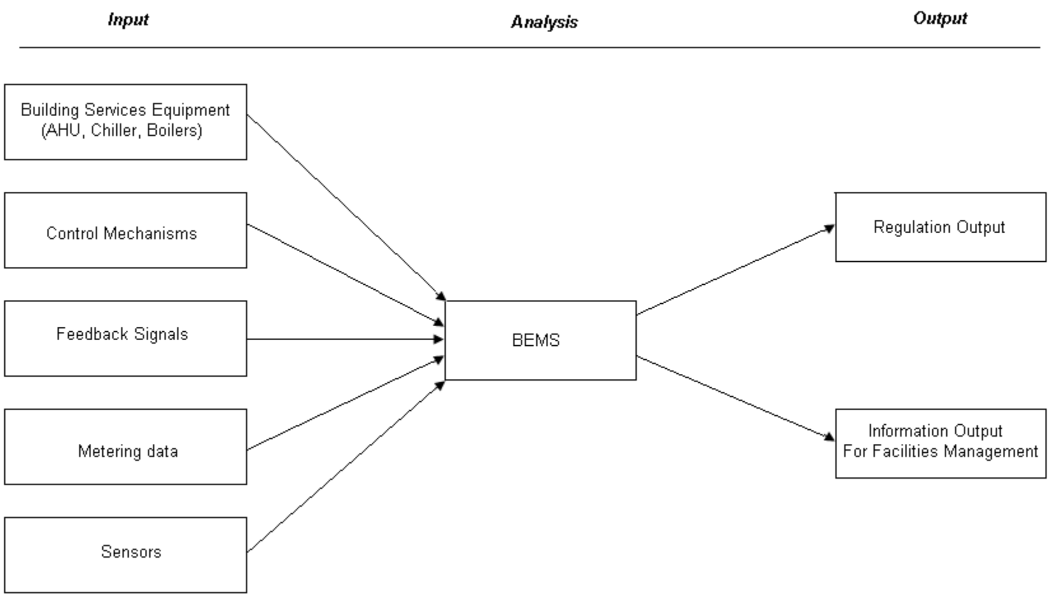

Figure 2: CBM data network

As illustrated in figure 2, the BEMS receives data from various sources, processes the information (as well as logging the data) before either continuing normal operation or informing the end-user of any problems in the system.

The analysis carried out by the BEMS is based on a model which is pre-programmed into the BACnet software base. There are two main types of decision-making models, Data Orientated Techniques and Knowledge Based Models. In the case of the of the Air Handling Unit (AHU) example shown below, Expert Knowledge (Knowledge Based model) algorithms shall be applied as this provides an illustrative method of decision making.

The knowledge based model analyses the various factors and provides a cause of failure based on what is known about the system (using rules and facts) [5]. The code structure takes knowledge about the system and converts them to 'if/and/then' sequences [6] it is based upon a set of rules dependant on knowledge known about the system and the symptoms shown when the system is malfunctioning. Take the example of an AHU which is showing a steady increase in energy consumption, the knowledge of the system can reveal that this will occur when the air inlet louvers are blocked given a certain period of time has passed.

Using the network of connections to the BEMS, energy performance can be monitored and analysed in the event of the building performing poorly, figure 3 shows the process by which this is accomplished.

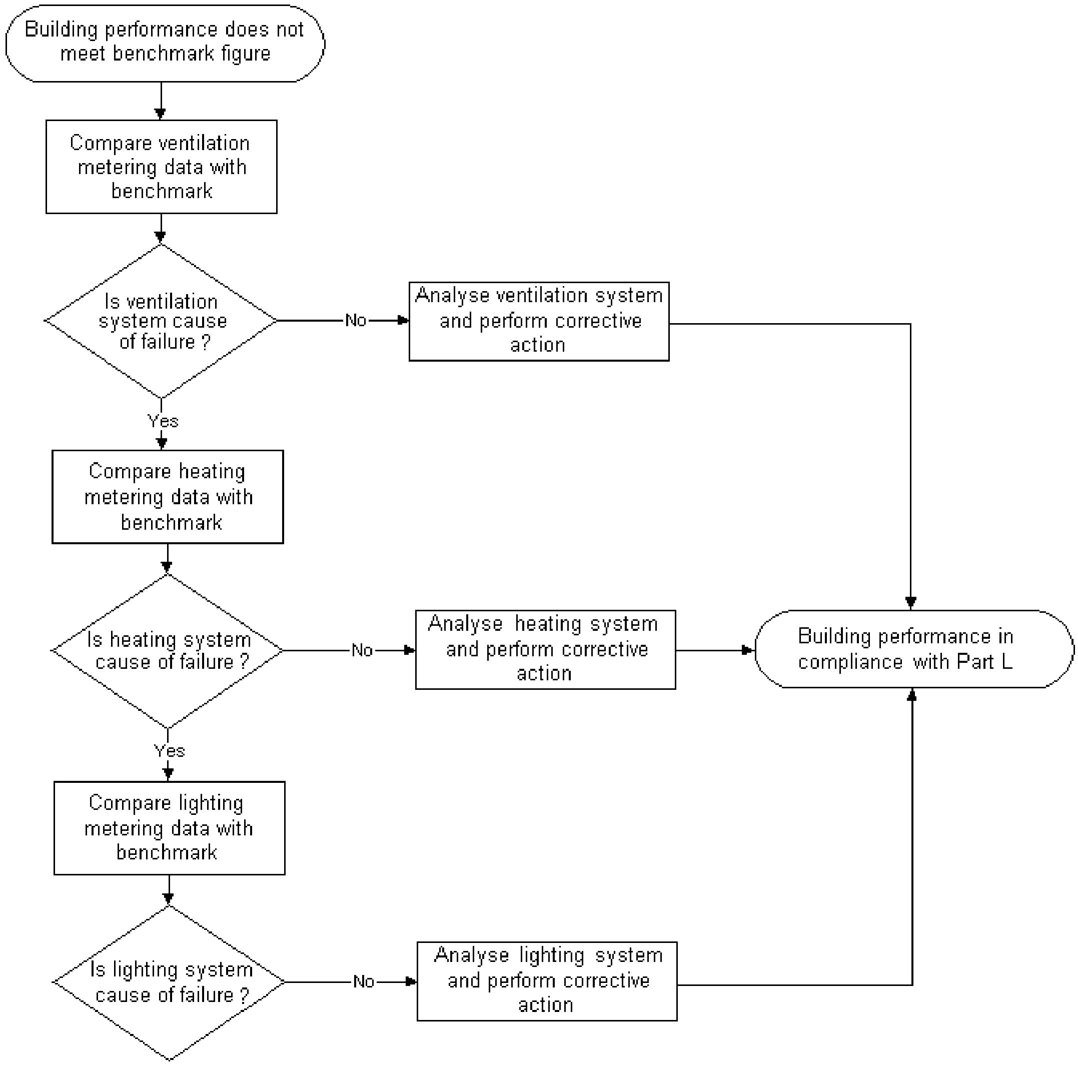

Figure 3: CBM flow chart applied to energy management

This level of monitoring allows for targeting of the areas that are underperforming in comparison to the benchmark. To explain the methodology further, consider the case of a building which is experiencing a large increase in the level of energy consumed by the ventilation system. Shown in figure 4 is the network of information between the BEMS and the components within a typical ventilation system.

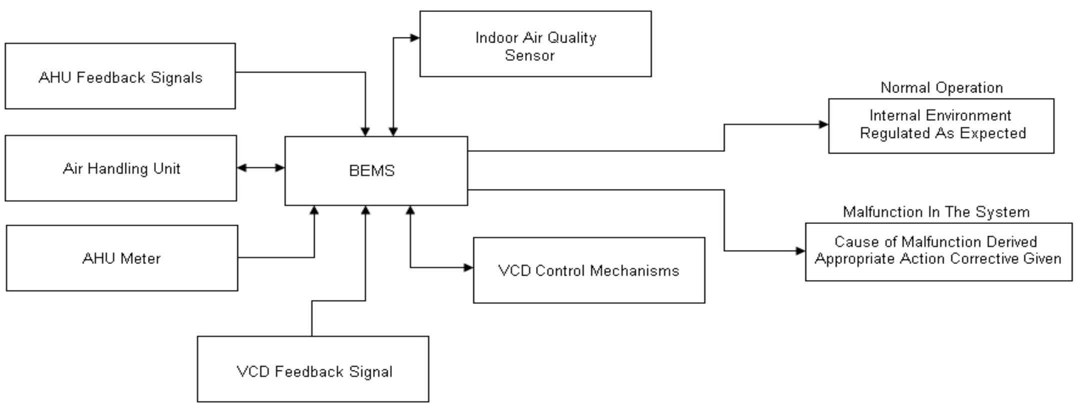

Figure 4: Information network of a typical ventilation system

The significant components are connected to the BEMS and analysis of the state of the system is carried out based on the expert knowledge model. Application of the CBM knowledge based model can be applied to specific areas (as shown in figure 6) within the building as well as the overall condition of the building.

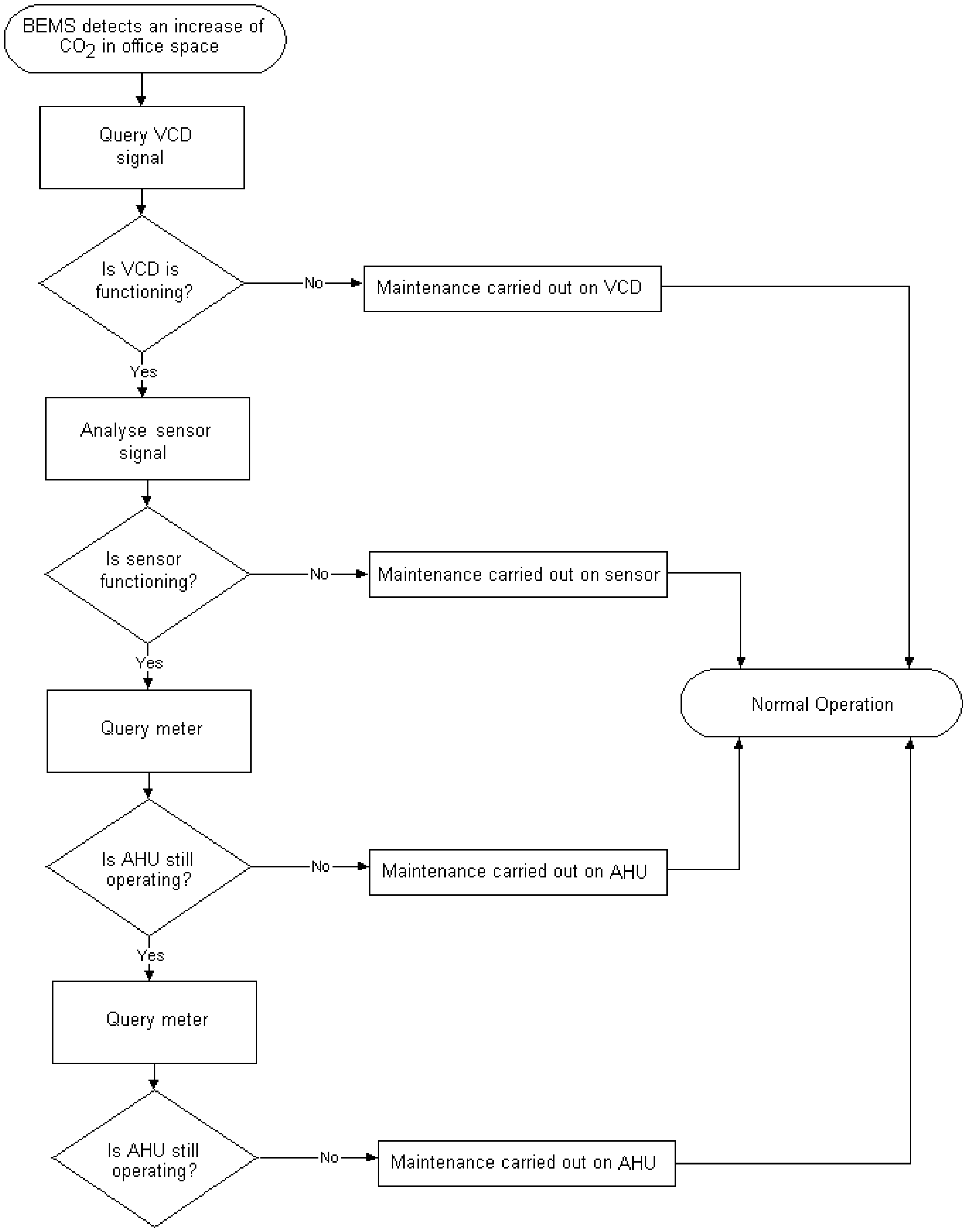

Figure 5: Flow diagram illustrating CBM methodology applied to the ventilation system

The flow chart provides several potential causes of failure which results in causing the building to fail compliance and their respective remedial action. It uses the knowledge based system to assume that there are only four causes of failure (although in reality there maybe anomalies that causes failure, which needs to be taken into account), and bases the decision for maintenance upon them. Maintenance action will be flagged and the end-user will be informed of the corrective action based on the analysis of the signal and most likely cause of failure.

By measuring the deviation of the signal the most probable cause of failure can be detected and isolated as the point of failure. For simplicity, the signal analysis branches have been omitted from the flow chart in figure 5; using the example of a malfunctioning VCD, it is possible to query the VCD unit if a feedback signal is available, this can be used to determine the probability of the VCD being the most likely cause of failure. Further analysis of the signal can provide greater insight into the problem. The table 1 highlights a range of possible problems dependant on the deviation of the feedback signal:

Table 1: Knowledge based model applied to signal analysis

Signal Deviation	***Model Based Rule***	***Action Required***
10%	Overcompensation for other malfunctioning system	None
30%	Damper hinges are 'sticking'	Oil damper hinges
50%	Dampers are stuck	Investigate cause of problem and maintain

An abnormal feedback signal can be analysed and compared with the feedback signals of the other equipment within the network, using a Expert Knowledge it is possible to determine which signal represents the cause of the failure. This allows for differentiation between a failure signal and one exhibiting a deviation due to the equipment overcompensating for the overall failure. If the deviation is caused by overcompensation it then the decision-making rule would exclude it from further analysis as shown in figure 6.

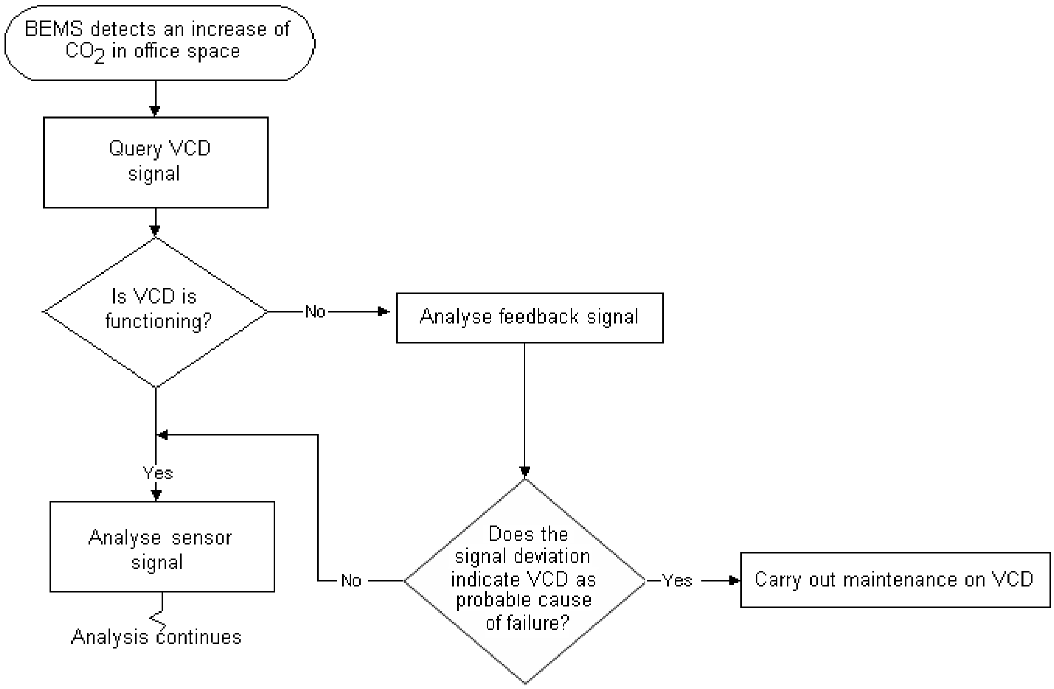

Figure 6: Flow chart of CBM and model based techniques

Application of CBM can be applied to any environmental control system with electrical connections to the relevant building services equipment. CBM techniques can be used to analyse overall energy performance to evaluating the health of an individual piece of equipment.

4. CONCLUSION

Taking into account metering data in combination with CBM provides a far more holistic approach to building energy management, it allows for the assimilation of data for monitoring and targeting. In addition to this, it provides a route for locating and targeting the causes of non-compliance as well as highlighting maintenance issues. Integrating an appropriate model into the BEMS can allow it to carry out CBM techniques will create an active method of monitoring energy consumption as well as providing end-users with a system by which they will be informed of how well they are performing in comparison with the benchmark and what actions (if any) need to be taken to improve building performance. Using the open source BACnet software base, a knowledge based model can be applied as a means of controlling the internal environment, monitoring and targeting energy consumption and for the application of CBM for maintenance.

Due to the large quantities of data being fed to the BEMS, provisions need to be made for data mining and assimilation of the incoming data to ensure that the system is not flooded with data. Appropriate model selection is imperative for ensuring accurate feedback is given to the end-user to act upon.

5. FUTURE WORK

Further analysis of the appropriate model for the system is required; data mining techniques must be applied to filter incoming data for processing.

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PROMOTING SUSTAINABLE BUSINESS COMPETITIVENESS IN CONSTRUCTION SMEs: MANAGING CHANGE ACROSS THE PROJECT DELIVERABLES

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Abstract: Change management is essential in driving continuous improvement within an organisation. This paper reports on how construction companies have managed change by addressing sustainability across four key project deliverables. The project is funded by the Scottish Executive, Expertise, Knowledge & Innovation Transfer Fund and the European Regional Development Fund to provide free and be-spoke assistance to participating small and medium construction enterprises in the West of Scotland. The project has involved assistance of over forty construction companies and this research study focuses on feedback obtained through interview questionnaires conducted with the participating companies.

It is concluded that the Construction Competitiveness Project has resulted in change within construction companies across a number of areas under the sustainability theme. This is evident from the number of new products and processes that have been introduced. Products include client packs that architects have developed with a sustainability focus, and new technology introduced by construction related manufacturers. New processes include auditing targets in Environmental Policy Statements and reviewing energy saving measures to reduce company carbon footprints. These changes have been endorsed by senior management, driven by an environmental champion and targets have been regularly monitored. It is concluded that the aims of this project have been met due to the participating companies being clear of what they have to do to address sustainability issues and how they can monitor this to ensure continuous improvement.

Keywords: change management, construction industry, deliverables, SMEs, sustainability

1. INTRODUCTION

The Construction Competitiveness project is targeted at small and medium enterprises (SMEs) across the construction industry which includes design professionals e.g. architects, contractors and surveyors and other key members of the supply chain; manufacturers, suppliers and the various trades. Table 1 shows the breakdown of companies. The project is a two year project now in the final stages of project delivery. The project aims to provide advice and assistance to at least thirty construction SMEs which includes both new and existing businesses. This paper reports on how construction companies have managed change by addressing sustainability across the project deliverables.

The project is being lead by the Sustainability Centre in Glasgow which is part of Glasgow Caledonian University. The Centre has been given project funding from the Scottish Executive, Expertise, Knowledge & Innovation Transfer Fund (SEEKIT) and the European Regional Development Fund (ERDF) to provide free and be-spoke assistance to participating SMEs in the construction industry in the West of Scotland. To deliver this service, the Centre is working in partnership with Laing O'Rourke (an international construction company), Dearle & Henderson (a multi-disciplinary consultancy company) and the Centre for the Built Environment (CBE) (an initiative between Glasgow Caledonian University, University of Strathclyde and The Glasgow School of Art to encourage knowledge transfer between businesses and academia).

Table 1: Company Types and Number Participating in Project

Company Type	No. of Companies
Architects	18
Manufacturers	5
General Building Contractors	4
Property Developers	3
Demolition Contractors	3
Electrical Contractors	2
Joiners	2
Quantity Surveyors	1
Aggregates Suppliers	1
Civil Engineers	1
Flooring Contractors	1
Maintenance Contractors	1
Total	**42**

2. SUSTAINABILITY AND SUSTAINABLE CONSTRUCTION

Sustainability means meeting the needs of the present generations without comprising the needs of the future generations. This can be achieved through effective and efficient use of natural resources causing less impact on the environment.

Concerning the construction industry, sustainable construction practices are regarded as one of the key success factors for strengthening business competitiveness and productivity in the industry. This has been highlighted in a number of documents published by government bodies; NAO, 2007; DTI, 2006; CRISP, 2003; SCTG, 2003; DTI, 2002; DETR, 2000. The DTI highlights that the promotion of sustainable development can be viewed as part of a wider improvement agenda within the construction industry. The UK government state that the construction industry should contribute to the achievement of sustainable development by the following:

- being more profitable and competitive;
- delivering buildings and structures that provide greater satisfaction, well-being and value to customers and users;
- respecting and treating its stakeholders more fairly;
- enhancing and better protecting the natural environment; and
- minimising its consumption of energy (especially carbon-based energy) and natural resources (DTI, 2006).

Therefore, from the above, it is evident that sustainability is a business driver and one that benefits both businesses and the environments they operate in.

2.1 Background on SMEs and their Impact on the Construction Industry

The EU definition of Small and Medium sized Enterprises (SMEs) are firms / organisations employing up to 250 employees and having an annual turnover of less than £26 million (European Commission, 2005).

Noticeably, SMEs have a particularly important role within the construction industry. In the UK, there were 3.7 million businesses in 1999 which in turn, could be regarded as actively small businesses, accounting for 99% of overall businesses and 50% of non-government employment. In Scotland, nearly 250,000 SMEs are the backbone of the economy, accounting for nearly half of all private sector employment. It should be noted that 18% of the UK SMEs base is within the construction industry and around a sixth in Scotland (Scottish Executive Social Research, 2003). Therefore change implemented within SMEs will have a significant impact on the whole of the construction industry.

3. CHANGE MANAGEMENT

This section summarises change management by outlining the issues associated with the effective implementation of change management, and presenting generic good practice in change management which can be drawn upon to inform any change initiatives. Change management is about change in individuals, teams and businesses / organisations that allows them to make the transition from where they are to where they want to be and involves learning new things and implementing new systems. For an organisation it is also about improving performance and ensuring a competitive edge.

It is recognised that organisations must strive to respond to forces for change or they may not be able to survive. A key responsibility of senior management therefore is to establish and implement new business strategies to meet the challenge of these new and competitive pressures. It is evident from the discussion above that sustainability must now be at the forefront of construction companies' change strategies. This section describes the cycle of change within a company, methods for implementing change, driving change, and the consideration of external factors affecting change.

3.1 The Cycle of Change

The activities involved in change are evaluating, planning and implementing change which may be strategic, operational or tactical. Therefore managing change involves ensuring these activities are done effectively to meet the requirements of the organisation. Any change initiative must not only be focussed on the business factors but also the people factor that is at the heart of the change process (Bechtel and Squires, 2001). From the project experience, any project deliverable has involved senior management who are responsible for driving change and gaining support of employees. Employees require to be made aware of change that is to be implemented in their organisation. This may be through working as a team to meet targets outlined in Environmental Policy Statements or reviewing their daily operations and how they work to minimise their energy use for the purpose of a reduction in the company's carbon footprint. Figure 1 illustrates the cycle of planned change which may be adopted in an organisation. This commences with identifying what requires to be done; 'scoping the change', making and maintaining any changes for improvement and embedding them prior to starting the cycle again.

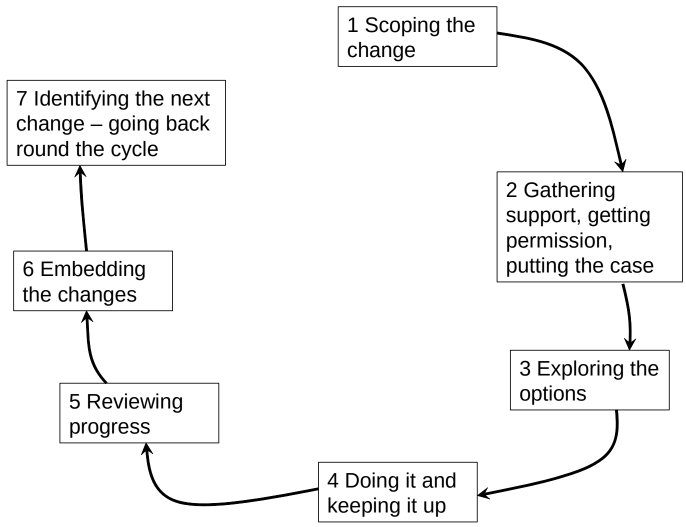

Figure 1: The cycle of planned change (adapted from IEMA, 2006)

Table 2 outlines how the seven stage cycle shown in Figure 1 is typically adopted by construction SMEs that have participated in the Construction Competitiveness Project. Each stage has an action which is essentially the SMEs responsibility but also includes where the Sustainability Centre project team have had an input.

Aladwani (2001) suggests three stages involved in the process of change management, these are; knowledge formulation, strategy implementation, and status evaluation. The knowledge formulation stage involves identifying the general attitude amongst stakeholders to change to enable understanding of the situation. The second stage; strategy implementation involves communicating and ensuring awareness as well as training to help employees adopt to change and to build a positive attitude. A strategy to introduce a project at a suitable point in the organisations core business and the support of senior management is considered a critical factor to ensure success. The knowledge formulation stage occurs during meetings with the participating companies to identify what knowledge they have and how they want to improve. Strategy implementation occurs when the company begins to make changes such as introducing an Environmental Policy Statement to the business or preparing Site Waste Management Plans. The status evaluation stage involves monitoring and evaluation of the impact of the change using a performance measurement system to determine if the initial change objectives were met. How construction companies are expected to monitor change in the Construction Competitiveness Project is outlined in Table 3.

Table 2: The Seven Stages of Change in the 'Construction Competitiveness Project'

Stage of Change		Actions adopted by SME / Sustainability Centre
1.	Scoping the change	SME identifies requirement for change under the broad theme of sustainability and contacts Sustainability Centre for assistance through SEEKIT / ERDF project.
2.	Gathering support, getting permission, putting the case	SME ensures support from senior management team in driving change for improvement. Sustainability Centre explains level of support provided through the project.
3.	Exploring the options	Sustainability Centre discusses how SME can improve in light of their current activities and requirements. This is likely to be across a number of areas covering waste reduction, minimising energy use etc.
4.	Doing it and keeping it up	Sustainability Centre provides advice and assistance and makes further recommendations for improvement. SME makes the changes recommended by the Sustainability Centre e.g. targets set in their Environmental Policy Statement or recommendations to reduce their carbon footprint.
5.	Reviewing progress	Sustainability Centre follows up progress with SME, and SME review their progress on a regular basis.
6.	Embedding the changes	SME is responsible for ensuring change becomes part of the company's way of doing things / culture. An environmental champion is usually appointed to perform this role.
7.	Identifying the next change – going back round the cycle	To continuously improve, the SME will have to make changes and to do this they will have to identify what other changes can be made to move their company forward. SME keeps in regular contact with Sustainability Centre throughout project duration.

3.2 Implementing Change

Bechtel and Squires (2001) outline six dimensions of change, these are; (1) 'addressing people issues, (2) the vision and running the business, (3) leadership development, (4) communications, (5) individual and team development, and (6) culture.' Through the Construction Competitiveness Project, all these dimensions of change have been addressed across the participating companies. Change is described as taking on many forms such as that of being planned or unplanned, incremental or radical, continuous or discontinuous, and recurrent or unprecedented (Kitchen and Daly, 2002). In the Construction Competitiveness Project, it is generally the case that change within the SMEs is planned through discussions with the project team, incremental by being introduced in stages, and it is anticipated that it will be continuous and recurrent for the participating companies to ensure continuous improvement.

There are various approaches to implementing change, these may be referred to as 'Big Bang,' 'Parallel Running,' 'Phased Introduction' and 'Trials and Dissemination.' The strategies vary from the most radical; when companies stop using the old system one-day and switch to a fully new system the next, to the most evolutionary, where companies progressively make the change over a period of months. The more the change is likely to happen in one go the more difficult it is for the company to adapt. A useful example of this is the implementation of an Environmental Management System (EMS). Two SMEs involved in the Construction Competitiveness Project selected a 'phased introduction' for working towards an EMS to allow gradual changes to be made as the SMEs move forward in addressing environmental aspects and managing the impacts on their business. One SME undertook the 'trials and dissemination' approach by implementing an Environmental Policy Statement in one branch to be trialled and reviewed by the other branches of the company. Another SME adopted a 'Big Bang' approach by introducing an Environmental Policy Statement, reviewing their carbon footprint and adopting the recommendations made, as well as introducing a 'Sustainability' focus in their client packs and including a 'Sustainability' section on their company website.

3.3 Driving Change and Communication

The key areas of change management, also described as the enabling functions are education, training and communication as well as team and leadership development (Bechtel and Squires, 2001). Also cited in Aladwani (2001) are the words such as 'involve' and 'support' to ensure change management efforts are successful. Bechtel and Squires (2001) suggest that project managers involved in the change process be appointed in an organisation to ensure that the change process is managed effectively and employees are educated in the changes to be made. In the case of the Construction Competitiveness Project, it has been recommended that an environmental champion is appointed to drive change. In most cases, it has been evident who this person is, generally being the person that made contact with the Sustainability Centre in the first instance e.g. Business Development Manager, Knowledge Manager or Company Director or Partner. It is suggested that a change plan is used to determine the organisations current position and where they want to be with the steps in between that will make the transition. Three questions an organisation should ask itself, outlined by Cicmil (1999) are the why, what and how questions. Why, being the purpose for the project, what, being the desired outcome and, how, being the process for implementation. Another aspect to consider is how a communications strategy and training plan may be used to support the change project (Bechtel and Squires, 2001). Communication is a key factor for the effective implementation of change projects because it is the tool that is used to convey information about the change and its effects. This is being addressed by participating SMEs through staff training sessions, CPD seminars on a variety of topics conducted in-house and incorporated in staff inductions. The participating companies highlighted that following project assistance there was an increased emphasis on addressing sustainability issues.

3.4 External Issues Affecting Change

External issues that affect change are competitive pressures, legislation, demands of population, changes in lifestyle, changes in the culture of workplaces and, management of people (Paton and McCalman, 2000). Other factors outlined by Kitchen and Daly (2002) are new technology, changes in the marketplace, changing expectations, quality and standards, and political values. In the case of the Construction Competitiveness Project, change in SMEs has been instigated as a result of a number of factors which include competitive pressures between companies in having an Environmental Policy Statement to be able to tender for public sector work, impending legislation in the case of Site Waste Management Plans, expectations of a ‘green’ company, and through general awareness of changing times. More information on this is mentioned in the following section on ‘Project Deliverables.’ Therefore change management is about more than just managing change within an organisation but also about anticipating the effects of external factors.

3.5 Barriers and Success Factors

Kitchen and Daly (2002) cite Matheson and Matheson (1998) who outline a number of factors that hinder the successful implementation of change management, these are; ‘internal focus, lack of credibility, secrecy, lack of proper skills, lack of resources, lack of discipline, lack of strategy, metrics are misused, tendency to oversimplify, people are reluctant to change and, power and politics.’ Barriers that affect the performance of a change management initiative in an organisation identified by Male *et al.* (2002) are; changing client requirements, lack of understanding of the impact of late changes on costs, time delays, morale, motivation and performance of staff responsible for delivery of the project, the slow pace of adoption of new ways of working, lack of opportunity for organisational learning and knowledge sharing and, lack of clarity / understanding about roles and responsibilities of participants.

Many of the problems identified have organisational, managerial, legal, and financial elements associated with them. This was found to be the case in the Construction Competitiveness Project. Barriers to implementing change within SMEs were focussed around company size impacting on resources, skills, time, and finance. This was specifically the case with the smaller sized companies within the SME bracket who had identified a requirement to become more sustainable and make improvements but lacked the resources, skills and time to address this. Other problems involved some SMEs not having senior management commitment to driving sustainability issues and companies having more than one branch whose senior management teams required to be consulted with before any changes were made affecting business practice involving time pressures. For these companies, in particular, the Construction Competitiveness Project offered an opportunity to move forward and address the key issues impacting their business.

4. PROJECT DELIVERABLES

The variety of construction SMEs involved in the project, illustrated in Table 1, resulted in a broad scope of project deliverables, primarily focussed on the development of Environmental Policy Statements, the preparation of site waste management plans, and carbon footprinting, although not restricted to these three areas. These deliverables were chosen following the identification of a requirement through discussion with trade organisations which included Scottish Building and the

Federation of Master Builders (FMB) who represent the interests of the construction industry, through general research conducted by the Sustainability Centre, and the fact that these deliverables would appeal to the broad spectrum of construction related companies. The three primary project deliverables and their significance for construction SMEs are outlined below.

4.1 Environmental Policy Statements

An Environmental Policy Statement is a voluntary document detailing a company's environmental commitment. Environmental Policy Statements are now becoming a requirement for companies when tendering for public sector work. An investigation during the project, asked public sector clients within Scotland whether they expect evidence of an Environmental Policy from contractors. The general consensus was that Environmental Policies are required, illustrated by the responses below.

- 'There is a clause in all tender documents requesting confirmation of an Environmental Policy.' (East Renfrewshire Council)
- 'A Sustainable Development Statement is being developed which will include all aspects of sustainable procurement (available 2007).' (North Lanarkshire Council)
- 'It is standard practice for tenders / contracts to ask for copies of Environmental Policies and certification that all relevant legislation will be complied with.' (Falkirk Council)

4.2 Site Waste Management Plans

A Site Waste Management Plan (SWMP) is a plan that details the amount and type of waste that will be produced on a construction site and how it will be reused, recycled and disposed of (www.defra.gov.uk). SWMPs were selected for project delivery due to the powers to make SWMPs a legal requirement being introduced, in England and Wales, under the Clean Neighbourhood and Environment Act 2005. More recently, DEFRA issued draft regulations for consultation in April 2007 (www.defra.gov.uk). These draft regulations see SWMPs being compulsory for projects exceeding £250,000 in value.

Despite SWMPs not yet being a legal requirement in Scotland, large companies and local authorities are increasingly requiring their contractors / sub-contractors to implement a SWMP to demonstrate their commitment to sustainable development and to demonstrate compliance with other waste regulations. For instance, Edinburgh City Council requires their contractors and sub-contractors to implement SWMPs and Laing O'Rourke (an international construction company) include in their contractual agreement, a requirement that their supply chain members implement SWMPs.

4.3 Carbon Footprinting

Due to climate change and the increasing awareness of environmental issues the requirement for companies to reduce their carbon footprint is growing. A carbon footprint is the quantity of greenhouse gases produced by a company which will comprise of emissions from energy, waste and transport. Carbon footprinting was chosen as a key area for project delivery due to the growing emphasis on climate change, sustainability and increasing energy costs largely publicised in press articles and news reports particularly over the last year. Carbon footprinting has been particularly popular with the architects involved in the project evident in Table 1. The following reports published in Building magazine (a trade journal) highlight the growing awareness of climate change issues and suggests that companies require to take action urgently to prevent increased carbon emissions.

- *"UN says construction should play key role in cutting carbon"* (11 May 2007)
- *"Big thinkers point to zero-carbon future"* (4 May 2007)
- *"Climate change report warns of economic disaster"* (30 October 2006)
- *"Carbon efficiency urged"* (29 September 2006)
- *"Construction Industry under fire over global warming"* (3 November 2006)

However, with changing requirements, new legislation and an increased awareness of sustainability issues, there comes the issue of change management through the introduction of new business products and processes. New products introduced by participating companies have included client packs that architects have developed with a sustainability focus, company websites that have included a sustainability section, and new technology introduced by construction related manufacturers. New processes include auditing targets set in Environmental Policy Statements and reviewing energy saving measures to reduce company carbon footprints. The following section briefly describes the research method of the study and how change can be monitored within the SMEs.

5. THE RESEARCH METHOD

Once the participating companies had received their two days support from the Sustainability Centre project team, the company was contacted three to six months later to identify business improvements as a result of involvement in the project. A feedback questionnaire was conducted either face to face with the company or over the telephone. The questionnaire covered the results and impacts for each company and was tailored to suit the nature of assistance provided to each participating company. The main focus of the questionnaire was to identify what had changed within the company as a result of the Sustainability Centre project teams' influence. The results of this questionnaire have been useful for the Sustainability Centre project team in monitoring success and understanding the barriers that SMEs face in addressing change which largely focus on time and resource pressures. Once all data has been collated for each participating SME, this information will also be used to report to the two funding bodies.

5.1 Monitoring Change

With each project deliverable, the Sustainability Centre project team have ensured that there are ways in which change can be monitored to identify where there are business improvements. Mechanisms for this were incorporated for a various reasons. Firstly, it is important for the participating companies to have the facility to monitor change to ensure that what they are doing results in improvement. Secondly, it was important for the Sustainability Centre project team to ensure that improvements were being made within participating companies. Finally, the Sustainability Centre project team were responsible for reporting impacts and results to the project funders for them to gauge project success. The three primary project deliverables and how change is monitored under each are outlined in Table 3. It should also be noted that the project deliverables were not restricted to these three areas. Other deliverables resulting in business improvements included; revising the content for pre-qualification questionnaires (PQQ) (this was monitored through an increase in successful tenders) and the introduction of a Sustainable Design Reference Guide which was used to make the case for sustainable design to clients. Improvement here was monitored through the uptake of more sustainable design solutions.

Table 3: Project Deliverables and Methods for Monitoring Change

Project Deliverable	**Methods for Monitoring Change**
Environmental Policy Statement	Progress in relation to targets monitored at monthly meetings
	Increase in number of tenders submitted from possessing an Environmental Policy Statement
	Impact on financial bottom line
Carbon Footprinting	Reduction in energy bills from reduced energy use
	Reduction in amount of waste produced daily / weekly
	Increase in recycling from waste previously disposed of
	Reduction in expense claims for company car mileage
	Reduction in carbon footprint reviewed 6 months / 1 year later
	Impact on financial bottom line
	Comparison of footprint with similar type and sized companies
Site Waste Management Plan	Increase in waste recycled and re-used
	Reduction in waste sent to landfill monitored through waste transfer notes
	Reduction in waste contractor costs
	Comparison of costs across projects between project value, floor space and volume
	Impact on financial bottom line

Through discussion with the participating companies enough information was collected to assess change. A more thorough investigation of this will be conducted towards the end of the project. The participating companies remarked that regular management meetings take place monthly or quarterly which would be used as a forum for discussing sustainability issues and progress in meeting targets.

6. SUMMARY AND CONCLUSIONS

The purpose of the Construction Competitiveness Project was to promote sustainable business competitiveness through the provision of bespoke advice and assistance to construction SMEs. The project has delivered this for the forty-two companies that have participated in the project. The individuals driving this change are now clear of what changes require to be made, how this can be monitored and what they need to do to ensure continuous improvement. For this reason, the project has been regarded as a success.

People are at the heart of any change process; therefore communication and involvement is the key to ensure change management success which was evident by the commitment from senior management in the project who were responsible for driving change. Finally, it was apparent that change management involves more than just managing change within an organisation but also anticipating the effects of external factors.

It is evident from the number of new products and processes that the Construction Competitiveness Project has resulted in change within SMEs across a number of areas under the sustainability theme. The changes implemented have been endorsed by senior management, driven by an environmental champion and monitored on a regular basis.

Further work following this project may involve the continuation of a similar project depending on funding availability, a review of the carbon footprint results established for the participating companies to be used as case studies, and the compilation of a Sustainability Framework document to be produced at the end of the project, which will be used as a valuable resource for construction SMEs.

7. ACKNOWLEDGEMENTS

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A REVIEW OF TECHNOLOGY TRANSFER CONCEPTS AND THEIR APPLICABILITY TO CONSTRUCTION

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Abstract: Much research effort has been devoted to studying technology transfer between technologically advanced and less technologically advanced countries or organisations. Models have also been developed in order to facilitate the transfer since technology transfer involves complex and difficult processes. It can occur within a single product line in a single company or across organizational or national boundaries. However, there is still scope for improving technology transfer in the construction industry since much research attention was focused on other industry sectors. This paper reviews and assesses technology transfer issues and models. It discusses some of the important issues such as the need for adequate planning, formulation of a technology transfer agreement and building trust between both parties. The need for effective technology transfer within the construction sector in many developing countries is then explored. The paper concludes with an outline of the potential technology transfer paths in the construction industry.

Keywords: construction, knowledge, project, technology transfer.

1. BACKGROUND

Threats such as global competition and rapid technological changes push enterprises to continuously search for alternative strategies that would enable them to respond more effectively to these changes. Amongst other strategies, the transfer of technology has been one of the most popular. In general, technology transfer was believed to improve standards of living in the developing countries (UNCTAD, 1985). Adjusting to the changes in the new world environment, UNCTAD (1995) recognised that a new setting for investment and technology flow has emerged due to the increasing liberalisation trends and greater cooperative arrangements among enterprises. Therefore, UNCTAD (1995) emphasised technological capability building in developing countries for achieving economic development and sustaining competitiveness, which also points to transfer of technology.

Reflecting this, the commitment of government towards technology transfer was primarily based on the requirement of laws and executive orders (Spivey et al., 1994) such as environmental goals and international dialogue (IPCC, 1999). Corporations, which indirectly contribute to the more global aim, address individual goals for technology transfer. Kremic (2003), established that principally, corporations are focused on profit making for their owners. Secondary goals include building new business, competitive advantage, reputation and image (Lundquist, 1996); reduction in technology acquisition costs, diversification of risk, and reduction in technology life (APCTT, 2007); seeking to develop R&D networks (Keller and Chinta, 1990); and competitive sparring (Eiteman, 1998). In reviewing technology transfer in construction, the transfer of information and automation technologies is identified to significantly reduce costs for the performance of construction activities. Pursuant to the benefits achievable, technology transfer would require the "technology" in order to begin or even complete these transaction.

Technology, in accordance to Abetti (1989), is a resource that can be developed or acquired, stolen or wasted, disposed of or applied to growth and profitability. For example, Goldhor (1983) presented a case study of a university-to-industry technology transfer where the technology was developed at the Natural Language Processing Group (NLPG) and later acquired by a small private manufacturing firm. The case study also revealed that the technology transfer (Modular Speech System (MSS)) was the first project undertaken by NLPG although the group was actively occupied in expanding this system. This suggests that the NLPG's research system may be wasted since it has been identified that the system must be transformed to production software in order to benefit the targeted users. In doing so, technology was considered having value as it created wealth and improved the quality of life (Abetti, 1989). Based on these issues, technology transfer was considered a preference in technology transaction between two parties. Abetti (1989) emphasises that the corporation alternatively has two basic choices either to develop or buy, which each can lead to transfer of technology.

This study was carried out based on an extensive literature review in the areas of technology transfer theoretically which includes definitions, theories, models, processes and people, and technology transfer in the construction industry. This paper, therefore reviews existing technology transfer concepts and explores their applicability to the construction sector. The next section focuses on these concepts and is followed by a discussion of the construction context.

2. TECHNOLOGY TRANSFER

2.1 Definitions

Technology

Earlier studies acknowledge technology as a physical product. More research into the technology transfer area suggests that technology could be regarded as embodying knowledge. According to the Oxford English Dictionary (2005), technology is "the application of scientific knowledge for practical purposes; and the branch of knowledge concerned with applied sciences." Levin (1993) argued that any technological object and knowledge is inseparable as access to knowledge is required in order to design or even to operate a machine or a tool. In addition, Lundquist and Thomson (1999) see technology as "the ability to produce a functional design, based in science and engineering, that meets specific performance criteria. A functional design is the commonly understood result, such as a prototype, of a step in product development." This suggests that technology is a body of knowledge that is used in the development, design, production, and application of products, processes, systems, and services (Abetti, 1989).

Both views, technology as a physical product and knowledge considered undeniably correct, as Eden et al. (1997) establish that technology is "a combination of both the physical tool and the related know-how either to make or use that tool." Srinivas (1998), also stated that skills, abilities, knowledge, systems and processes are part of technology, which are often labelled as the 'soft' aspects. The 'hard' aspects include the transfer of actual machinery and equipment into developing countries (Aslam, 2000). The items labelled 'soft' aspects may also be termed knowledge and can generally be classified as explicit or tacit (Nonaka and Takeuchi, 1995). Explicit knowledge refers to knowledge that can be easily transferred in the form of hard data, scientific formulae, manuals, computer files, documents, patents and standardised procedures. Tacit knowledge is hard to communicate and transferred as it is mainly located in people's heads such as experiences. Table 1 shows the summary of the technology definitions.

Table 1: Technology definitions summary

Author (Year)	**Physical product**	**Knowledge**	
		Tacit	**Explicit**
The Oxford English Dictionary (2005)	-	1. The branch of knowledge concerned with applied sciences	2. The application of scientific knowledge
MacKenzie and Wajcman (1985)	1. The physical objects/artefacts.	2. The knowledge necessary to operate the artefacts.	3. The process of making artefacts.
Eden et al. (1997)	1. Technoware: object-embodied technology such as tools, machines, and physical facilities.	2. Humanware : person-embodied technology.	3. Orgaware: institution-embodied technology facilitating integration of the previous three components. 4. Infoware : document-embodied technology such as process specifications and theories.

Technology Transfer

Over many years, technology transfer has been defined in rather broad connotations (Kremic, 2003). However, principally, technology transfer is either considered as the movement of technology from one place to another and/or a series of actions. UNCTAD (1985) defines technology transfer as the "transfer of systematic knowledge for the manufacture of a product, for the application of a process, or for the rendering of a service." According to Souder (1987), technology transfer is "a process of moving or transferring technologies from one organizational entity or location to another, where the entity may be a department within a firm, a firm, or a country." Again, Large et al. (1998) discovered that technology transfer is "the dynamic process of handing-off of a technology from the federal lab to an industry receptor, with varying degrees of involvement by lab personnel."

Apart from the two basic components, a more comprehensive definition would describe the value generated from the transaction since technology has no value unless it is applied (Abetti, 1989). Example of definition suggested by the researchers include Madu (1988), which defines technology transfer as "the acquisition, development, and utilization of technological knowledge by a country other than that in which this knowledge originated." Similarly, Wei (1995) agreed that after the host has been able to absorb, adapt and resell the technology then the transfer is considered complete. Meanwhile Lundquist and Thompson (1999) defined technology transfer as "the movement of the ability to realise a technology from one person or group to another, as confirmed by demonstration of performance against agreed requirements". Hence, the receiver must demonstrate the ability to reproduce and/or use the technology in their environment, to their standards, at particular levels of performance. It shows that the right skills, experience and tools are required to produce a system that works. Taking into account the above arguments, technology transfer is the formal transfer of new discoveries and new technology resulting from:

- leading edge companies into an organisation that already performs similar tasks (Zelkowitz, 1995) since the sufficient technological base is required to efficiently transfer technology.
- scientific research conducted at universities and non-profit research institutions, or to the commercial sector for public benefit.

2.2 Theories

Subsequent to the definitions presented previously, Gibson and Smilor (1991) suggests that technology transfer has three levels of involvement: technology development (Level I), technology acceptance (Level II), and technology application (Level III) as shown in Figure 1. The first level consists of creation and development of technology whereas the technology is discovered and disseminated through research reports, journal articles and computer tapes. Hence, the transfer process is more passive than at the second and third levels. However, the second level requires that technology transfer involvement is more active with the technology made available to a receptor that can understand and potentially use the technology to their own benefit. Technology transfer at the third level is the most active since the technology is used to generate more profit to the receptor either in the marketplace or in another technology transfer transaction.

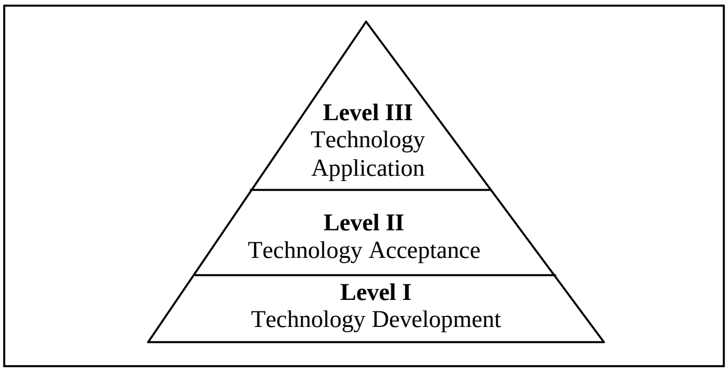

Figure 1: Three levels of involvement of technology transfer (Gibson and Smilor, 1991)

Meanwhile, Marcotte and Niosi (2000) proposed 2 learning phases for technology transfer: learning by adapting and learning by modifying. The first phase requires an adaptation of the new technology to the local environment such as adaptation to the local raw materials or production scale by the recipient firms. The transfers are specifically on information about problem solving and specific organizational skills such as production efficiency, which lead to learning-by-doing method within the recipient firms. Thus, the recipient firms are more concerned with adaptation of the technical skills rather than to improve the acquired technology. In the second phase, the learning growth continues leads to modification and improvement of the technology. Information on marketing, and research and development are transferred between the supplier and recipient. This may change the recipient organisation's structure and strategy such as creating a research and development department in order to produce further benefit from the acquired technology.

2.3 Models

In recent years, models have been introduced, generally according to the types of technology transfer. According to Souder (1987), there are two types of technology transfer: internal and external technology transfer. The internal technology transfer is a transfer process that occurs between departments within an organisation (firm or country). External technology transfer is beyond the national boundaries of either a firm or a country. Nonetheless, the traditional model of technology transfer processes is comparatively static and follows a linear pattern such as a sequential model, which reaffirms the process of technology transfer as a one-way sequential process as shown in Figure 2 (Levin, 1993). According to Morrissey and Almonacid (2005), the weaknesses in this model include: inefficient transfer of knowledge, and passive communication systems as the process is set up without a feedback mode. Key questions that are important for receiving feedback would include the following (Malik, 2002):

- Is the knowledge received and utilised?
- Is clarification sought from the supplier?
- Is feedback received by the supplier?

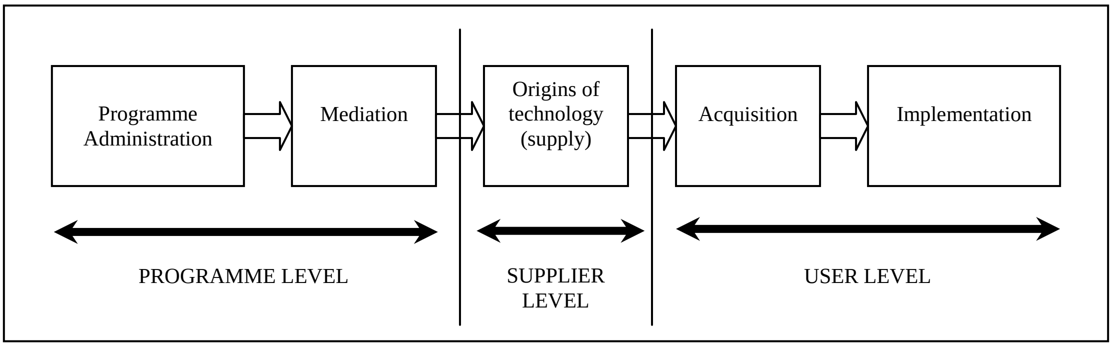

Figure 2: The sequential model (Levin, 1993)

One of the models that illustrates an active communication system and promotes 'real-time' learning is shown in Figure 3 (Morrissey, 2005). Based on the identification of a problem, the researcher and an entrepreneur, with each having their individual expertise and knowledge, and the finance agency forming a collaboration at the early stages of the project. An evaluation of internal and external impact is conducted before the project begin. The project will proceed to the implementation stage if there is no significant impact towards the project. During the project progresses, the evaluation exercises is repeated. The project would be revised if there is a significant impact towards the project, or otherwise, the project is considered a success. The model allows communication through networking, business-to-business relationships, and outreach to other disciplines. Changes such as market forces and project goals may arise as the project progresses. Based on the evaluation of internal and external impacts, the parties involved may decide either to proceed or stop the project, allowing flexibility in conducting a project. Overall, this model considered the new ways of transferred of information and technology such as intellectual property rights (Goldhor, 1983), partnerships in business ventures (Walter, 2000), and trading of research for equity with business ventures and with companies.

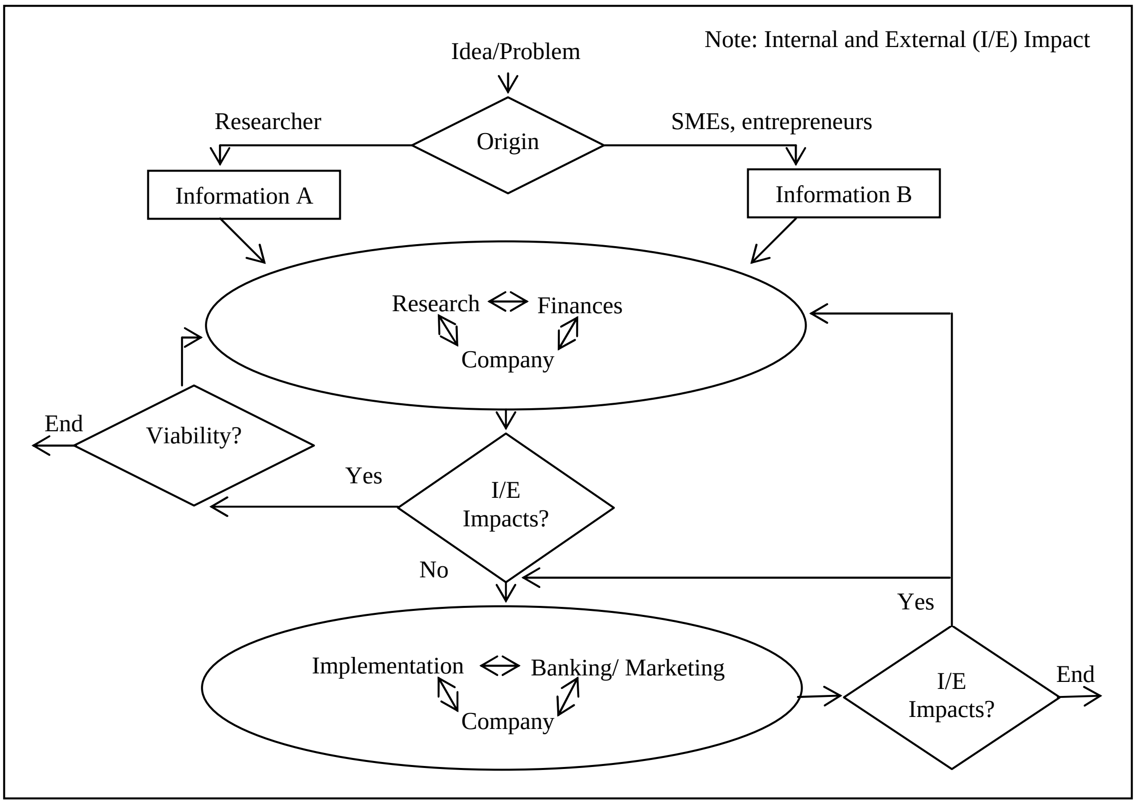

Figure 3: Dynamic model (Morrissey, 2005)

2.4 Processes

Technology transfer process consists of a series of steps that assist the adaptation of new technology within an organisation. Based on a case study, Goldhor (1982) lists four steps in the technology transfer process: searching, learning, adapting and using. UNCTAD (1985) reported that technology transfer processes consist of assessment, selection, adaptation, development and use of received technologies. Trott et al. (1995) proposed four capabilities for an inward technology process: awareness, association, assimilation and application. Nonetheless, Major (1999) suggested various technology transfer were identical under most of the technology transfer processes. The similarities and differences between the processes are summarised in Table 2.

2.5 People

Technology transfer can be done by a person or team and the effectiveness of technology movement processes almost always depend on their skills (Lundquist, 1999). Similarly, UNCTAD (1985) stated that technology transfer can be undertaken by any person either individually or collectively, such as corporations, companies, firms, partnerships or other association, or any combination thereof regardless of any relationships between and among them (i.e. government, private-sector business, multilateral banks, international institutions, research centres/ labs and universities (IPCC, 1999)).

Table 2: Comparison of technology transfer processes

TT process	Goldhor (1982)	UNCTAD (1985)	Trott et al. (1995)
1. A process whereby an organisation searches for a matching technology and donor	Searching	Assessment	Awareness
2. A process whereby an organisation decides that both the donor and recipient have the skills, motivation and resources to make the transfer succeed		Selection	Association
3. A process whereby the knowledge associated with the technology is being captured by the recipient	Learning	Adaptation	n/a
4. A process whereby the recipient organization utilizes the received technology and knowledge to meet their own needs	Adapting	Development	Assimilation
5. A process whereby the recipient produces a new product or a series of related products	Using	Use	Application

Basically, transferring technology implies two parties which has been referred in different terms such as recipient and donor (Goldhor, 1982), and adopter and source (Lundquist, 2000). The parties has been defined as follows:

- An acquiring party (i.e. recipient and adopter) is “the party that obtains a licence to use or to exploit, purchases or otherwise acquires technology”; and
- The supplying party (i.e. donor and source) is “the party that licenses, sells, assigns or otherwise provides technology” (UNCTAD, 1985).

3. TECHNOLOGY TRANSFER – THE CONSTRUCTION CONTEXT

Challenges

Challenges in the construction sector include ‘construction globalisation’ (Kumaraswamy and Shrestha, 2002); besides the poor construction image (Tombesi, 2006); and the slow uptake of innovation (Edum-Fotwe, 2004). Construction globalisation leads to the reduction of natural, cultural and man-made barriers, that enables the construction organisations to operate anywhere in the world (Kumaraswamy and Shrestha, 2002). As a result, competition among the construction companies increases either with the local or foreign organisations (Raftery et al., 1998). Construction has also been acknowledged as a complex, under-productive, under-capitalised and risk-averse sector which produces tangible and intangible components (i.e. buildings and knowledge) (Tombesi, 2006). Changes in technology for operations and processes, and the development of breakthrough technologies are required to increase innovation in construction and project-related organisations (Edum-Fotwe, 2004). Based on these challenges, the transfer, adaptation and development of technologies can assist the developmental goals of emerging nations (Kumaraswamy and Shrestha, 2002).
In accordance with the above, Kumaraswamy and Shrestha (2000) was of the view that the transfer of technology in construction “has long been advocated for

transferring essential core knowledge and skills from one country/region/organisation to another to facilitate longer-term development." However, he also stated that barriers and restrictions such as the nature of the construction industry with fragmented and one-off projects restricts the replication and extended usage of any technology. Another barrier is the focus of transfer on process rather than on product-technology, which shows the imbalanced weighting in technology transfer (Tombesi, 2006). For example, Gehry Technologies Inc provides their contractors and fabricators with digital and project management training rather than focusing on building projects (Boland et al., 2003). More general barriers in technology transfer, particularly for developing countries, include the need for adequate planning, formulation of a technology transfer agreement and building trust between both parties.

Opportunities

Previous study on the local construction companies found that construction companies are having difficulties to differentiate their products/services from their competitors (Kale and Arditi, 2002). Nevertheless, the authors highlight the companies that stress on all four basic competition modes would be among the top. The modes include competing on quality of product/services, competing on product/service and process innovations, competing on cost, and competing on time. A mean to compete on quality of products/services are to improve communication within the parties involved in a construction project, which in turn have positive impact on the quality of finished product. Also, regardless of barriers to innovation in construction such as fear of risk, and codes and regulations restriction (Laborde and Sanvido, 1994), competing on the basis of innovation is achievable. Kale and Arditi (2002) describe there are much potential for innovation such as construction materials, equipment, and a new construction processes and methods. Again, the improvement to speed the execution in construction and the generation of significant cost reductions posses a potential solution for a company to be a step further than the others.

The present discussion pointed out that the four modes can be linked to transfer of technology. A study on the application of information technologies on construction alliance projects is proven to enhance the quality of data and communication between parties, and to avoid project delays (Baldwin et al., 1999). Other studies, such as Sheehan et al. (2000) reviewed the need, potential and barriers of Smart technologies in construction, Akinci et al. (2006) studied the impact of automated reality capture technologies at construction sites, and Poon et al. (2003) compared the low-waste building technologies in Hong Kong. All these technologies has been transferred to the construction industry. There is limited (if any) evidence that technology transfer on multi-national construction projects is effective.

A review on a generic product development value chain described that "every technology transfer is part of a value chain, and every value chain is a tightly linked series of technology transfers" (Lundquist, 2000). A value chain consists of a series of steps taken to move from concept to a fully commercialized product to customers, and every arrow implies a technology transfer as shown in Figure 4. This demonstrates that when one encounters problems and requires new knowledge in order to solve it, one of the ways would be to transfer technology even at a small scale. Technology transfer in a construction project may be in accordance to the described chain. The parties showed in the model may be describe in accordance to the construction team: vendor (consultant), parts manufacturer (supplier), systems integrator (contractor), distributor (developer) and end customer (client). The requirement to complete a construction project such as to meet the client’s innovation expectation, demand the cooperation from all parties with technology transfer.

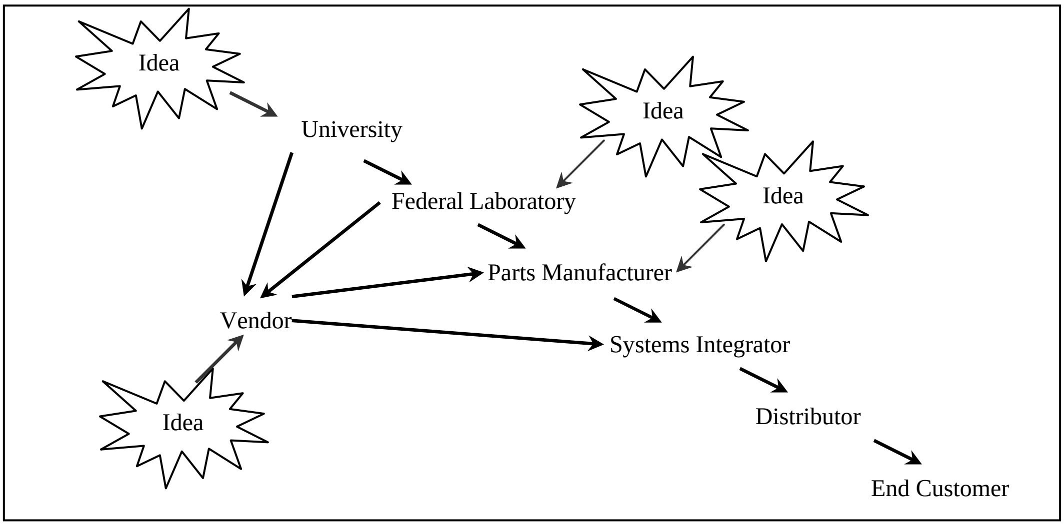

Figure 4: Product-development value chain (Lundquist, 2000)

Moreover, as two parties involve in a single transfer transaction, by having more transactions reflect a huge potential to improve the end product. Cooperation among the identified parties (i.e. contractor, university and funding agency) at an earlier stage (i.e. conception or design) may provide more opportunity to either achieve incremental and/or revolutionary innovation (refer to Figure 3). This promotes a continuous growth on learning, which helps construction companies to generate profits as a result of transfer of technology. There is an opportunity in construction projects to enhance the value chain which includes overcoming the more common barriers (i.e. proper planning, agreement formulation, trust) to ensure effective technology transfer. This is of particular importance in multi-national projects, as they usually involve multi-national companies working closely with local firms, with considerable opportunities for technology transfer and capacity building.

4. CONCLUSIONS

In summary, this paper has reviewed technology transfer theories and their applicability to technology transfer in construction. It presented issues such as the need for technology transfer in the construction context and also a general overview of technology transfer theories, models, processes, people. The key conclusions that can be drawn from the study so far include:

1. There is growing interest in the effective transfer of technology (and more widely, knowledge) within the construction industry, particularly in multi-national projects involving firms from developed and developing countries;

2. Existing technology transfer theories, models, processes and other mechanisms have been well established in other industry sectors (notably manufacturing) and have some applicability to the construction sector;
3. There is a need to explore in more detail, through case studies, the extent to which technology/knowledge is transferred on multi-national construction projects; and
4. There is scope for an exploration of more approaches to technology transfer in the construction industry.

Further work will involve detailed case studies of technology transfer in construction and other industry sectors with a view to establishing elements of good and bad practice. The findings from these will then be used to develop a framework for technology transfer in multinational construction projects.

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THE APPLICATION OF A RESISTIVITY METHOD TO FIND AND IDENTIFY SUB-SURFACE VOID SPACES

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Abstract: Hidden subterranean defence structures, such as tunnels and military bunkers can be environmental hazards. There are many of this type of structure still beneath the ground, but without any traces on the surface landscape. The city of Cologne in Germany was very securely defended by rings of fortress systems during the 19th century. A geophysical survey was carried out, to search for one segment of suspected tunnel between two military buildings in Cologne. The objective of this survey was to confirm the suspected tunnel route by geophysical measurements.
The two-dimensional multi-electrode DC resistivity method was used, employing an ABEM Terrameter SAS 4000. The high-resistance nature of an air-filled tunnel, compared to the background geology was the principal contrasting property in the resistivity survey. The predictive modelling and interpretations were done using DC2DInvRes software. The inversion results showed one highly resistive anomaly in both profiles at a depth of around 13m, indicating a probable tunnel between two military buildings aligned with the direction of the suspected tunnel line.

Keywords: Geo-electric, Multi-electrode, DC-Resistivity, Cologne, Fort IV, Tunnels

1. INTRODUCTION

1.1 General Remarks

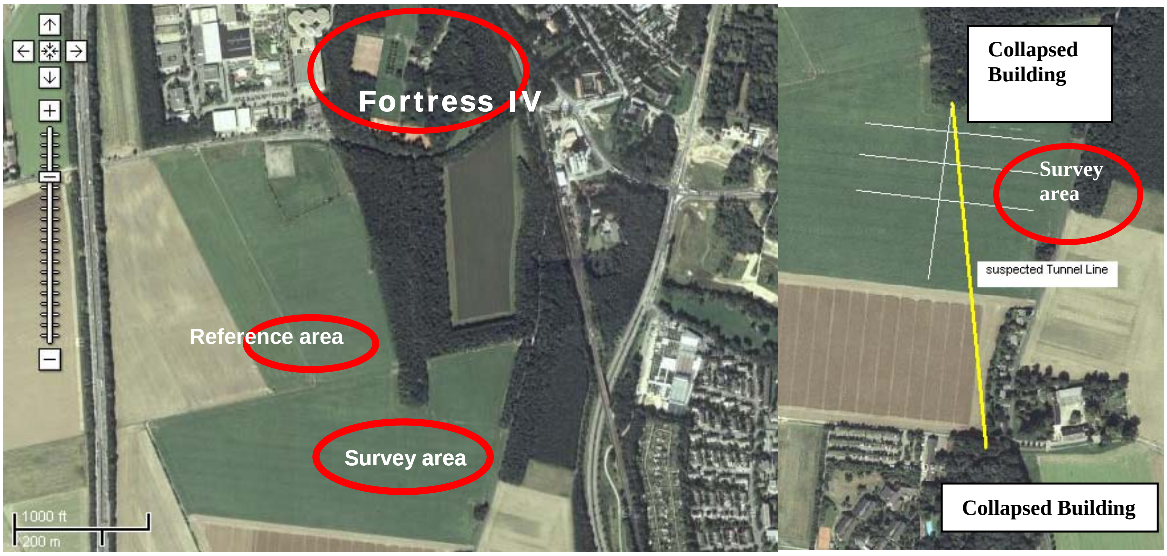
Historical data reveals that the city of Cologne, Germany was very securely defended by rings of forts around the central part of the city. There are hardly any details about this network of underground tunnels because these systems were military secrets. The aim of this research was the search for suspected tunnels, believed to be located in the old military fortress area (Fort IV). The survey was carried out with geophysical surveying techniques. Particularly, a two-dimensional DC resistivity method was applied.

1.2 The Geophysical Survey of the Fort-IV Area

This was the first research in this area using geophysical techniques to investigate underground features. There are many areas where similar tunnel systems are thought to exist, along the ring of fortresses. The survey area selected was one of the suspected tunnel areas which was thought to have the best conditions for geophysical measurements as it has the least side effects for a geophysical survey, such as effects from roads, buildings, power-lines, or water pipes. Generally, these elements can disturb or influence the geophysical results. The survey area is farmland located nearly 800 m from the centre part of Fort IV (see Fig 1).

The main goal of this project was to find evidence of a tunnel-line between two suspected military buildings (Fig 1. B). These buildings no longer exist, but their

debris is still visible. Now, these building areas are fully covered by small bushy forests.
A reference area was chosen for comparison with the survey area measurements. This reference area is nearby, but is an area highly unlikely to have tunnel lines, although close enough to the survey area that the geology in both areas is mostly the same. The directions of the profiles selected in both areas are also nearly parallel, so that any heterogeneity in geology would not affect the comparison of the results.
This 2-D DC resistivity measurement was carried out with an ABEM Terrameter SAS 4000 instrument. The total geophysical survey consisted of three 250m long profile measurements in the survey area and one 175m profile in the reference area. The Terrameter instrument can measure multi-channel and multi-electrode resistivity measurements. The DC resistivity data was interpreted for both synthetic and field measurements, using DC2DinvRes software (Günther, 2004).



(A) **(B)**

Figure 1 (A) Satellite picture of Fort-IV area and survey area, **(B)** View of suspected tunnel line direction on satellite picture (Both pictures were taken from Google-Earth and edited by the author) (Coordinate of the mid-point of first profile in survey area is: Lat 50° 57' 52"N Long 6° 51' 39"E; Google, 2006)

2. RESISTIVITY SURVEY

The resistivity survey is a geophysical technique to determine subsurface resistivity distribution by taking measurements at the surface (Kearey, Brooks, 1984). Figure 2 gives a schematic diagram of the basic principles of DC resistivity measurements. A current is injected into the ground, using two current electrodes (A and B), and the resulting potential difference between two potential electrodes (M and N) is measured. From the injected current (I) and measured voltage (V), the apparent resistivity can be calculated.

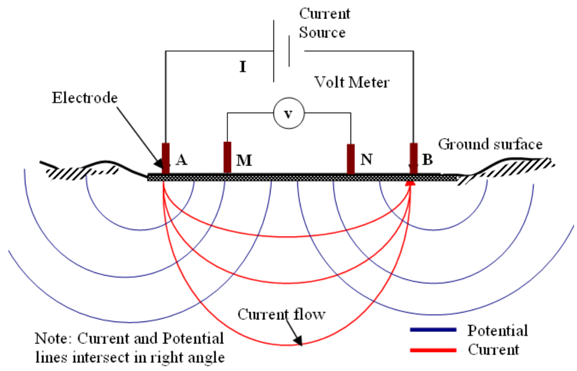


Figure 2 Schematic view of the DC resistivity measurement principle

The Apparent resistivity is given by,

$$\rho_a = \frac{\Delta V}{I} K$$

Here, K is a geometry factor, defined by the geometry of the electrodes.

2.1 Two-Dimensional Resistivity Survey

A 2-D resistivity survey produces a subsurface resistivity distribution which is two-dimensional: i.e. in the vertical direction as well as in the horizontal direction along the survey line. The conventional sounding method is a one-dimensional technique, which can produce data in a vertical direction exactly below the mid-point of the profile, and hence is also known as vertical electrical sounding (VES). It cannot show the horizontal variation of resistivity along the vertical plane of the profile line. To get the horizontal changes with 1-D sounding, the sounding position would have to be moved along the profile line within the profile length, which would be a very time-consuming task.

Because of this great limitation of the 1-D method, the 2-D resistivity method is generally preferred (Loke, 1999). Generally 2-D surveys are automated resistivity measurements. By considering the data from different sets of electrodes, the subsurface volume is mapped horizontally and vertically. This method is called continuous vertical electrical sounding (CVES). In this method, it is assumed that resistivity does not change in the direction perpendicular to the survey line. In comparison with a 2-D survey, the 3-D method is more data intensive and able to resolve the target three-dimensionally (Loke, 1999). However, it is even more costly in both time and labour. In this case, a 2-D resistivity survey was considered the more optimal solution for subsurface imaging.

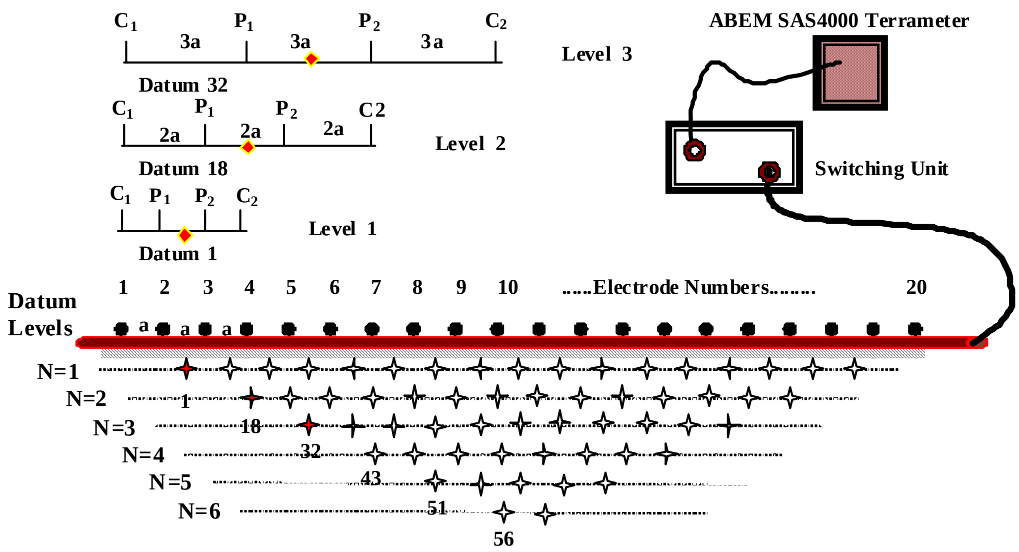


Figure 3 Typical measurement setup of the two-dimensional DC resistivity method and the formation of a pseudosection plot. (modified from Loke, 1999)

As shown in Figure 3, two-dimensional resistivity measurements are done as an automated process. In this example, 20 electrodes are attached to a multi-core cable, at equal intervals. The cable is connected to the switching unit and it is connected to the microprocessor-controlled Terrameter. As shown, the three different spacing Wenner layouts represent the first three levels of measurements (1st, 18th and 32nd data positions). According to the protocol file used by the instrument, the microprocessor decides the proper electrodes to use and the sequence of measurements. For each measurement, the instrument sends a signal to the switching unit to select the four proper electrodes with respect to the protocol file. The instrument also chooses the current and electrode array with respect to the control file. The file formats differ, depending on the instrument and the measurement systems used.

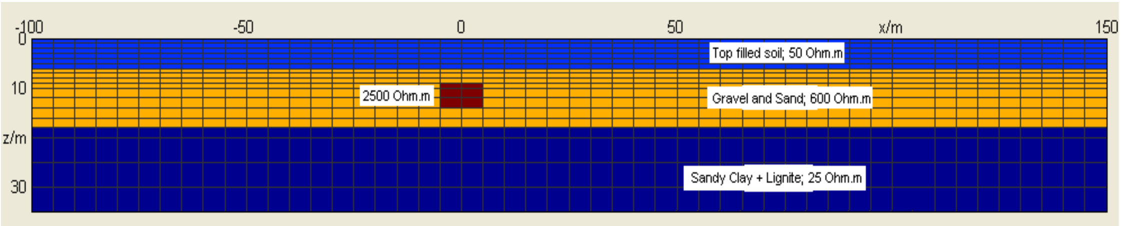
During the apparent resistivity measurements, two electrodes work as potential electrodes and the other two work as current electrodes. The measurement points are decided by the electrode spacing and array configuration. Figure 3 shows how the data points related to selection of four sets of electrodes in the Wenner configuration.

2.2 Modelling and Field Measurements

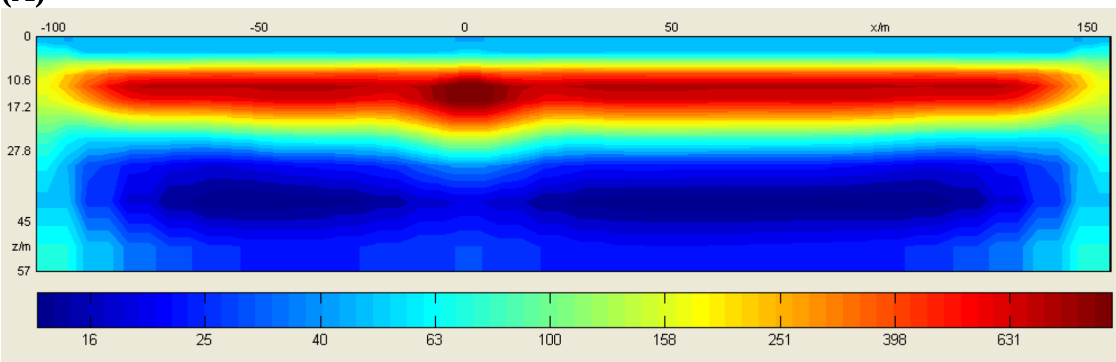
The basic principle behind this resistivity survey is the resistivity contrast between a target body and the background medium. Tunnel structures are considered to be analogous to air cavities. These objects behave as high resistive bodies, except when they are filled with water or some other conductive material. The mean ground-water-level (GWL) of the survey area is around16m below the ground surface (Geologisches Landesamt Nordrhein-Westfalen, 1986). The target depth ranges between 10-15m. The GWL lies slightly below this depth range. The GWL was not considered in the predictive modelling, i.e. the expected tunnel body was assumed to be an air-filled high resistive body, not saturated.

A DC resistivity modelling and inversion program called DC2DInvRes from Günther (2004) was used for all synthetic calculations. The predictive models were calculated using the parameterisation shown in Figure 4A. To simulate a tunnel, one highly resistive body was defined as having the dimensions of 10m width and 5m height. The modelling was done with many trials, by changing unit electrode spacing for dipole-dipole and Wenner configuration.

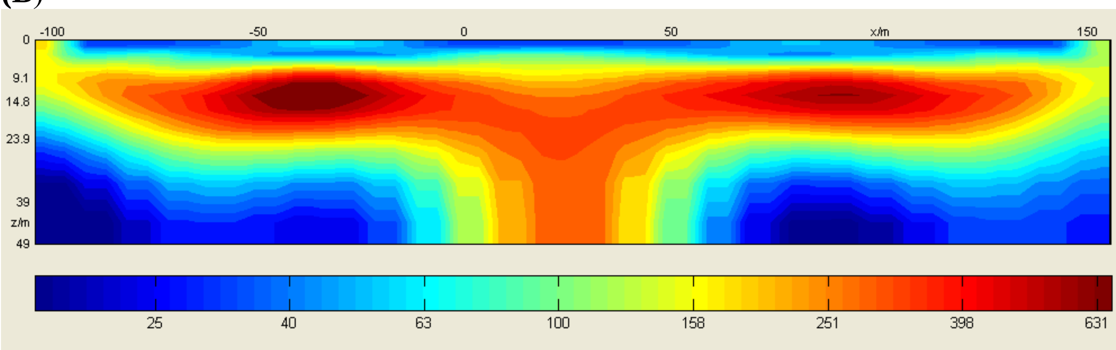
Figures 4.B and C show the final inversion results of the dipole-dipole and Wenner synthetic data respectively with 5m unit electrode spacing. Among these inversion results, the defined body was resolved as exactly in the model, with dipole-dipole configuration. The defined highly resistive body was well-resolved in the right position, i.e. at the correct depth and distance along the profile. However, the size of the body in the inverted result was slightly larger than as defined in the model, which may be due either to artefacts of the inversion program or poor data resolution. The value of resistivity of this body was defined in the model as 2500 Ωm, but in the final inversion result this body was resolved with a high but smaller, resistive value (around 1500 Ωm).



(A)



(B)



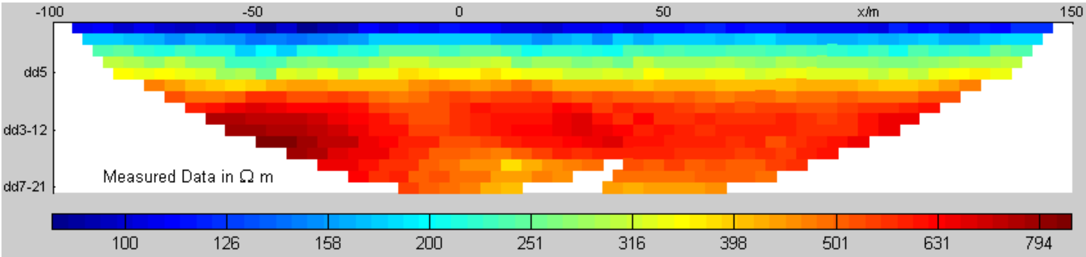
(C)

Figure 4 (A): Initial model simulating high resistive body, **(B)**: Inversion result of dipole-dipole configuration data, **(C)**: Inversion result of Wenner configuration data ;(all the colour scales represent resistivity in Ωm)

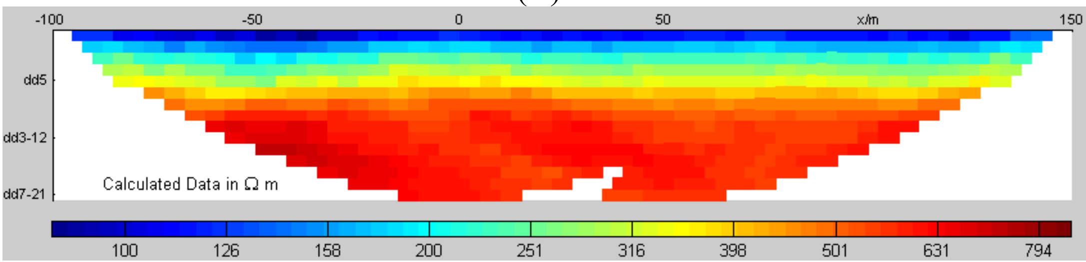
In the Wenner configuration data, even though background detail was resolved as defined in the model, the highly resistive body was not resolved as defined in the model. However, the inversion produced two, separated highly resistive anomalies (Fig 4C). This result completely contradicts the defined model. So, from the modelling, the defined target was resolved correctly by the dipole-dipole configuration.

2.3 First Profile Field Data

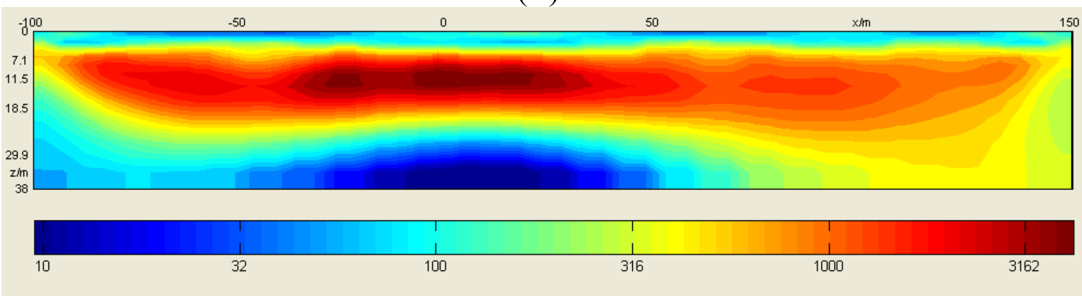
The plot of the first profile of apparent resistivity values measured using dipole-dipole configuration is shown in Figure 5A. Figure 5.B shows the program-calculated resistivity plot at the end of the inversion process. The inversion result is shown in Fig 5C. From the inversion result, it is clearly seen that one high resistive body was resolved at around 13 m depth with very high resistive values around 3500 Ωm. This anomaly appeared to be located around the 0m profile location and it is nearly 50m wide to both sides from 0m (see the white square).
The coverage distribution of the first profile measurement is shown in Figure 5.D. By comparing the coverage plot and inversion result plot, the high resistive body was resolved in a good coverage region. This further supported the result that there is a highly resistive anomaly located in this position.



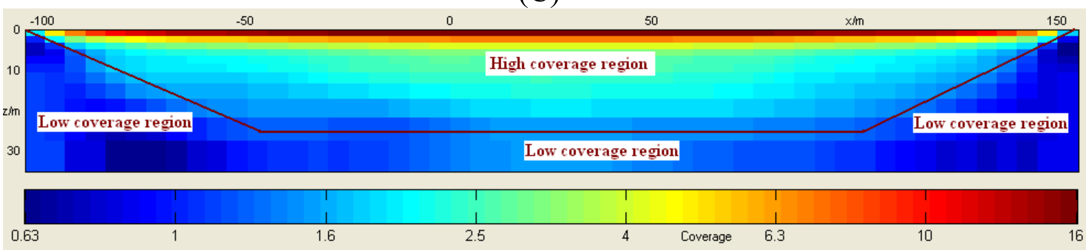
(A)



(B)



(C)



(D)

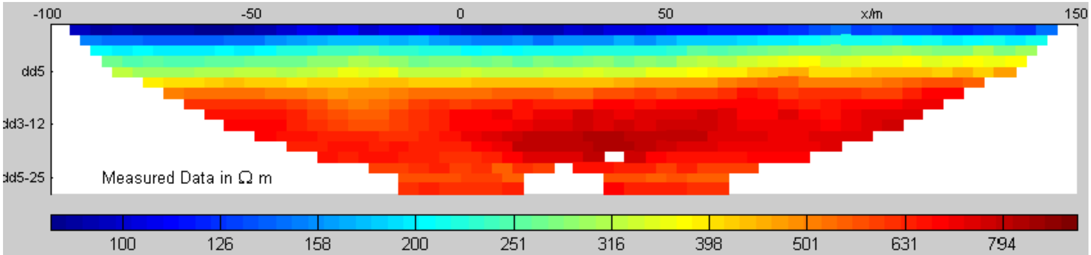
Figure 5 (A): Pseudosection plot of resistivity raw data of first profile, **(B)**: Calculated resistivity data plot at the end of inversion process by program **(C)**: Final inversion result of first profile dipole-dipole resistivity data (RMS=8.36%) **(D)**: Coverage distribution of dipole-dipole data of first profile measurement, drawn black line represents coverage of 1.2, where it separates high and low coverage region;(all the colour scales except (D) represent resistivity in Ωm)

So, from the inversion of first profile DC data and the predictive modelling results for dipole-dipole configuration, it can be concluded that there was likely to be a highly resistive body, caused by a tunnel at around 13 m depth around the 0m profile position (mid of the profile).

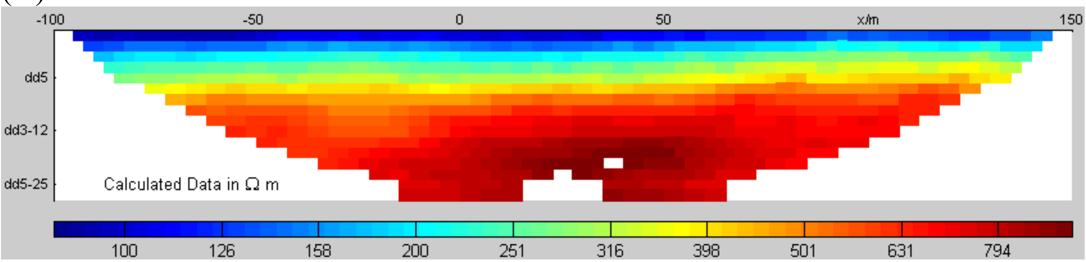
2.4 Second Profile Field Data

Figure 6.A shows the plot of second profile apparent resistivity values, measured using dipole-dipole configuration. Figure 6.B shows the resistivity plot at the end of

inversion process calculated by the software program. The inversion result is shown in Figure 6.C. From the inversion result, it is clearly seen that one highly resistive body was resolved at around 13 m depth, with very high resistive values: more than 4000 Ωm. This anomaly appears to be located around the 25 m profile length.



(A)



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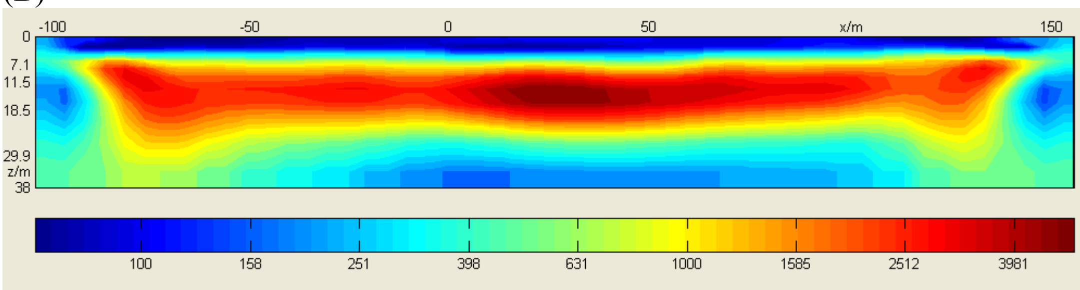
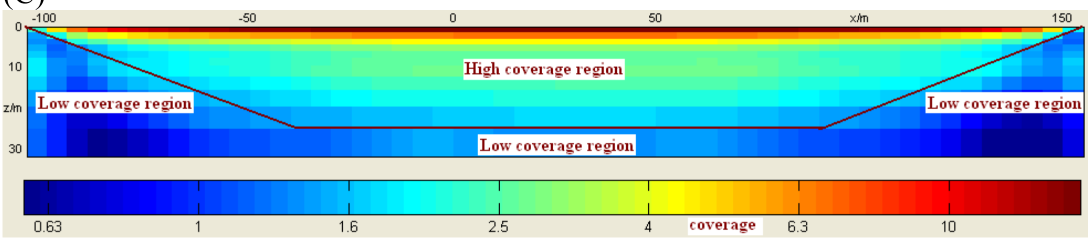


(C)



(D)

Figure 6 (A): Pseudosection plot of resistivity raw data of second profile, **(B)**: Calculated resistivity data plot at the end of inversion process by program **(C)**: Final inversion result of second profile dipole-dipole resistivity data (RMS=11.76%) **(D)**: Coverage distribution of dipole-dipole data of second profile measurement, drawn black line represents coverage of 1.2, where it separates high and low coverage regions;(all the colour scales except (D) represent resistivity in Ωm).

The coverage distribution of second profile measurements are shown in Figure 6.D. By comparing the coverage plot with the inversion result plot, the high resistive body was resolved in a good coverage region. This further supported the result that there is a high resistive anomaly to be located in this position.

2.5 Interpretation

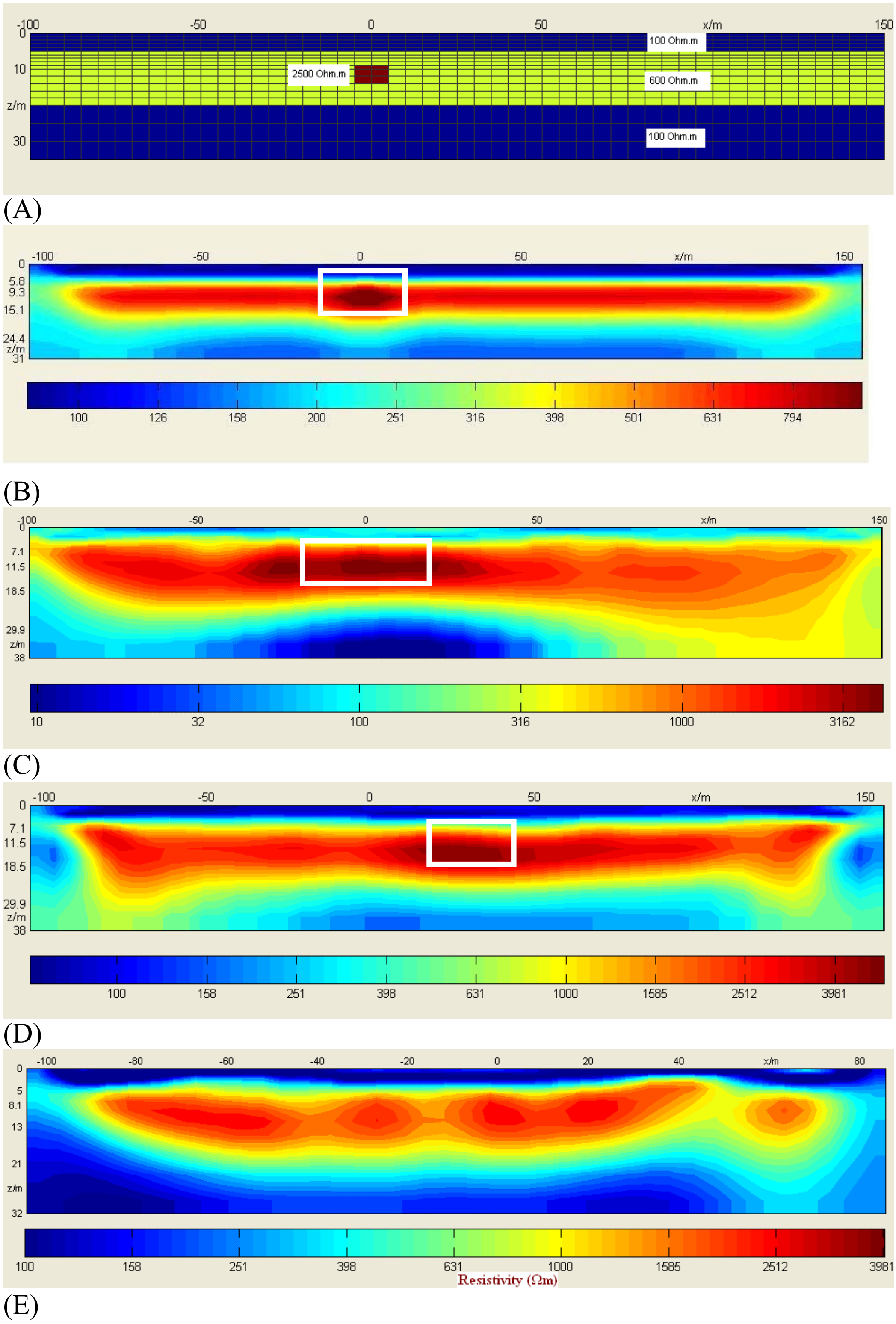


Figure 7(A): Synthetic model-space defines background geology and high resistive body **(B)**: Synthetic data Inversion result **(C)**: Inversion result of first profile field data **(D)**: Inversion result of second field profile and (E): Inversion result of reference site profile ;(all the colour scales represent resistivity in Ωm)

The synthetic data inversion (Figures 7.A and B) shows the defined high resistive body simulating a tunnel has been inverted by this program. It shows that the dipole-dipole configuration can clearly resolve this type of body in such geological conditions.

By comparing synthetic and field data inversion results (Figures 7.B and C), it can be concluded that one high resistive anomaly is located at around the 0 m profile position. The middle of the anomaly was resolved at around 13 m depth (see white square).
Similarly, by make a comparison with the second profile field data inversion result (Figs 7.B and D), it can be significantly shown that there should be a tunnel-like body at a 25 m profile location along the second profile, at around 13 m depth.

The reference area inversion result (Fig 7.E) shows the geology of this area. By comparing the inversion results of the reference area and the survey area, it can be seen that they have similar geology. The top and bottom layers had a resistivity of nearly 100 Ωm and the middle layer resistivity is nearly 1500 Ωm.
Having the same geology, for both the reference site and the survey area, further supports the interpretation. The high resistive anomalies from both profile results could be caused by the existence of a tunnel structure in this region.

3. RESULTS AND CONCLUSIONS

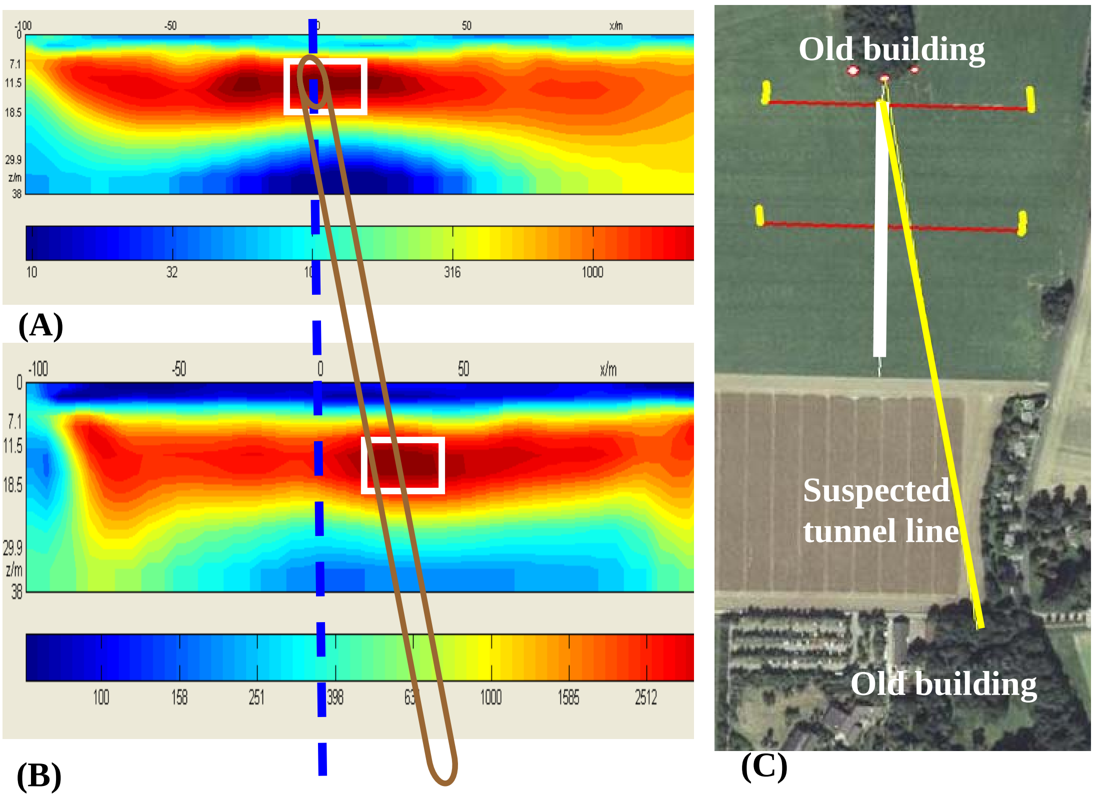


Figure 8 (A): First profile DC inversion result, **(B)**: Second profile DC inversion result, **(C)**: Trend of the suspected tunnel line (yellow) between two military buildings in the survey area

Figures 8 A and B show the inversion results of the first and second resistivity profile, respectively. The blue dashed line represents the perpendicular line of the parallel profiles. The distance between the two parallel profiles is 95m. The high resistive anomaly is located close to 0 m in the first profile (see the white square) and at 25 m in the second profile. The line connecting the two anomalies makes an angle of 15° with the blue line.
Figure 8 C superimposes a yellow line, representing the location of the suspected tunnel line between two military buildings, onto the satellite image of the area. This line makes an angle of nearly 15° with the perpendicular line (or blue line) of the profiles. The line connecting both anomalies, matches with the direction of the suspected tunnel. The overall appearance of anomalies at the suspected location favours the correctness of the supposed tunnel position. Conclusively the DC survey results show that there are good possibilities for a tunnel line at a depth of 13 m.

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THE PERFORMANCE OF DOWEL-TYPE FASTENERS IN TIMBER-TO-CONCRETE CONNECTIONS

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Abstract: The connection of the sole plate to the substrate is critical to ensure that timber frame construction is robust, safe and serviceable. Considering the build process, timber platform frame is an off-site modern method of construction (MMC) which is manufactured to a high degree of accuracy. Therefore, the setting out and levelling of the sole plate has to be accurate to ensure construction tolerances are met.

From a design perspective the connection method must be capable of transferring the applied wind action on the system to the foundations. Using Eurocode 5 Structural timber design rules (EC5) Section 8.2.3 *Steel-to-timber connections* as a basis, this paper presents an experimental investigation on the performance of a range of commercially available fasteners. The test program replicates the connection using C16 timber and a range of substrate materials typically used in foundations. The withdrawal capacity of each fastener is shown to vary between substrates and the effect of this on the connections performance is demonstrated. The contribution from secondary effects such as the “rope” effect is analysed. It is shown that all fasteners tested fail through the development of a plastic hinge and embedment in the timber member. The paper concludes by making recommendations for the use of EC5 Section 8.2.3 *Steel-to-timber connections* in the design of soleplate connections.

Keywords: Fasteners, rope effect, timber-to-concrete connections, withdrawal capacity.

1. INTRODUCTION

Modern methods of construction (MMC) using timber are particularly suited to the needs of the current housing market. Using the timber frame as a structural base, domestic dwellings can be erected with improved quality control and reduced site times. These advantages have lead to timber frame construction becoming the preferred method in North America, with 90% of all domestic builds utilising the method. Furthermore, it is predicted that by 2008 1in 4 homes in the U.K will be built using timber frame (UKTFA, 2006).

The purpose of the timber frame is to transmit both horizontal (wind) and vertical loading (permanent and variable) to the foundation. Stud walls, typically comprising of C16 timbers at 600mm centres, are utilized throughout the construction to provide resistance to vertical loading, partitioning and resistance to shear and overturning forces (racking resistance) caused by wind loads. The timber frame walls are connected to the foundations via a pre-installed locating plate (soleplate) fixed down by timber-to-concrete connectors. The purpose of this research programme was therefore to evaluate the strength of this connection considering a range of industry standard fixings and substrates, demonstrate the applicability of a suitable Eurocode 5 design method and make recommendations for specification.

2. SITE PRACTICE AND DETAILING

The performance of a timber frame building is reliant on the initial positioning and fixing of the soleplate. Figure 2.1 shows the soleplate in relation to a typical wall footing detail:-

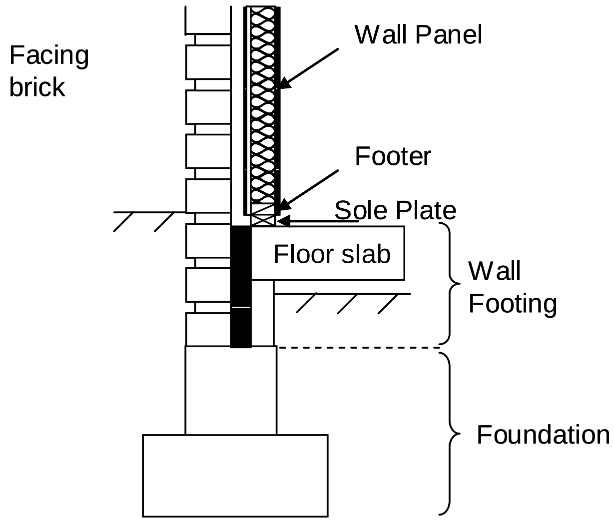


Figure 2.1 Detail of a typical wall footing

Dowel type fasteners including nails, screws and anchors are typically used to fix the soleplate in position. Low velocity shot fired dowels are the preferred method employed throughout the U.K due to their ease and speed of application. However, these offer relatively low withdrawal strength and therefore do not contribute to overturning resistance. Whilst overturning forces are resisted by the self weight of the structure and strapping, any resistance offered by the fastener is advantageous due to the additional contribution to the overall racking performance. This is particularly pertinent in multi-storey builds as a result of large frontages leading to increased applied wind loads.

At present there is no method for the calculation of timber-to-concrete connection capacity. Due to this fact the designer has two courses of action that can be undertaken to asses a joints structural suitability:-

1. Test a range of test samples and obtain the characteristic value of connection strength for use in design.
2. Assess the suitability of a current code of practice.

Although, data from a small scale test schedule would generally be deemed insufficient to enable reliable estimates of characteristic strength to be made (Hilson, 1995) the comparison of test results with values calculated to an existing design code would, if a high level of correlation is demonstrated, provide sufficient information for safe specification.

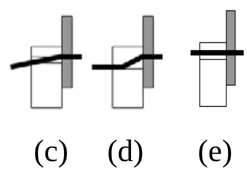
The objective of this study was to evaluate the performance of a range of commercially available fasteners when used as soleplate connectors as well as observe their behaviour under load. In conjunction with this a range of commonly used foundation substrates were also considered within the test regime to analyse their effects on overall connection capacity. The withdrawal capacity was tested with the aim of developing a further understanding of secondary effects, specifically the “rope” effect. A design method which gave the closest approximation of the behaviour of a timber concrete connection was selected and its suitability assessed.

3. EXPERIMENTAL PROGRAM

3.1 Determination of the experimental program

A review of current literature showed that the series of equations developed by Johansen (Johansen, 1949) were suitable for calculating the connection capacity of dowel type timber connections. These have been rigorously tested and verified in subsequent experimental programmes (Moller 1951, Aune and Patton-Mallory 1986, Hilson et al. 1990). Therefore, considering the variables of this calculation method a laboratory test programme was derived. Johansen’s equations also form the basis of Eurocode 5 Section 8.2.3 *Steel-to-timber connections* (Equation 3.1). This method allows the calculation of the connection strength and the prediction of the mode of failure, shown as a graphical representation. This calculation method was deemed the most appropriate method for determining timber-to-concrete connection strength due to the steel element acting as a rigid body which restricts embedment of the fastener.

$$F_{V,Rk} = \min \begin{cases} f_{h,k}.t_1.d\left[\sqrt{2+\dfrac{4M_{y,Rk}}{f_{h,k}.d.t_1^2}}-1\right]+\dfrac{F_{ax,Rk}}{4} & \text{(c)} \\ 2{,}3\sqrt{M_{y,Rk}.f_{h,k}.d}+\dfrac{F_{ax,Rk}}{4} & \text{(d)} \\ f_{hk}.t_1.d & \text{(e)} \end{cases}$$



Where:

$F_{V,Rk}$ is the characteristic load - carrying capacity per shear plane per fastener

$f_{h,k}$ is the characteristic embedment strength in the timber

t_1 is the smaller of the thickness of the timber side member or the penetration depth;

d is the fastener diameter

$M_{y,Rk}$ is the characteristic fastener yield moment;

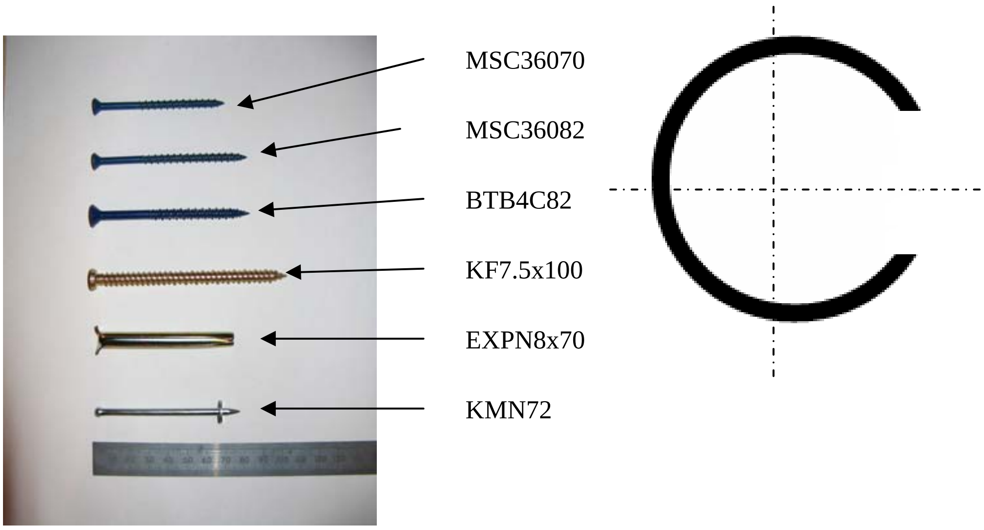
$F_{ax,Rk}$ is the characteristic withdrawal capacity of the fastener

Equation 3.1 Eurocode 5 Section 8.2.3 *Steel-to-timber connections* with graphical representation of predicted mode of failure

The addition of the term $F_{ax,Rk}/4$ to the Johanson's equation in modes (c) and (d) allows for the contribution of the "rope" effect. This is the development of increased frictional resistance between the timber and concrete members caused by them being forced together due to the bending of the fastener. This leads to a contribution to the overall connection capacity. The withdrawal capacity ($F_{ax,Rk}$) is taken as the lesser of the fasteners point side withdrawal and headside pull through strengths. For this reason these two variables were included in the test program- detailed in Section 3.2.

3.2 Test set up

Six fasteners (Figure 3.1) were selected to reflect those already used in practice and those deemed suitable for purpose: - MSC36070, MSC36082 and BTB4C82 (Countersunk masonry screws), KF7.5x100 (All purpose masonry screw), EXPN8x70 (Express nail) and KMN72 (Low velocity shot fired dowel)



(a) (b)

Figure 3.1 (a) Test Fastener range (b) EXPN8x70 Express nail cross section with approximation of the neutral axis.

Both the tensile strength and yield moment of the fasteners were determined to BS EN 1002-1 and BS EN 409 respectively. A minimum of 5 tests were carried out for each. The fastener yield moment test involved each fastener being subjected to 4 point bending until it either yielded or was bent to and angle of 45 degrees. Since fastener EXPN8x70 does not have a uniform cross section it was therefore tested in 3 different orientations- with the gap facing up, down and to the side. It was found that orientating the gap to the side gave the lowest results. Due to the fact that it is impractical to specify which way the fastener is installed on site it was the minimum value obtained (gap to side) that was taken.

The force required to pull out the fastener (point side withdrawal) after insertion into each substrate as well as the force required to pull the fastener head through the timber (head side pull through) member were determined in accordance with BS EN 1382 and BS EN 1383 respectively.

Due to test practicalities, the soleplate connection could not be replicated identically. Therefore, lateral load carrying capacity tests were carried out based on BS EN 1380 as illustrated in Figure 3.2. Samples were constructed using the following substrates: Common brick and dense aggregate blocks with characteristic compressive strengths of 7N/mm^2 and 20N/mm^2. A C16 timber sample measuring 45x90x215mm was placed either side of the substrate with the grain orientated parallel to loading. To give an accurate replication of the soleplate connection a layer of Damp Proof Coursing (D.P.C) was placed at the timber concrete interface. Loading was applied at a rate of 2mm/min.

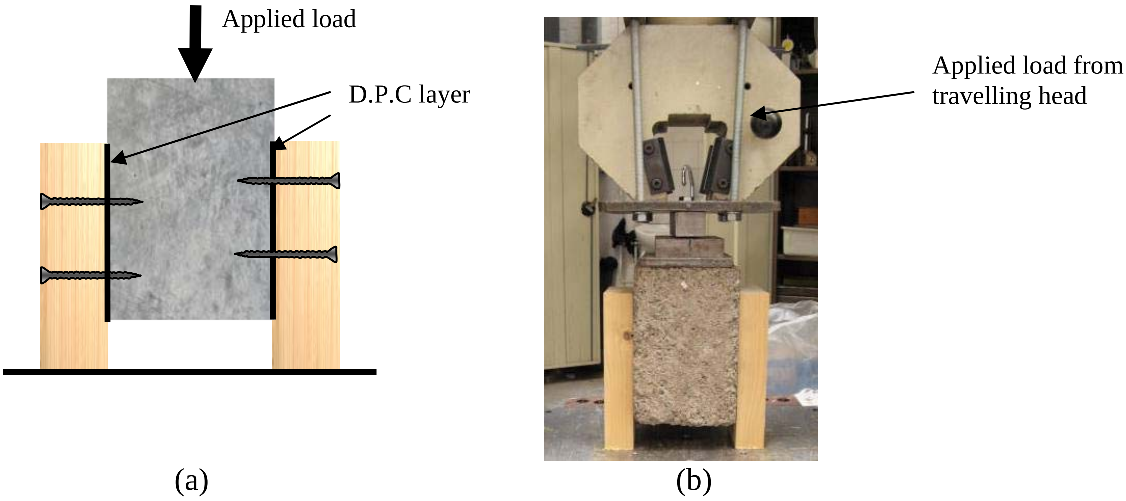


Figure 3.2 (a) Lateral load test set up (b) subject under test

Fasteners were installed via pre-drilled pilot holes, the diameters of which were as per manufactures specification. Opposite holes were drilled at staggered intervals to prevent convergence and weakening the substrate sample. It was found through additional testing that the development of eccentric forces due to this method of application were negligible. Threaded fasteners were screwed into place, their heads set flush with the timber. The Express nails were hammered into position and the KMN72 shot fired dowel was fired into place via a cartridge delivery tool. The application of the KMN72 shot fired dowel was found to break the brick substrate apart and the cartridge delivery tool did not have sufficient power to drive the fastener home in the 20N/mm^2 block. Therefore, only results from tests carried out in 7N/mm^2 block are presented.

4. RESULTS AND DISSCUSION

From the test results logged Load vs. Slip curves were produced (Figure 4.1)

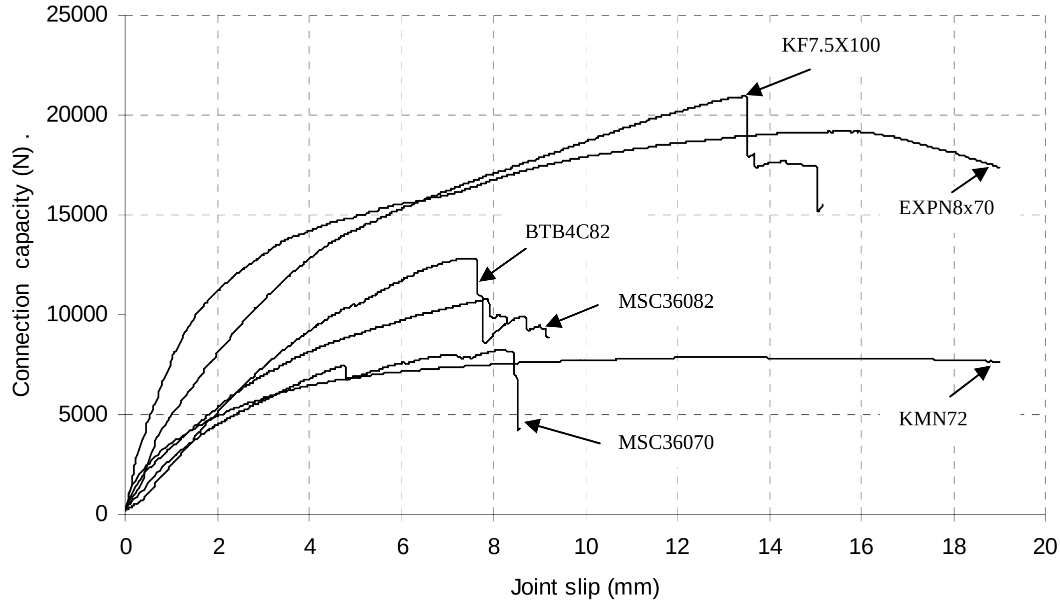


Figure 4.1 Average Load vs. Slip curves for fastener range tested in 7N/mm^2 block

In particular two types of ultimate failure can be observed: ductile and brittle. Fasteners which failed in a ductile manner (EXPN8x70 and KMN72) did so in a gradual, predictable manner. This is particularly advantageous for any type of connection but particularly as it provides warning about the on set of failure. Threaded fasteners were found to fail in a sudden brittle fashion. This was attributed to the hardening process used which caused brittleness within the fastener. Results from Figure 4.1 can be related to the fastener yield moments shown in Figure 4.2:-

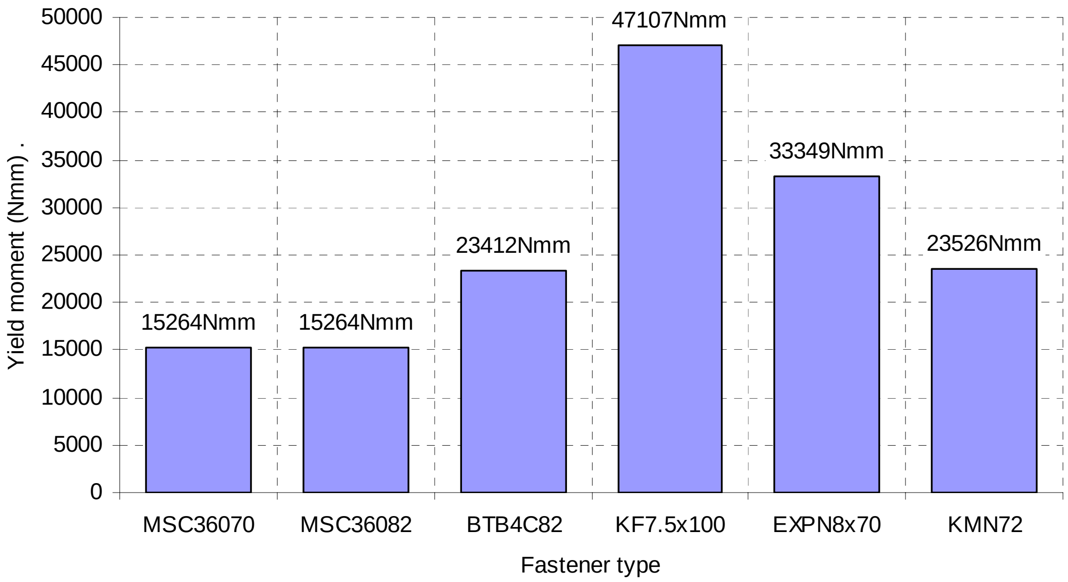


Figure 4.2 Results from fastener yield moment test

Through comparison, the results from yield moment tests mirror the fasteners lateral load performance with the exception of KMN72. This is attributed to the fasteners low point side withdrawal strength, with the fastener being pulled from the substrate by the slip of the timber member. Figure 4.3 shows that KMN72 was found to have the highest tensile strength of fasteners tested.

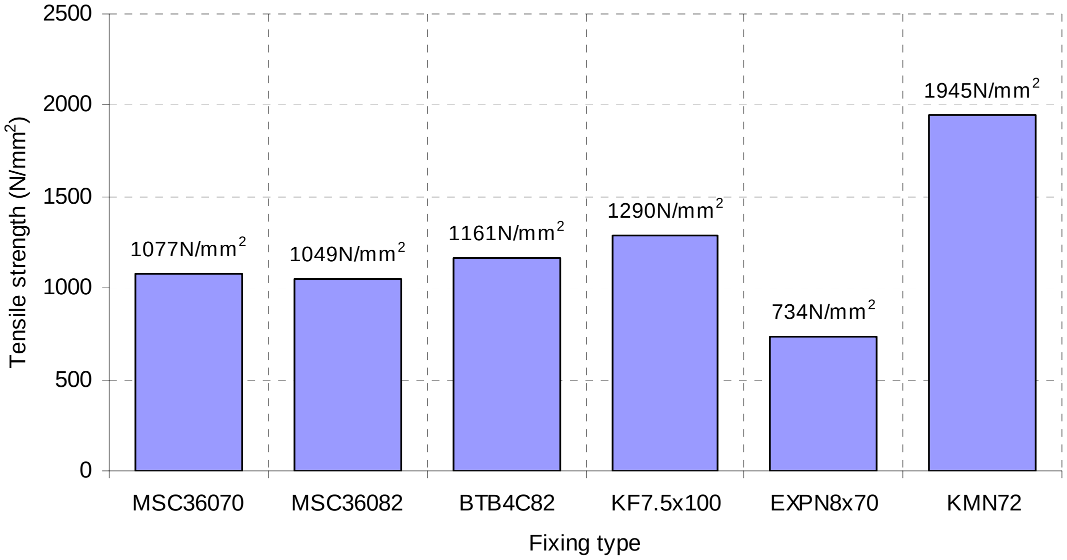


Figure 4.3 Results from fastener tensile strength tests

However, this was found not to be critical to connection capacity with the connection failing through either the embedment of the fastener in the timber, head side pull through or point side withdrawal- long before the tensile strength was exceeded.

Substrate type was found to have a negligible effect on connection capacity with a high degree of correlation exhibited between the lateral load carrying capacities for fasteners tested in each of the three substrates. This is illustrated in Figure 4.4 which has been normalised for the effects of timber density to allow for direct comparison.

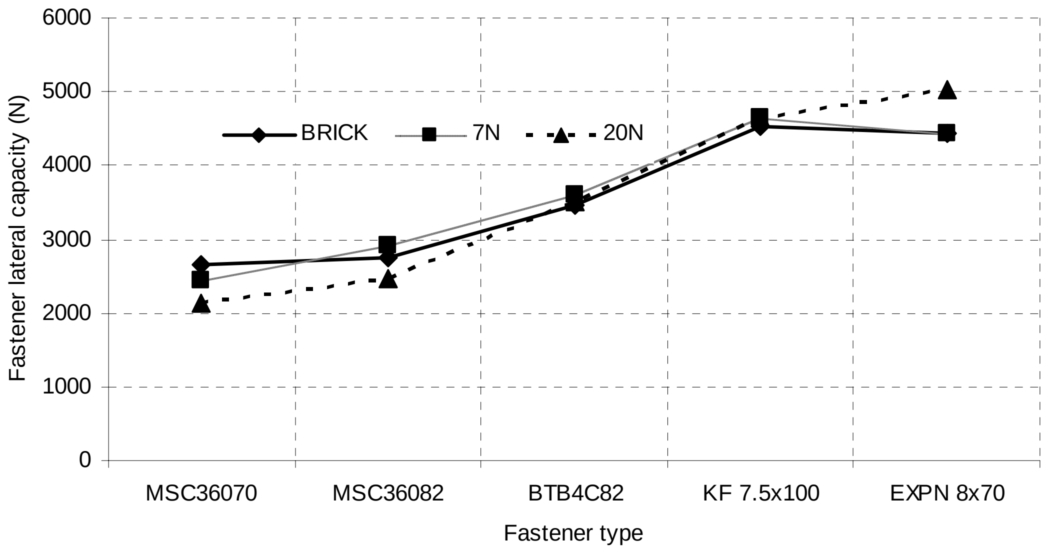
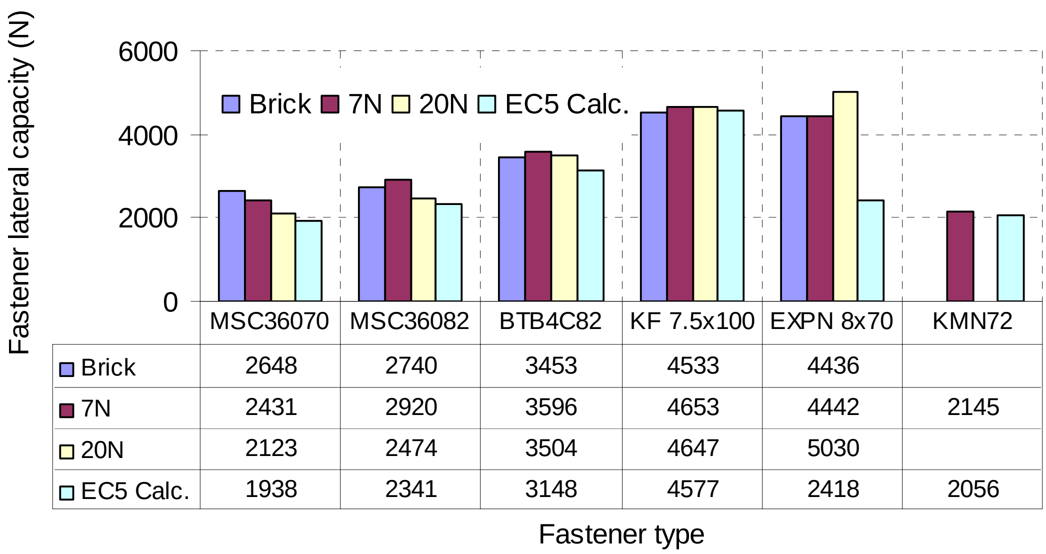


Figure 4.4 Comparison of lateral load tests carried out in brick 7N/mm^2 and 20N/mm^2 dense aggregate block.

Although substrate type was shown to have a negligible effect on overall capacity, the composition of the material did cause variation in the connections behaviour under load. The development of the plastic hinge in the fastener caused spalling of the substrate. This was particularly pronounced in the brick substrate, where it lead to the propagation of cracks and ultimately the breaking apart of the brick as shown in Figure 4.5:-

Figure 4.5 Propagation of cracks leading to the breaking up of brick substrate.

Calculations using Equation 3.1 were carried out using a timber density value of 450kg/m^3 - the average value of the samples used during test. Although this series of equations is not applicable to Express nail type fasteners calculations based on the cross sectional area of EXPN8x70 were carried out for investigatory purposes. The comparison between calculated and test values are illustrated in Figure 4.6:-



	MSC36070	MSC36082	BTB4C82	KF 7.5x100	EXPN 8x70	KMN72
Brick	2648	2740	3453	4533	4436	
7N	2431	2920	3596	4653	4442	2145
20N	2123	2474	3504	4647	5030	
EC5 Calc.	1938	2341	3148	4577	2418	2056

Figure 4.6 Comparison between normalised test and calculations based on Eurocode 5 Section 8.2.3 taking the timber density to be 450kg/m^3

This illustrates a good degree of correlation between the calculated capacity of each fastener and the value obtained from test. Fastener EXPN8x70 does not follow the exhibited trend, confirming that this design method is not suitable for use with Express nail type fasteners. The mode of failure for all fasteners was calculated as mode c - the embedment of the fastener within the timber due to the development of a single plastic hinge. This did correlate with the mode of failure observed after test (Figure 4.7).

(a)

(b)

Figure 4.7 (a) Development of the plastic hinge within the fastener (b) Embedment of the fastener within the timber. Both are consistent with failure mode "c"

Whilst correlation between results has been shown to exist it is important to highlight the variations between the behaviour of a timber-to-steel and timber-to-concrete connection. The fundamental difference is that where fasteners are installed through steel first (primary member), the fastener heads can not be pulled through and therefore "tear off". The thickness of the steel member (typically around 10mm for flitch beams) is less than that of timber used for the soleplate (38 or 45mm) this considerably alters the length of fastener in the primary member (t_1). The length of fastener (t_1) affects the development of the plastic hinge with greater lengths providing a longer lever arm and therefore greater moment forces. Since embedment of the fastener within the timber is common to all modes of failure, the connection capacity was found to rise linearly with timber density (Figure 4.8). In order to allow for accurate comparison between fastener capacities the effects of timber density were normalised.

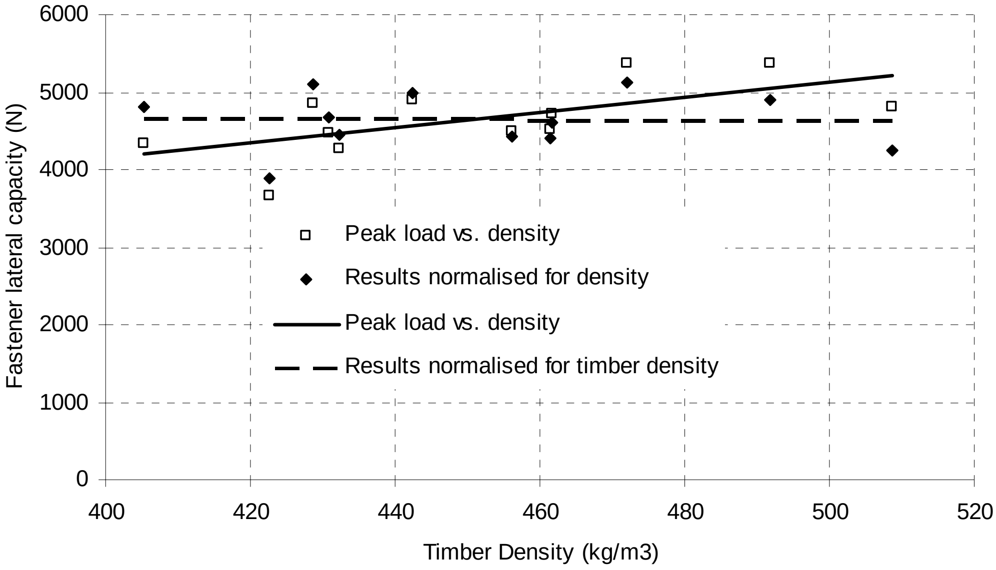


Figure 4.8 Timber density vs. peak load and the effect of normalisation for fastener EXPN8x70

Samples used in the lateral load test were matched according to density; which ranged between 377kg/m^3 and 530kg/m^3 with a mean value of 450kg/m^3. A total of 4 tests were carried out for each suite with the paired timber samples selected to give a range of densities which were designated high, medium or low respective to the to the overall measured range.

Although not able to test the contribution from the rope effect directly its influencing factors can be examined. Considering the behaviour of the joint, the development of the “rope” effect is dependent on the fasteners secure anchorage both in the substrate and primary member. It is also dependent on the ability of the primary member to resist the forces applied by the fastener head. Results from test showed that the critical factor for threaded fasteners was typically the headside pull through as this force is applied perpendicular to the grain. However, for smooth fasteners and those installed in 7N/mm^2 dense aggregate block the point side withdrawal capacity became critical (Figure 4.9)

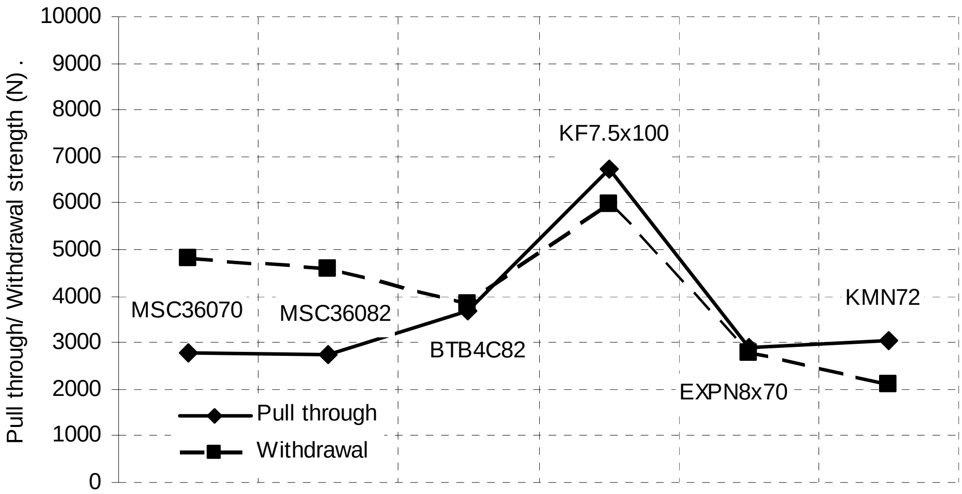


Figure 4.9 Comparison between headside pull through and point side withdrawal for fasteners in 7N/mm^2 substrate.

By carrying out parametric studies using Equation 3.1, the contribution to connection capacity from the "rope" effect can be estimated. Figure 4.10 shows comparisons based upon the following: -

- No contribution from the rope effect.
- Contribution from the rope effect determined from the characteristic withdrawal capacity of the fastener calculated as per EC5.
- Contribution from the rope effect determined based upon the yield moment and withdrawal capacity values obtained through testing.

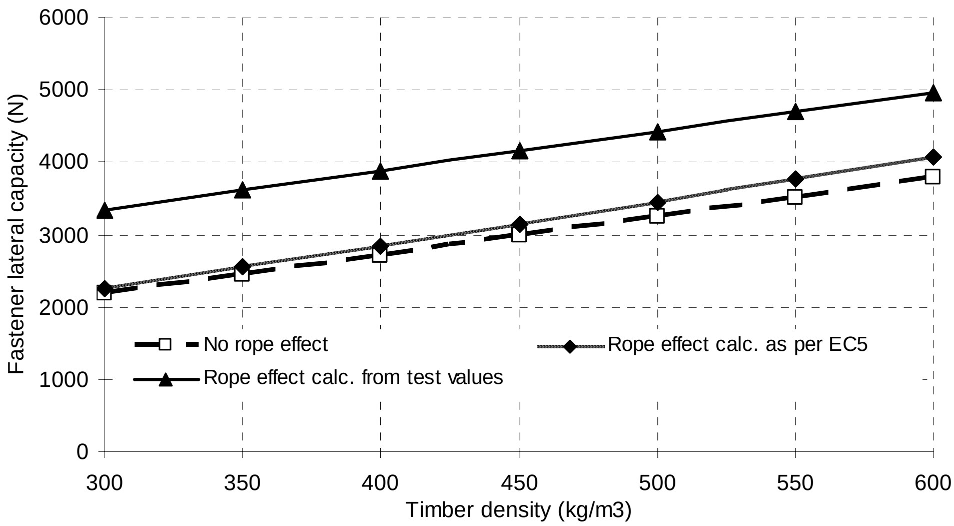


Figure 4.10 Comparison between contributions to connection capacity from the rope effect based on parametric study of fastener BTB4C82.

Based upon these findings the contribution from the rope effect can be estimated to be approximately 30%. However, it has been found that for long nails with threaded shanks the theoretical contribution can be as high as 2.6 times the initial connection strength (Kuipers and Van der Put, 1982).

5. CONCLUSION

Tests carried out to determine the lateral load carrying capacity of the fastener test range identified KF7.5x100 and EXPN8x70 as having the highest capacity. These fasteners differ in both type and form. KF7.5X100 provides connection strength as a result of its high tensile strength and yield moment. EXPN8x70 provides strength and a preferential mode of failure as a result of its cross sectional design. The maximum yield moment for threaded fasteners was found to relate directly to the ultimate failure of the connection. The Service Limit State (S.L.S) failure for all fasteners occurred through embedment of the fastener within the timber. Due to this it was found that connection strength increased linearly with timber density although the specifying of high density timber for this purpose may prove uneconomical in practice. The effect of substrate type on connection capacity was found to be minimal. Inspection of samples post test showed the cracking and break up of brick substrate due to fastener deformation (Figure 4.5).

Considering the suitability of Eurocode 5 Section 8.2.3 *Steel-to-timber connections*, the calculation method gave excellent correlation with the connection capacity determined through test. However, design methods typically give lower values than those reached as a safety measure. Therefore it is recommended that a modification factor is applied relative to the proposed purpose of the connection to ensure safety tolerances are met.

5.1 Future Work

The investigation of the properties of the tested fastener range and the assessment of Eurocode 5 Section 8.2.3 are part of wider research aimed at the collation of an information database used for the specification of soleplate connectors.

Future work in this area will include the following:

- Further investigation of a wider range of fastener types.
- Further investigation into the effects of soleplate thickness and timber type, specifically concentrating on engineered wood products.
- The study of moisture transportation through the damp proof coursing layer as a result of capillary action.
- Optimising fixing specification in terms of structural performance, on-site application and economic cost.

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DEVELOPMENT OF HYBRID-LIGHT CONCRETE BRICKS WITH IMPROVED HEAT-INSULATING PROPERTIES

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Abstract This paper presents the actual state of a research project, currently running at the University of Luxembourg. With regard to energy saving and energy performance of buildings the aim of the project is the development of highly heat-insulating bricks. For this reason, new concrete formulations, the application of new composite materials and the design of new brick geometries regarding the mechanical and thermal requirements are the key aspects of the project. This should lead to a hybrid exterior masonry wall with only a thickness of 30 cm and U-values in the range of 0.2-0.25 W/m^{2}K without regress to additional heat insulation materials or facade elements outside the brick. Different brick geometries and natural renewable and artificial insulating materials are analysed in mechanical and thermal laboratory tests. Supplementary, the finite element method is used for simulating the thermal and static properties of existing bricks to study their weak spot and to use this experience for the construction of new prototypes. In the following paper first results and gained experiences by the FEM-based calculations and experimental validation as well as theoretical basics in building physics and static requirements on masonry structures are presented to obtain a sustainable, high insulated masonry wall.

Keywords: brick, heat transfer, insulating material, light concrete, masonry wall.

1. INTRODUCTION

The popular necessity of sustainable reduction of heating energy with its expected permanently increasing requirements of heat insulation in the future led the University of Luxembourg to issue a project to develop hybrid-light concrete bricks with improved heat-insulating properties. In the beginning the industry developed light concrete hollow and solid bricks made of porous concrete and inner air holes. The influence of the geometry and the dimensions of these inner air holes on the heat transfer properties of heat insulating blocks was studied. It was noticed (Anton, 1992), that the optimum of the thermal resistance of the air holes is reached when their thickness is less than 10 mm. The convection phenomena of the heat transfer mechanisms inside the holes can be neglected in this case and the total heat transfer through the brick can be reduced. However, the thermal optimization of these hollow and solid bricks is limited by the used primary raw materials and the necessity of a minimum thickness of at least 10 cm of the load bearing section of the block. Therefore new concrete formulations, new composite and insulating materials have to be taken into account to combine the advantages of each material. Extreme heat protection while little thickness at the same time should be reached for the whole masonry structure.

After a short description of the theoretical basics in building physics and static requirements of masonry structures the experimental work and the test methods are described in the first part of this paper, a parameter study of the heat insulating and mechanical properties of existing masonry bricks is presented in simulations by the Finite Element Method in the second part.

Finally, proposals for further efficiency possibilities and optimization potential will be given, taking into account the experiences which were made through the market study of existing masonry bricks.

2. THEORETICAL BASICS IN BUILDING PHYSIC

Heat may be transmitted in three ways, by conduction, convection or thermal radiation (VDI, 1997).

Heat Conduction is defined as the transport of energy caused by atomic and molecular exchange of pulse. During this process heat is transferred from places of higher to lower temperature by thermal swinging of the atoms in the lattice of solid materials (Hauser, 2003).

In the case of **convection** the heat transfer occurs between a fluid medium and the surface of a solid state body or the opposite way around, which are moving relatively to each other (e.g. Heat transfer of a fluid to a house wall). So the convection is only possible in a fluid medium (Hering et al., 1997).

Thermal radiation is an electromagnetic radiation which is based on the temperature swinging of the particles of solids and which can spread out with speed of light in vacuum. Therefore the heat radiation can be defined as a transport of energy caused by electrical waves. The radiation only depends on the temperature and the optical properties of the emitter, with its internal energy being converted into radiation energy (VDI, 1997).

The three main heat transfer mechanisms often occur combined in nature and engineering applications. In case of the study, pure conduction is supposed in the light concrete structure and in the insulating materials of the hollow and solid blocks. The convective heat transfer is always accompanied by thermal conductance. In our engineering analysis the convective heat transfer is regarded as a heat transfer between a stream of liquid or gas and a solid surface. That means in the case of the hollow bricks, among the air surrounding the wall and the wall itself and the inner holes of the brick.

The heat transfer properties of a specimen of material may (ISO 8302, 1991)

- vary due to variability of composition of the material
- be affected by moisture
- change with time
- change with the mean temperature.

2.1 Mathematical models of heat transfer process

Within a temperature-field, points of the same temperature are called isotherms. These isotherms can depend on place and time, then these temperature fields are called transient temperature fields. If no time-dependency as assumed for the calculations mentioned in this paper exists, the heat transfer process is called steady-state. In this context the Fourier's-law of the molecular heat transport describes the relation between the cause of the **thermal conductivity**, the spatial temperature gradient $\partial\vartheta / \partial n$ in the spatial direction n and the transmitted heat flow-rate ΔQ through an interface A in the period of time Δt, the so called thermal flux $q=\Delta Q/A\ \Delta t$ (Hering, 1997).

$$q = -\lambda \cdot \frac{\partial \vartheta}{\partial n} \tag{1}$$

with temperature gradients: $\frac{\partial \vartheta}{\partial n} = \frac{\partial \vartheta}{\partial x} \cdot i + \frac{\partial \vartheta}{\partial y} \cdot j + \frac{\partial \vartheta}{\partial z} \cdot k$

For steady-state conditions follows a quasi-harmonic general equation (Clemens/Müller, 1995):

$$\frac{\partial}{\partial x} \cdot \lambda_1 \cdot \frac{\partial T}{\partial x} + \frac{\partial}{\partial y} \cdot \lambda_2 \cdot \frac{\partial T}{\partial y} + \frac{\partial}{\partial z} \cdot \lambda_3 \cdot \frac{\partial T}{\partial z} = f(x, y, z) \tag{2}$$

In matrix form for steady-state problems it can be written,

$$[k_{th}] \cdot \{T\} = -\{q\} \tag{3}$$

where k_{th} is a matrix of dimensions 3 x 3, generally symmetrical due to energy arguments, T is the vector of temperatures and q the vector of the external applied and conducted heat flux.

In the case of **convective heat transfer** adhesion forces between the fluid and masonry wall atoms are responsible for the development of an interface where the velocity $\vec{v}$ of the fluid in motion tends to zero. In this laminar air zone heat transmission takes place through conduction. Therefore the Fourier's law is valid in this case (see Eq. (1)). For the convective heat transfer a constant of proportionality between the heat transferring wall surface *A* referring to the heat flux q_c and the temperature of the fluid ϑ_F and the wall ϑ_W is defined as (Hering, 1997):

$$\frac{dQ}{dt} = q \cdot A = \alpha_k \cdot A \cdot \left(\vartheta_F - \vartheta_W\right) \tag{4}$$

The inclusion of the **radiation** boundary condition converts the heat transfer process into a non-linear problem due to the Stefan-Boltzmann non-linear relationship (VDI, 1997):

$$\dot{Q}_{12} = C_{12} \cdot A_1 \cdot \left(T_1^4 - T_2^4\right) \tag{5}$$

The parameter q is the heat flow velocity for radiation, C_{12} is the radiation exchange coefficient depending on the surface emissivity, the geometry view factors and the Stefan-Boltzmann constant, A is the area through which heat flows, T_1 is the absolute temperature of the body surface and T_2 is the surrounding temperature.

3. LIGHTWEIGHT AGGREGATE CONCRETE (LAC) AND INSULATING MATERIALS

3.1 Lightweight Aggregate Concrete (LAC)

For housing structures and office buildings a great interest in light building materials with good physical material behaviour, with respect to an energy conscious and ecological design, which meet all strength and serviceability requirements, exists. Therefore Lightweight Aggregate Concrete (LAC) offers interesting solutions for wall elements such like masonry bricks.

There are at least three types of porous concrete which have to be distinguished (Wolf, 1999). These include cellular concretes made by introducing preformed foam into fresh mortar or causing the creation of gas bubbles in the mortar due to a chemical reaction. Also lightweight aggregate concretes can be made with natural or synthetic aggregates or concrete which uses single-size aggregate, so that there aren't any fine aggregate fractions in the mixture and therefore it is also called "no-fines" concrete (Figure 1).

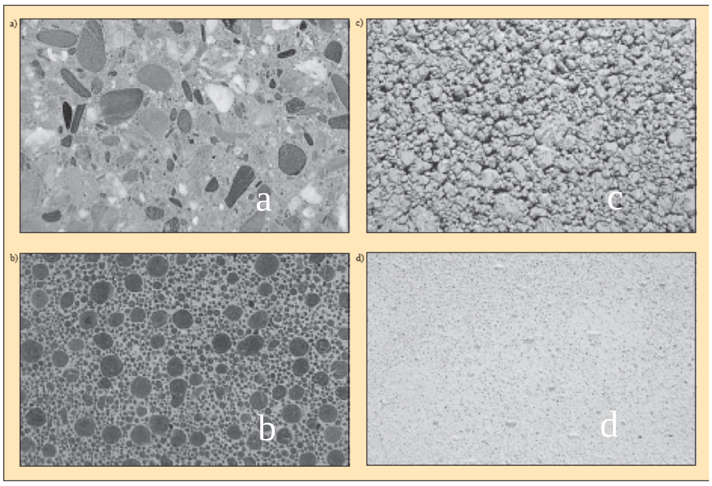


Figure 1: Normal concrete in contrast to different types of light concrete (LC): a) normal concrete with dense structure, aggregate gravel sand; b) LAC with dense microstructure, air lock in aggregates; c) LAC with porous or open structure, air lock in concrete and aggregate microstructure; d) gas concrete, air locks in the form of air pores (Wolf, 1999)

In this paper the focus is turned on Lightweight Aggregate Concrete with open structure (see Figure 1 c). LAC with open structure is a concrete which, depending on the compacting process and the grain size distribution has a defined number of cavities between the single aggregates. It is produced by reducing the cement paste and the fine mortar proportion to a quantity which is necessary to bind the aggregates together at their contact points. Therefore it is a great problem, when producing the LAC, that a seeping of the cement paste into the cavities may occur, due to a liquid consistency.

Only an extremely low range of possible amounts of cement paste depending on the grain size can be considered. The normally used range of cement contents in LAC is between 160 and 250 kg/m^3 (Dehn, 1998). This typical range of cement content could also be proved by the development of own LAC-concrete mixtures with expanded glass and expanded clay aggregates from different producers.

Due to the open structure LAC has in comparison to normal concrete or structural lightweight concrete a low dry density and a better thermal insulation capacity. By using lightweight aggregates, a dry density below a value of 500 kg/m^3 is reachable (see Figure 2). But as it can be seen in the diagrams below, such a low density, reached by reducing the content of fine aggregates and cement, results in a low compressive strength. The strength of the cube specimen of 150 mm is below 3 N/mm^2 and therefore to low for the production of masonry bricks with inner air holes (DIN 18152/DIN 18151, 2003). An exact mix composition for LAC is very difficult to define, because the volume of the cavities cannot exactly be estimated in advance. Considering the relation between the dry density and the compressive strength (Figure 2) the air content of the porous concrete is proportional to the oven dry density (dried at 105 °C) while the compressive strength is inversely proportional and increase by augmenting densities. The (Figure 2) shows the results achieved at the University of Luxembourg for LAC with expanded clay of a range of grading of 0 to 10 mm with a gab grading between 2 and 4 mm. The density was changed by augmenting the cement and fly ash content.

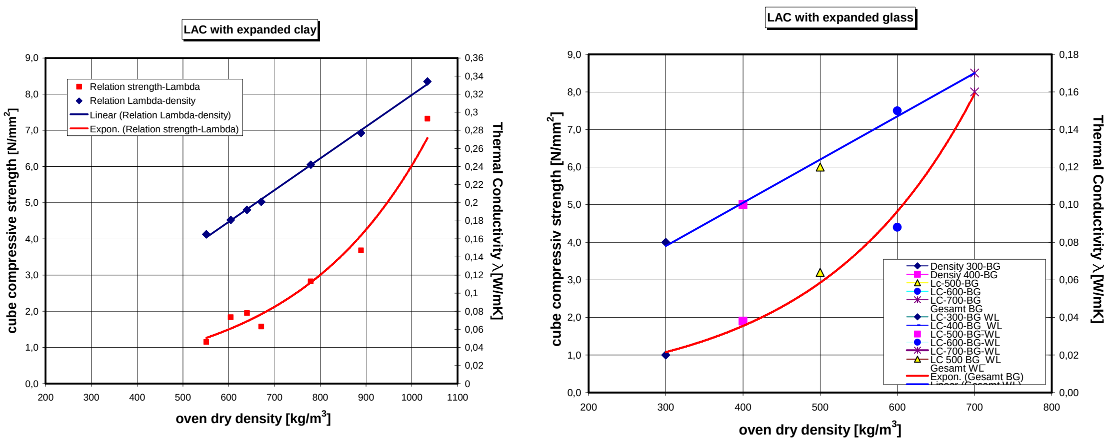


Figure 2: left side: Comparison of the compressive strength of 150 mm cubes made of LAC mixed with expanded clay aggregates after 28 d to their densities and design thermal values (EN 1745, 2002)
right side: Relation of cube compressive strength, thermal conductivity and oven dry density after 28 days for cubes made of LAC with expanded glass

For the production of prefabricated masonry bricks made of LAC, the stability of the fresh concrete has a great influence, because the blocks have to be removed from formwork quickly after concreting and compacting. This can be reached by the use of fly ash, mainly additives and cement mixtures, since they show a clearly bigger specific surface and an increased adhesive strength.

As mentioned before, the hygroscopic behaviour of the LAC also plays an important role when considering the thermal conductivity. Hence, a great number of solid and hollow blocks made of LAC chosen by a market study were stored in the laboratory after they were dried at 105°C until they were conditioned to constant mass. Subsequently, they were stored during the summer and winter month in a changeable room atmosphere to reach equilibrium with the room air (constant mass). A relative mass changing after conditioning in room atmosphere is calculated from the mass determined before and after the drying. It can be seen from (Figure 3) that e.g. the three specimens shown in the diagram below, absorb only slowly, not really significant quantities of moisture from the laboratory air. This test was made to estimate the amount of absorbed water and the time required by the specimens to absorb water to predict a typical moisture content value for each LAC and bloc geometry. Finally, this prediction will be used for calculations of typical design thermal values for FEM-based simulations. Procedures of calculations of the design thermal equivalent conductivity are given in the standards (EN 1745, 2002) and (DIN 4108-4, 2004) respecting the moisture correction coefficients for each material.

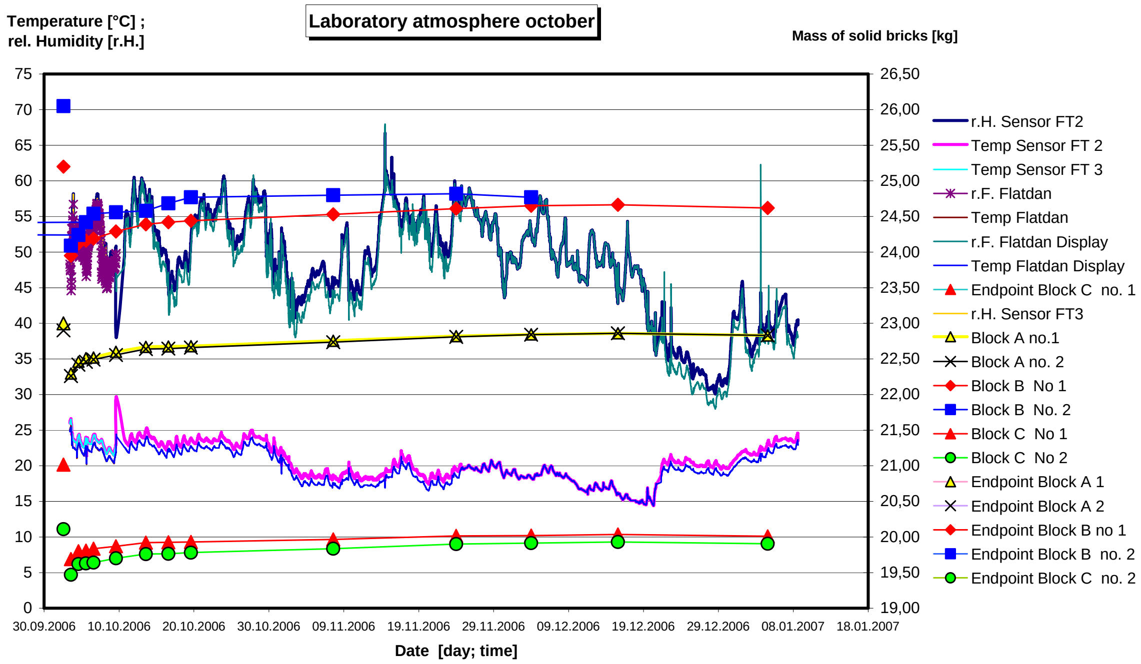


Figure 3: Hygroscopic-time-dependent behaviour of lightweight concrete solid bricks with advanced thermal requirements in Laboratory atmosphere

3.2 Insulating materials

Insulating materials considered in this project are natural, renewable ones, which can be divided into organic or mineral materials, e.g. Cannabis, Flax and Cork or as mineral Perlite and Pumice. Own experiments with renewable raw materials have also been done. In (Figure 4) prisms after the bending moment test are presented. The prisms are made of lightweight aggregates such as flax, expanded glass and clay and as binders different mixing ratios of cement and clay were used, which was recycled from the sand washing process of Luxembourg’s cement industry. In the mechanical laboratory tests, like the cube compressive resistance and the bending moment test, it became apparent that the strength of prisms with a low cement ratio has not turned out satisfactory for use as construction material for load bearing units.

On the other hand, artificial insulating materials such like PUR – 2-component foams or EPS insulation panels were examined. For e.g. expanded polystyrene is a very dense particle foam having a closed cell structure with lots of tiny air holes and therefore it has very good insulation properties. In (Figure 4) two examples of the use in building materials are shown. In the middle an experiment in our laboratory is shown with air voids of the brick filled with 2-component-polyurethane foam to reduce its thermal conductivity. This block was measured in a special apparatus and simulated by a finite element analysis described in the next chapters. On the right side of (Figure 4) a product sold on the free market with the internal volume made of Styrofoam is shown.

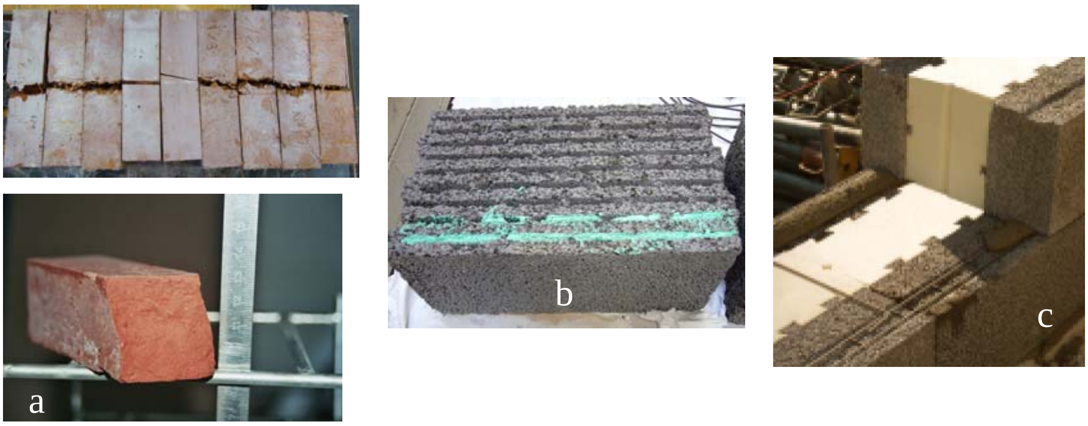


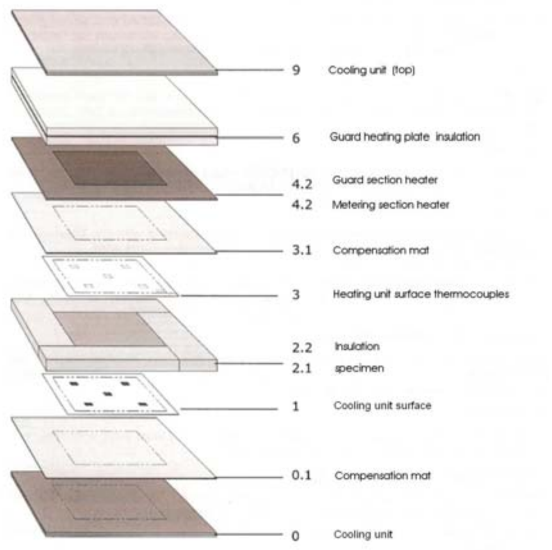
Figure 4: left (a): Prisms of renewable raw materials after the bending moment test middle (b): Experimental setup for filling the air holes of a solid masonry brick made of LAC with 2C-PUR-insulating foam right (c): Example of a sandwich masonry block used in Scandinavia

4. THERMAL AND MECHANICAL LABORATORY TESTS

In this section the experimental setup and program will be described for the thermal and mechanical laboratory tests. First the methods and the methodology adopted for thermal measurements and afterwards the mechanical tests which are made to obtain initial parameters, necessary for simulating masonry bricks in 3-dimensional FEM-models, are shown. Furthermore, whole masonry bricks are tested to compare the experimental results with those achieved by the FEM-model based calculations.

4.1 Thermal experimental program

The equivalent thermal conductivity of lightweight concrete masonry bricks is measured by a guarded hot plate apparatus (Taurus 2005), which is built following the restrictions of (ISO 8302, 1991). At 105°C oven dried specimens with a brick-thickness of 30 cm corresponding to the project aim to develop blocks for masonry walls of 30 cm are measured. The influence of moisture within a specimen on the heat transfer during a measurement is difficult to define and very complex. Therefore, only oven dried specimen with constant mass shall be tested according to the European and international standard procedures (DIN EN 12664, 2001) and (ISO 8302, 1991). The basic design of a guarded hot plate instrument can be seen in (Figure 5). Two different types of guarded hot plate apparatus were derived from the basic principle. On the one hand the Two-specimen apparatus and on the other hand the Single-specimen apparatus. Because of the great thickness of the specimens, only the Single-Specimen method is used in this research project. A sample is positioned between a heating and a cooling unit. A well-defined power is put into the hot plate during the measurement. The guard heaters around the hot plate and the specimen setup guarantee a linear, one-dimensional heat flow from the hot plate to the cooling unit. By measuring the power input of the hot plate, the temperature gradient and the thickness of the specimen, the thermal conductivity can be determined according to the Fourier equation.



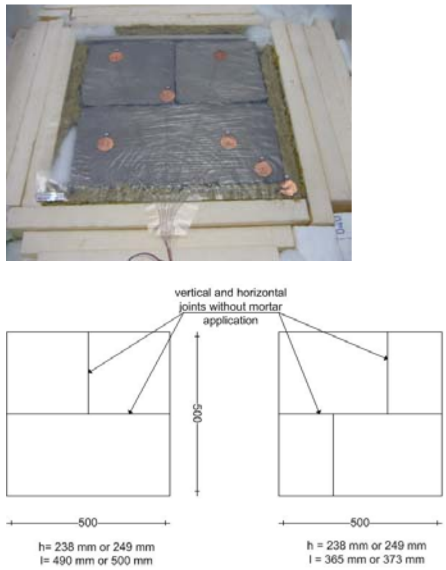


Figure 5: left: Schematic structure of the guarded hot plate apparatus right: Experimental set-up with brick specimens in the metering section surrounded by insulation materials in the chamber of the hot plate apparatus

According to the European and International standards e.g. (DIN EN 12664, 2001) and (ISO 8302, 1991), specimens of a maximal thickness of 150 mm or of 200 mm, if following the German DIBt-guideline (DIBt, 2003) shall only be tested in a guarded hot-plate apparatus. Specimens of a greater thickness than 200 mm shall be measured according to (DIBt, 2003) as Half-Brick Measurement, which means that 300 mm thick blocks are divided into about half the wall thickness parallel to the surfaces of the wall, dried at 105°C to weight constancy and assembled in the plate apparatus to form a test specimen with the dimensions of 0.5 m x 0.5 m, see (Figure 5). During the research work a great number of different types of solid and hollow bricks made of LAC with open and dense microstructure, gas concrete and clay bricks chosen from the free market to test the actual standard of the heat-insulating and mechanical properties were tested. To reduce the time requirements and the effort to prepare the test specimens as well as for the reason of symmetry of the solid bricks, it was decided to measure whole bricks. Solid bricks following the design rules of the German standard (DIN V 18152, 2003) have on half the wall thickness on their symmetry axe an inner line of air holes. The influence of these air holes on the heat transfer would be neglected, if the block is cut into two halves. For this reason, the influence of the specimen height and the uncertainty in measurement had to be evaluated separately, because there are no standards existing and the uncertainty of measurements is a significant quality feature.

4.2 Uncertainty of the guarded hot plate apparatus measurements

The determination of the measurement inaccuracy was implemented in accordance to the “Guide to the Expression of Uncertainty in Measurement (GUM)”. The exact methodical approach can be gleaned in (GUM, 1993). Consecutively, only the finally calculated resulting combined standard deviation is given, which was calculated after the input quantity, sensitivity coefficients and individual standard uncertainties were determined. The absolute combined standard uncertainty can be calculated, for e.g. for the measurement of solid bricks made of LAC with a thickness of 30 cm, to $u(\lambda) = \pm 5.711 \times 10^{-3}$ W/mK and the expanded uncertainty *U* is obtained by multiplying $u(\lambda)$ by a coverage factor *k*. Typically, *k* is in the range of 2 to 3. For these calculations *k* was chosen to 2, defining an interval having a level of confidence of approximately 95 percent. The expanded uncertainty in measurements follows to $U(\lambda) = 0.011423$ W/mK and the complete result and its uncertainty of a hot plate apparatus measurement is reported for the regarded specimen with $\lambda=(0.15 \pm 0.0114)$ W/mK. This means a relative measurement uncertainty of 7.6 % has to be considered for this way of testing the bricks. In (ISO 8302, 1991) a typical range of uncertainty is given by 5 to 6 %. Thus, the influence of the greater thickness of the specimens is acceptable.

4.3 Mechanical experimental program

The mechanical experiments are done according to the European standards (EN 1352, 1997) and (EN 1354, 2005). Tested are separately in the laboratory cubes and cylinders made of LAC (see chapter 3) and 13 types of different blocks taken from the building market for evaluating the compressive strength, E-modulus, transverse and compressive strain. These material properties were tested to adopt the measured parameters as initial parameters for the FEM-based calculations using ANSYS as FEM software. The compressive strength and strain of the blocks is tested to validate the results calculated numerically by a FEM analysis for stress-strain-curves of these blocks. The following pictures show the specimens for the material laboratory tests and the experimental setup developed at the University of Luxembourg to test blocks position-controlled for obtaining stress-strain curves.

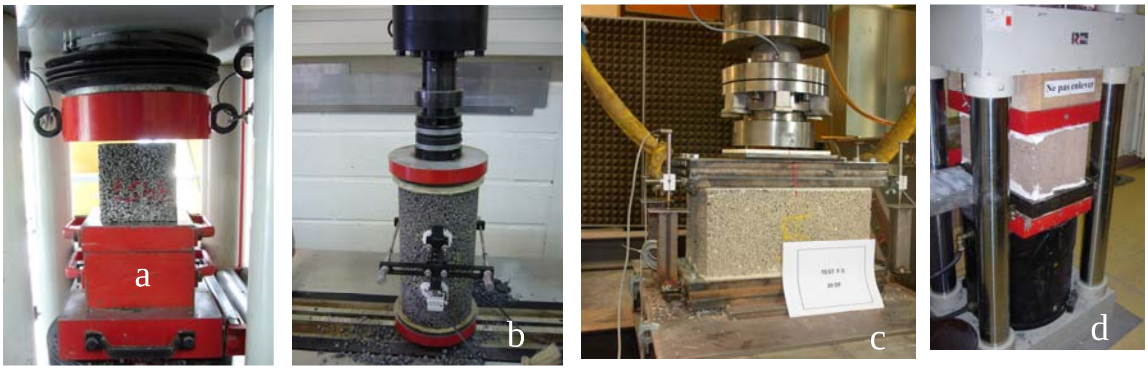


Figure 6: from left: Test set-up for cubes (a), cylinders for E-Modulus Testing (b), position-controlled measurement of bricks for obtaining stress-strain curves (c), and force-controlled measurements (d) following German standard (DIN V 18152, 2001)

5. FINITE ELEMENT ANALYSIS

Two FE-Models used for simulating the thermal and mechanical behaviour of existing bricks, also analysed in laboratory tests, are presented. For realistic modelling of geometry and the various materials a 3-dimensional masonry model was developed and implemented in ANSYS. Only by modelling the 3-dimensional non-linear effects, realistic thermal, stress and strain fields could be determined and the serviceability and static requirements were comprehensively proven.

For the solid lightweight concrete brick (see Figure 7) a parameter study was done, changing the thermal conductivity values of the air holes from the perforated brick. The

LAC-material conductivity was set to 0.175 W/mK according to experimental measurement tests in the hot plate apparatus from plates cut out of the brick. The thermal conductivity of the inner air holes was changed from 0.09 W/mK (case 1), recalculated from a measurement of a brick, to 0.07 W/mK, value of the equivalent conductivity achieved by using the equation for thermal resistance of air gaps from (DIN EN ISO 6946, 2003) and 0.03 W/mK (case 3) assuming, that the air gaps are filled with PUR-insulating foam. Simulated was the oven dried material without influence of moisture. In the modelling a solid type, named SOLID 90 (Ansys, 2005) with tetrahedral finite elements with 20 nodes has been used for light concrete and material filled air gaps. Convective heat transfer was excluded from the analysis and the external film coefficient on the wall sides was set to zero, because during the real measurement in the hot-plate apparatus convection on the surfaces of the brick shall also be excluded. The boundary conditions were chosen like during a hot-plate measurement. The internal temperature distribution is caused by surface temperatures of 5 and 15°C. The ambient temperature is set to 273 K. The next (Figure 7) shows the 3D-FE-Model for a solid light concrete brick and results obtained for varying material parameters.

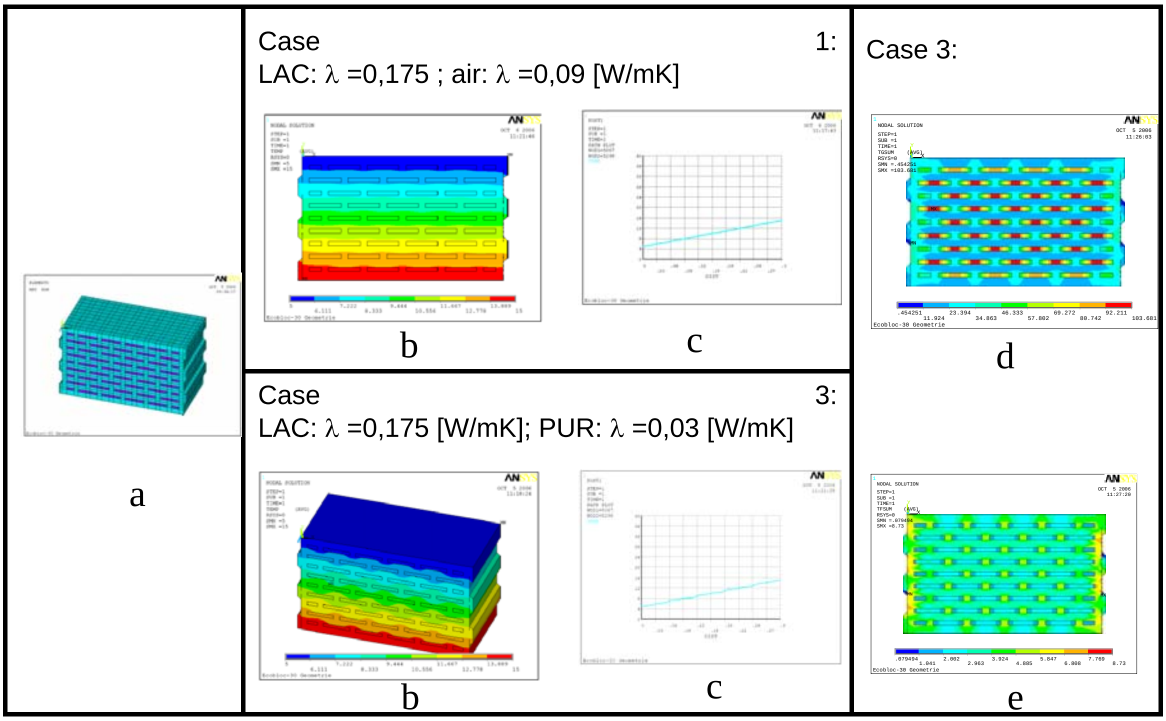


Figure 7: left: FE-Model, isoperimetric view (a) middle: temperature distribution (b) for case 1 and 3 and plotted graphs of temperature distribution over the cross-section of the brick (c) right: above temperature gradient (d) and below thermal flux caused by external boundary conditions (e)

The influence of the insulating PUR-foam in the inner air holes of the brick can be seen in (Figure 7). Due to the fact, that for the load case 3 the air gaps have a 3-times higher thermal resistance than in case 1, the isotherms of the temperature distribution are much more curved and the thermal flux in W/m^2 is concentrated in the area of the small concrete webs between the air holes of the block. This is also shown by the much higher temperature gradient of the air holes in comparison to the LAC-parts of the block (see Figure 7, right side above).

Another example which is presented in this paper is the FE-Model of a Scandinavian Sandwich-Brick. The brick with its dimensions and the 3-D Model can be seen below. For this brick the thermal and static simulation will be shown. The brick is used for reinforced masonry walls with a thickness of 38 cm, it is made of two outer layers of lightweight concrete and an internal layer made of Styrofoam. The layers are connected by 5 stainless steel masonry tie bars per square meter. In the modelling SOLID 90 has been used for the light concrete layers and the internal Styrofoam volume and the tie bar is modelled as 3-dimensional heat conducting bar, named LINK 33. For the mechanical, static analyses the elements were switched from SOLID 90 to SOLID 186, structural solid with 20 nodes and from LINK 33 to LINK 8, a uniaxial tension-compression element with three degrees of freedom.

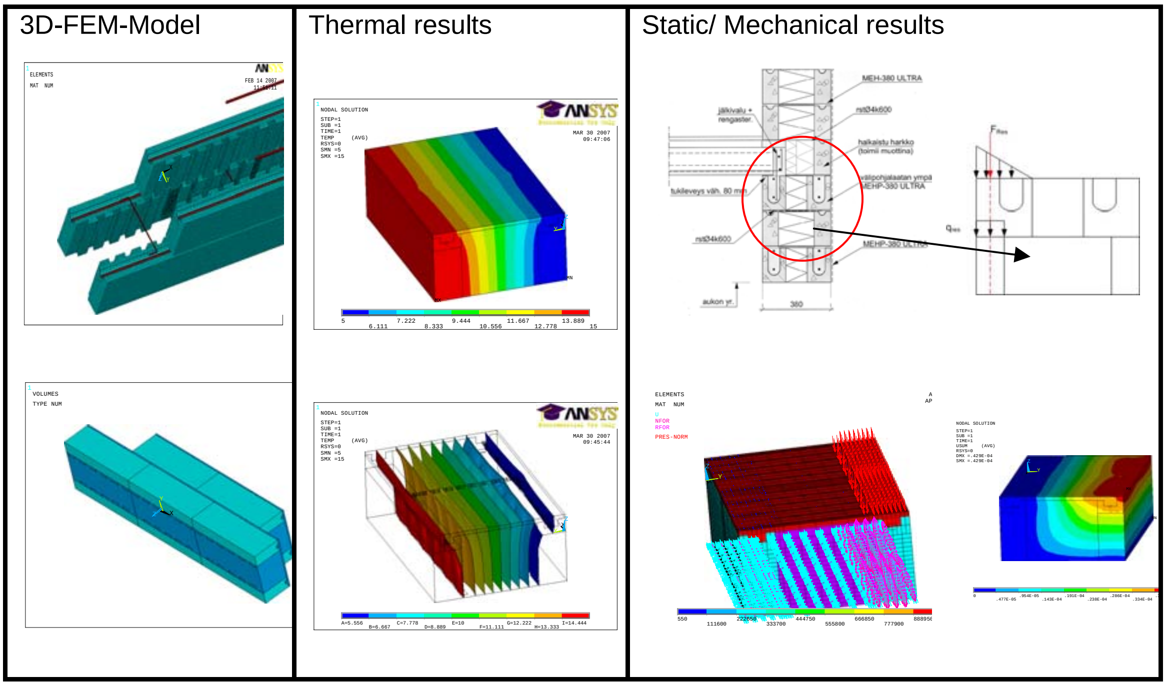


Figure 8: from left to right: model of a wall section with reinforced masonry, temperature distribution by thermal calculation, and simulation for one universal brick in the sphere of influence of the ceiling

The thermal calculation has been done to show the influence of a block walled in an incorrect manner. Normally the horizontal joints, following the guidelines of the producer, shall be interrupted in the middle of the block above the internal insulation material by a layer of mineral bounded rock wool, to avoid direct heat flows through the not well insulated, cement based mortar layer. As it can be seen by the curved isotherms the mortar has the biggest influence on the heat transfer. The influence of the stainless steel tie bar is nearly negligible, cause of its small diameter of 4 mm. So in this case, it can be seen, how important a continuous layer of insulating material is for reducing the heat transfer through a masonry wall. Regarding the static analysis, it was proven, that the inner light concrete layer of 9 cm is thick enough for a load bearing capacity of 4 N/mm^2. However, it couldn't be proved, if the thickness of the wall is big enough to avoid a buckling of the wall, if the free buckling length is over 2.3 m. Further tests are necessary, to found the critical load and to see, if the outer concrete layer can be considered in a static calculation.

6. CONCLUSIONS

It could be shown that the measured thermal conductivity is inseparably linked with the material's density, the moisture content and measurement temperature and for solid and hollow bricks specially linked to the geometry of the brick and the arrangement of the inner air gaps. Thus, developing new light concrete formulations, attention should be paid on choosing the type of light aggregates, the cement and paste content and specially the method and forces of compacting them. By mechanical and thermal testing of specimens made separately in the laboratory, the relation between density, compressive strength and conductivity was determined. Additionally, a parametric study has been done by using the FEM. Although, the initial moisture content of bricks stored in the laboratory for at least 3 months after production was tested. It became apparent, that the initial moisture content is strongly depending on the bricks geometry, the way of handling and storing of the bricks by the manufacturer, and the type of lightweight aggregates used in the concrete mix. Therefore a great range in the initial moisture content between 2.4 to 22.6 % referring to the dry mass of different bricks made of LAC was observed.

The finite element method (FEM) has been shown as a very suitable method in modelling and analysing single structures for heat transfer and mechanical analysis. A fine FEM mesh with the parameter ranging from 0.001 to 0.01 m was used. Due to the special and irregular geometry of these hollow, solid and sandwich reinforced masonry bricks, the user of the meshing tool of ANSYS is challenged by finding a solution in order to discretize the brick volumes. The numerical results achieved by the FEM based numerical simulation were proven by analytical calculations in 2D and experimental tests. Comparing these results, a good agreement between calculation and measurements was found. The differences are smaller than 9% by a measurement uncertainty of the hot-plate apparatus of 7.6 %. As it is demonstrated by the FEM results, if mortar and material conductivities increase, the insulation of the entire wall decreases and the temperature distribution among a brick section strongly depends on the mortar conductivity.

After all, the comparison of the measurements, the testing methods and the finite element analysis showed reliable results. Therefore the FEM-tool is suitable for getting accurate results in a reasonable period of time, which allows the researcher and the brick producing industry to optimize the design of bricks easily prior manufacturing and testing prototypes. The methodology adopted, allows the use to every brick design in order to optimize the thermal and static behaviour of these bricks. Typically, only the thermal or static behaviour is tested separately, but as shown in this paper, they are influenced by each other. The FEM can save costs by reducing the number of laboratory and real scale tests of bricks and walls. Finally, this research methodology should lead to a resource saving development of hybrid light concrete bricks with heat insulating properties by studying the actual standards and testing materials in small tests and simulating the whole structure by the FEM.

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THE SWORD OF DOMCELES: ERROR CONTAINMENT AND REDUCTION IN PROJECTS

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Abstract: A plethora of mega-projects have commenced to meet the increasing demand for new infrastructure in Australia. Such projects are typically complex in nature and are prone to cost and schedule overruns. A significant factor that often contributes to these overruns is rework. Omissions errors (i.e. failures to carry out necessary steps in the performance of a task), in particular, have been found to account for as much as 38% of the total rework costs experienced in projects. To date there has been limited research that has sought to determine the underlying factors that contribute to omission errors in construction and engineering projects. Using data derived from 59 in-depth interviews undertaken with various project participants the causal nature omission errors is examined. It is suggested that once an understanding of the archetypal nature and underlying dynamics of errors is acquired then *error reduction* (measures designed to limit the occurrence of errors) and *error containment* (measures designed to enhance the detection and recovery of errors, as well as minimize their adverse consequences) strategies can be implemented in projects.

Keywords: Omission, error, rework, error containment and management.

1. INTRODUCTION

In the construction and resource engineering sector in Australia, particularly in Western Australia, a plethora of mega-projects have commenced to meet the increasing demand for new infrastructure and resources such as oil and gas, bauxite, copper, iron ore and nickel. Such projects are typically complex and are prone to cost and schedule overruns. A significant factor that often contributes to these overruns is *rework* (Love *et al*. 2005). While several definitions of rework can be found in the literature, a common theme that can be derived from them is that it relates to "the unnecessary of effort of redoing a process or activity that was incorrectly implemented the first time" (Love, 2002). Design changes, errors and omissions have been found to account for 79% of the total rework costs experienced in a project (Love and Li, 2000). In particular, omissions errors have been found to account for as much as 38% of the total rework costs experienced (Willis and Willis, 1996). Omissions errors are failures to carry out necessary steps in the performance of a task and are deemed to be the single most common form of human error (Reason, 1998). Reason (2002:p41) states that "affordances in this context are situational factors-as distinct from personal factors- that promote the likelihood of an omission error". Omission errors are a result of *pathogens* within a system that translate into error provoking conditions within the firm and project (e.g., time pressure, under staffing, fatigue and inexperience) and contribute to unworkable relationships, procedures and design and construction deficiencies (Reason, 2000). Using data derived from 59 in-depth interviews undertaken with various participants operating in the construction and resource engineering sector the causes of omission errors are examined.

2. PROJECT PATHOGENS

Pathogens are latent conditions (Reason, 1990) and tend to reside in a system until an error comes to light, but before they do, project participants are generally unaware of the impact of particular decisions, practices or procedures can have on a projects performance (Busby and Hughes, 2004). Pathogens have been defined by a number of qualities (Busby and Hughes, 2004:p.428):

- they are relatively stable phenomena that have been in existence for a substantial time before the error occurs;
- before the occurrence of the error they would not have been seen as obvious stages in an identifiable sequence failure; and
- they are strongly connected to the error, and are identifiable as principal causes of the error once it occurred.

The pathogens that have been revealed to contribute to the occurrence of errors can be categorized as (Busby and Hughes, 2004):

- *Practice* – arising from people's deliberate practices;
- *Task* – arising from the nature of the task being performed;
- *Circumstance* – arising from the situation or environment the project was operating in;
- *Organisation* – arising from organisational structure or operation;
- *System* – arising from an organisational system;
- *Industry* – arising from the structural property of the industry; and
- *Tool* – arising from the technical characteristic of the tool.

Busby and Hughes (2004) found that many of the pathogens identified in their study of errors in engineering firms were based on *practices* (i.e. those pathogens from people's deliberate practices) that attempted to solve a particular problem. For example, reusing design details and specifications (without examining their application in detail) to reduce time in order to meet the increasing demands imposed upon designers by their clients. The practice of starting work on the basis of tentative information is often a consequence of working within the realm of non-traditional procurement methods (overlapping of activities) and therefore short lead-times are often needed to meet a project's schedule.

Individuals may repeat practices, such as taking short cuts and not following due processes, and if they find the practice provides them with an outcome to be deemed satisfactory, and then they continue with this practice on future projects if they can get away with it (Busby and Hughes, 2004). For example, the decision by designers to eschew audits, checks, verifications and reviews prior to releasing documentation for pricing or construction. Despite the importance of such activities, this practice has become a norm due to the financial and time pressures being imposed upon design firms by their clients (Love and Edwards, 2004). Tilley and McFallen (2000) have suggested that the greater the demands imposed by clients for earlier completion of projects, then the greater the likelihood that designers are to produce erroneous contract documentation. Lack of attention to quality management during the design process has resulted in the notion of rework becoming entrenched in work practices and consequently less profit is being experienced (Love *et al*., 2003).

3. NATURE OF ERROR

Senders and Moray (1991:p.5) defined error as “something that has been done, which was: not intended by the author; not desired by a set of rules or an external observer; or that least the task or system outside its acceptable limits”. Knocke (1992:p.32), however, defines an error and omission as “any departure from correct construction (including checking and supervision) technical inspection; and absence of adequate instructions for maintenance and operation of the building”. In practice, the definition for ‘correct construction’ can be found in the Building Code of Australia (BCA) and technical product material that is often specified by suppliers.

Reason (1990:p.9) describes human error in psychological terms as “all those occasions on which a planned sequence of mental or physical activities did not follow as intended if that sequence of plan could proceed, it failed to achieve its desired outcome”. Implicitly, there are difficulties in objectively interpreting the ‘mental or physical’ activities of people and thus determining if they were the cause of the error (Busby, 2001). In fact, it is a matter of contention whether individuals can justifiably be blamed for all errors, as making mistakes is seen to be an innate of human nature (Reason, 1990). Hagan and Mays (1981:p.339) defined human error as “a failure of the human to do a designed task within specified limits of exactness, sequence or time”. This definition is ambiguous inasmuch as it is impossible to determine what is meant by exactness, and the sequencing and timing of activities can vary without causing error or being erroneous. Nowak and Carr (1985:p.3), on the other hand, define human error as “a performance that deviates from an acceptable standard of practice”. Likewise, Bea (1994: cited in Atkinson, 1998:p.340) defines human error as “a departure from acceptable or desired practice on part of an individual that can result in unacceptable or undesired results”. While these definitions are succinct, it is difficult to determine an acceptable standard of practice unless a specific reference is made to charters provided by professional bodies such as the Royal Australian Institute of Architects or Institute of Engineers, Australia.

Design consultants (such as architects and engineers) are expected to use reasonable and ordinary care in the practice of their profession and their responsibilities are in part defined by *social ascription* (Grunwald, 2001). From a legal perspective this is well known among the professions, but clients are not always aware or made of aware of this (Guckert and King, 2002). Architects and engineers cannot guarantee the results of their service. However, their liability for errors and omissions can be “determined by whether they have performed their services with the standard of care consistent with other professional designers within their community” (Guckert and King, 2002). What remains troublesome for many clients once they are aware of their designer’s obligation is to define what is meant by *standard of care*. Usually this is left up to a court of law or a panel of experts once a breach of the standard of care is identified, but this can be a long and tedious process for clients with no guarantee of a successful outcome (e.g., Chapman, 1998). Even when a standard of care is agreed upon, any financial recovery may hinge on whether the mistake was an error (mistakes made by the designer) or omission (omitted from the contract). What is even more difficult to determine is the management practice that should have been implemented to prevent the error or omission from occurring in the first place. For example, Rounce (1998) has suggested architects specifically lack procedures to control the design process and generally do not implement activities that assure conformance. As a result, the design related documentation that is produced often contains errors and omissions. In fact, it has been found that errors and omissions contained within design documentation are the major cause of contractual claims (Kumaraswamy, 1997), change orders and rework (Tilley and McFallen, 2000).

There is an explicit moral belief within society that professionals should not make errors (Busby and Coekelbergh, 2003). Reason (2002:p.40) states that there are two corollaries to such a view: First, the errors of professionals are deemed to be invariably rare, but when the do occur they are significant to cause adverse events, and second, that errors of adverse consequences must be negligent or even reckless and deserve deterrent sanctions. Amalberti (1997) states that responsible and highly trained professionals regularly make errors, many of which are detected and recovered or inconsequential in nature. The identification of errors, particularly during design, can be useful in 'trail and error' learning or serendipitous discovery (Reason, 1990; Busby, 2001). In addition, Busby (2001) suggests that emergence of errors within a system may often help design professionals understand the underlying nature of a task that may have come become routine, automated, or simply taken for granted.

3.1 Causes of Error

Errors are often not immediately identifiable and only come to light after a period of *incubation* in the system (Busby and Hughes, 2004; Love and Edwards, 2004). For example, a dimensional error or spatial conflict may not arise until the project is being constructed. An array of factors could have contributed to this error, but in this case it is assumed it was due to a mistake made by the designer. Simply undertaking a design audit, verification and review are management practices that can be adopted to minimize the occurrence of errors, particularly dimensional errors, but they are very rarely implemented in small and medium sized construction projects. Yet, in resource-based engineering projects, for example, such practices are always implemented due to the complex nature and capital expenditure involved. Needless to say, errors still plague both construction and engineering projects. An error can arise due a number of reasons:

- *mistake* - an error occurs as a result of ignorance of the correct task or the correct way to perform it. According to Reason (1995) such mistakes can be either rule-based or knowledge based. With respect to rule-based errors, a practitioner may simply misapply a rule that is has worked in a previous situation because they failed to notice contraindications. Alternatively, a bad rule that has remained uncorrected in a practitioner's collection of problem solutions could be applied to the situation at hand. Knowledge based mistakes, occur when the practitioner, encounters a novel situation that lies outside the range of their learnt problem solving routines. Kletz (2001) refers to such mistakes as a *mismatch*, as they arise because they are beyond the physical or mental capability of an individual. When confronted with such a position, practitioners are often forced to resort to slow and effortful reasoning and as such susceptible to making errors (Reason, 1995). This is because a practitioner can only attend to and manipulate one or two discrete items at a given time, and they have to reply on a mental model of the current situation that is inherently incomplete (Reason, 1995). In addition, practitioners have a tendency to follow their instinct and select features of the world to support it, while neglecting contradictory evidence that may before them.
- *non-compliance* – an error occurs because an individual decides not to carry out a task or not to carry it out the way instructed or expected. They are deliberate acts and may occur due to motivational problems (e.g. low morale, poor supervision, perceived lack of concern, etc). Such errors occur in a regulated social context and the prevention of which must be addressed through motivational and organisational

remedies rather than improving the quality and delivery of information within an organisation and project.

- *slips and lapses of attention* – an error that occurs as a result of forgetfulness, habit, or similar psychological issues. Here the error typically occurs at the level of execution and generally involves routine tasks in familiar surroundings. Reason (1995) suggests such errors are associated with some form of attention capture, either distraction from the immediate surroundings or a preoccupation with something.

Fatigue, workload, cognitive overload, poor interpersonal communications, imperfect information processing, and flawed decision-making are also factors that have been identified as contributors to the occurrence of errors. A detailed review of the generic causes of errors in the construction and engineering projects can be found in Blockley (1992), Atkinson (1998a,b), Wantanakorn *et al*. (1999), Busby (2001a), Andi and Minato (2003a,b); and Love and Josephson (2004). The predominance of omissions arises from a variety of mental processes that are implicated in their occurrence (Reason, 2002). The determination of the exact cognitive processes that are involved in omitting a crucial task is an arduous process, as even the error maker finds it difficult to identify the cause of a specific failure. Reason (2002) has suggested that to reduce the incidence of omission errors in a process, there needs to be a shift away from examining the underlying mental processes involved to those characteristics most likely to afford them. Several authors have identified a number of task properties that are likely to increase the probability that a particular task in a process will be omitted, for example:

- the greater the informational loading of a particular task, that is, the higher the demands imposed upon short term memory the more likely it is that items within that step will be omitted (Norman, 1998);
- procedural steps that are functionally isolated that is ones that are not obviously cued by preceding actions nor follow in a direct linear succession from are more likely to be left out (Reason 2002);
- recursive or repeated procedural steps are particularly prone to omission. In the case where two similar steps are required to achieve a particular goal, it is the second of these two steps that is most likely to be neglected (Herrman *et al*., 1992);
- steps in which the item to be acted is concealed is liable to omission (Reason, 2002);
- steps located near the end of a task sequence are likely to be omitted. Such premature exits are due in part to the actors preoccupation with the next task, particularly when the current activity involves largely routine tasks (Reason, 1998); and
- tasks that involve planned departures from standard operating procedures or from habitual action sequences are liable to strong intrusions in which the currently intended actions are supplanted by a more frequently used routine in that context, and thus omitted (Reason, 2002).

A number of the above omissions may occur simultaneously and be combined into a single task. When this happens the effects are additive and the result is a recurrent *error trap* for those involved (Reason, 1998). According to Love *et al*. (2007) once an understanding of the causes of omission errors is acquired then *error reduction* and *error containment* strategies can be implemented in projects.

4. RESEARCH APPROACH

To determine the latent conditions that contribute to omission errors an exploratory research approach was adopted. This was because limited research pertaining to the causal ascription of omission errors has been undertaken within the domain of projects.

Fifty nine in-depth interviews with were conducted over a six month period with a variety of personnel from the construction, engineering and resource based sectors (Table 1). The interviews were used as the mechanism to determine the causal nature of omission errors inasmuch as they are an effective tool for learning about matters that cannot be observed. Firms from Melbourne, Perth, and Sydney were selectively sampled and invited to participate in the research. The interviews were conducted at the offices of interviewees. Interviews were tape recorded and transcribed verbatim to allow for the nuances in the interview to be apparent in the text. The interviewees' details were coded to allow for anonymity, although all interviewees were aware that it might be possible to identify them from the content of the text.

Table 1. Sample characteristics by position and industry sector

Position Type	**Industry Sector**		
	Oil & Gas (n=20)	*Mining* (n=18)	*Construction* (n=21)
Operations Manager	**	**	
Project Manager	************	****	*****
Structural Engineer	***	***	****
Procurement Manager		**	
Quantity Surveyor	*		****
Architect			********
Mechanical Engineer	**	*****	
Engineering Manager		**	

The format of the interviews was kept as consistent as possible following the themes associated with rework identified from the literature. Interviews were kept open using phrases such as 'tell me about it' or 'can you give me an example'. The open nature of the questions allowed for avenues of interest to be pursued as they arose. Notes were taken during the interview to support the tapes to maintain validity. Each of the interviews varied in length from 45 minutes to two hours. Interviews were open to stimulate conversation and breakdown any barriers that may have existed between the interviewer and interviewee.

4.1 Data Analysis

The text derived from the interviews was analysed using QSR N5 (which is a version of NUD*IST and combines the efficient management of Non-numerical Unstructured Data with powerful processes of Indexing and Theorising) and enabled the development of themes to be identified. One advantage of such software is that it enables additional data sources and journal notes to be incorporated into the analysis. The development and re-assessment of themes as analysis progresses accords with the calls for avoiding confining data to pre-determined sets of categories (Silverman, 2001). Kvale (1996) suggests that *ad hoc* methods for generating meaning enable the researcher access to 'a variety of common-sense approaches to interview text using an interplay of techniques such as noting patterns, seeing plausibility, making comparisons etc' (p.204). The use of the software package enabled the researchers to use an organic approach to coding as it enabled triggers or categories of interest in the text to be coded and used to keep track of emerging and developing ideas (Kvale, 1996). These codings can be modified, integrated or migrated as the analysis progresses and the generation of reports, using Boolean search, facilitates the recognition of conflicts and contradictions.

5. RESEARCH FINDINGS

The interviews revealed insights about participants their experiences associated with omissions and rework in projects. Table 1 presents a summary of interviewees sampled by industry sector. From the interviews a total of 85 omission error cases were derived from the interviewees' comments. For each of the omission errors identified the pathogen category (Busby and Hughes, 2004) and failure type (Reason, 2002) was identified. For the purposes of brevity an overview of the findings are presented.

5.1 Error Categorisation

It was found that 53 (62%) of errors were due to *practice,* 11 (13%) *task*, 5 (6%) *circumstance,* 11 (13%) *convention* and 5 (6%) *tool.* An example of a *practice* based pathogen was undertaking a peer-review of design documentation for internal purposes so as to reduce risk, and not to examine how the mechanical engineering design married with structural elements of the project. Such a practice not only results in the review process being less effective, but is likely to lead designers into a false sense of security and perhaps aberrant to self checking (Busby and Hughes, 2004). An array of practices contributes to the occurrence of an omission error. The practice of designing work based on tentative information, departing from established procedures and under estimating the time for engineering design are common conditions with which design firms are confronted with. The effects of adopting such practices can lead higher demands being placed project personnel (e.g. stress and anxiety), conflict and, naturally, increased project time and cost.

In terms of *tasks*, the causes of omissions related to designers and project personnel being placed under increasing pressure to complete their tasks within a specified time frame. Unrealistic demands and constraints were deemed to have been imposed on project personnel, which often resulted in tasks being 'unwittingly' overlooked or omitted from a pre-determined sequence. It was revealed in one incident that project personnel were confused about whose role it was to order materials. This situation arose because the engineering manager had not confirmed with the procurement personnel the required specification for some off-shore equipment that was required. Without the confirmation no order could be placed. Yet, the procurement personnel simply forgot to follow-up with the engineering manager and without checking assumed that an order had been placed.

Many of the underlying conditions that contribute to an omission are interdependent and in many instances it was difficult to isolate a specific pathogen, particularly in terms of *circumstance* and *convention*. The issue of design fees was identified by interviewees in the construction sector as a factor contributing to an omission and design related rework. Lower design fees juxtaposed with a 'stretched' design and documentation schedule invariably resulted in tasks such design reviews, checks, and verification being omitted. Moreover, to maximise fees and save design time existing design details and specification are reused, which may result in having a design that is inappropriate for its intended purpose. Of the 85 omission cases identified, *violations* accounted for 51 (60%) *slips* 14 (16%), *lapses* 13 (15%) and *mistakes* 7 (8%). Many of the violations identified were simply committed with the intention of increasing operational efficiency. Firms cannot and should not tolerate disregard for established procedures. The consequences of following such a course of action could be disastrous, not only in terms of increased project costs and time, but areas of safety and design integrity. There are several compelling reasons for this. One is, of course, that standardisation of operations cannot be achieved with idiosyncratic adherence to procedures.

6. DISCUSSION

The human error problem can be viewed at two levels: the *person approach* and the *system approach* (Reason, 2000). The person approach focuses on the errors of individuals, blaming them for forgetfulness, inattention, carelessness, poor motivation, negligence. The system approach concentrates on the conditions under which individuals work and tries to build defences to avert errors or mitigate their effects. The person approach focuses on the acts such as procedural violations that cause the error. Under the auspices of this approach individuals are targeted and blamed for an error occurrence as it is deemed to be more 'emotionally satisfying than targeting institutions' (Reason, 2000). Essentially, individuals are viewed as having a choice a between adopting *error free* or *erroneous* based behaviours. If an error occurs then it is obvious that an individual is responsible and so effort is spent trying to uncouple a person's acts from organisational liability.

The types of errors that continually arise in projects tend to be similar in nature and as a result 'recurrent error traps' materialise. For example, it has been demonstrated that failure to undertake procedural tasks during the design process (Love *et al*., 2007), and continual design re-use (Busby, 1999) are leitmotiv's that emerge as *practices* contributing to omission errors. The work practices implemented by organisations can provoke similar errors, regardless of the skills and experiences of the people involved in a project. An organisation's immediate attention should focus on the *task* and the identification of appropriate reminders/checks so that lapses, slips, mistakes, or even violations do not occur, especially during the preparation of contract documentation. Task analysis involves decomposing an activity or procedure into a meaningful number of discrete steps. This is not a particularly difficult process, but can be a time consuming for organisations, though those that have a quality assurance system in place would invariably have stepwise process protocol documented and in place. It is therefore necessary to be selective in choosing the procedures for omission management. The most obvious basis for selection is the criticality of the task; would the omission of a particular task adversely influence project performance or design integrity? Should the consequences of such omissions be severe, then this would warrant the use of suitable reminders to undertake the task at hand. Omission-based strategies that can be used include (Reason, 2002): *notes and post-its*, *dairies*, *lists*, *getting others to act as reminders*, *mental checking*, and *mental rehearsal*. While such strategies can be effective for addressing slips and lapses, and possibly even mistakes, they are ineffectual for preventing individuals from purposefully taking short cuts or missing out a process altogether.

Purely focusing on blaming an individual or attacking their ability to perform tasks may have detrimental consequences to learning and error reduction. Causal ascription after an error occurrence is deemed necessary to obtain knowledge about events for the purpose of undertaking subsequent action (Kelley, 1971). Assigned causes can lead to considerable differences in behaviour (Weiner, 1986). It has been shown that error causes such as lack of effort are desirable than 'lack of ability', as they lead to constructive rather destructive behaviour (Fösterling, 1985). Behaviour after error occurrence is influenced by the presentation of positive error heuristics, for example, "I made an error; I can learn from this!" (Heimbeck *et al*., 2003). Such positive error heuristics are presented to facilitate emotional coping after error occurrence, thereby aiding people to consider that errors can also be interpreted as informative feedback. It has been shown that error management training leads to more functional task behaviour such as more requests for assistance, less frustration and better performance (Nordstrom *et al*., 1998). Behaviour modification can occur at an individual level regarding omission errors due to mistakes, lapses and slips.

When an individual is deemed to be recalcitrant (e.g., due pressures beyond their control) and 'violations' arise, then behaviour modification needs to be perfunctory through *systemic intervention.*

Post project or retrospective reviews, undertaken at an organisational or project level, are fundamental to error management and learning, as individuals may not automatically learn from their own experience (Busby, 1999). To learn, individuals need to test new experiences against existing knowledge and then consciously reflect upon what has transpired (Busby, 1999). The knowledge that is acquired during the review is usually dispersed among several people and it is this accumulation of 'collective knowledge' that can be used as an enabler to systemic intervention by changing the conditions under which the individual performs their tasks so that omissions are eschewed in future projects. An organisations culture influences the behavioural practices adopted by individuals. Effective risk management in a project is dependent upon a culture of reporting being place. Such a culture is integral to those organisations that have openly embraced total quality management or significant aspects thereof. Without out a detailed analysis of errors that have occurred using techniques such as causal loop diagramming, Pareto analysis and fault tree analysis, there is no way of determining the 'recurrent error traps' and risks that may reside within an organisation and the project system. When a reporting culture is put in place then it is important that a collective understanding of where the line should be drawn between blameless and blameworthy actions (Marx, 1999). The development of an organisational and project culture based on 'objectivity and learning' is needed in this case. Many construction organisations, for example, have not actively embraced learning and quality practices (Love *et al*., 2003). Such practices are critical components of an effective continuous improvement programme, which invariably aims to negate errors.

7. CONCLUSION

Omission errors are a problematic issue in construction and resource engineering projects. The competitive environment within which firms operate often results in short cuts and procedural tasks being neglected in order to achieve the demands being imposed on them. Organisations and individuals tend to repeat such practices because they become complacent as there appear to be no direct consequences for their actions. Even when errors do arise, there appears to be no transfer of learning from previous experiences. This is because organisations operating in a project environment are subject to new demands and constraints by different client organisations. The findings presented can be used to provide project managers with a better understanding the omission affording features inherent to projects and therefore aid them in identifying and implementing error containment and reduction strategies. The caveat to this is that no one strategy is a panacea for reducing omissions, but focusing on the reduction of violations and adhering to procedures and protocols is the first step that is required in this instance.

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OPENING PANDORA'S BOX: REVISITING PROCUREMENT SELECTION IN THE PUBLIC SECTOR

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Abstract: The decision as to which procurement system to adopt is a complex and challenging task for clients. Despite a plethora of tools and techniques available for selecting a procurement method, public sector clients in Western Australia (WA) are still uncertain about what method to adopt for a given project to achieve success. This paper examines 'how and why' particular procurement methods are selected by a public sector client. The findings from two focus group workshops with 18 experienced senior managers in procurement selection revealed that traditional lump sum methods are still the preferred procurement methods even though alternative forms such as, design and construct, public-private-partnerships could be better suited for a given project. However, participants of the workshop agreed that alternative procurement forms should be considered for projects but an embedded culture of uncertainty avoidance invariably meant that the selection of traditional lump sum methods. Moreover, it was perceived that only a limited number of contractors operating in the marketplace have the resources and experience to deliver projects using the non-traditional methods considered.

Keywords: Procurement, public sector, procurement selection, uncertainty avoidance

1. INTRODUCTION

There is consensus that there is one procurement method that is in some sense 'better' than all others for an individual project, but that no one procurement method is likely to be better than others for any project (Love *et al*., 1998). Gordon (1994) however has suggested that the selection of an appropriate procurement method could reduce construction project costs by an average of 5%. While an appropriate procurement system may enhance the probability of project success (Naoum, 1994; Luu *et al*., 2005), some decision-makers may encounter difficulties in ascertaining the suitability of various procurement approaches because it is virtually impossible for them to capture a diverse continuum of procurement options, client characteristics and needs, project characteristics and external conditions through their own experiences of prior projects (Kumaraswamy, and Dissanayaka, 2001). A plethora of techniques have been developed to assist decision-makers in reaching an answer to which would be the most appropriate procurement method for a given project. The decision as to what procurement method to adopt has become a complex and challenging task as the number of methods available within the marketplace has proliferated in recent years (Mortledge *et al*., 2006).

The Western Australian economy is experiencing an unprecedented boom founded on the demand for natural resources such as oil, natural gas, nickel and iron ore. In addition, the State has been subject to increased migration and this is likely to continue for years to come. The demand for new building stock has placed increasing pressure on the public sector to 'procure wisely' for their facilities and to meet the immediate needs of an increasing population (i.e., new schools, affordable housing, hospitals etc). This paper presents preliminary findings from an on-going research project that is seeking to examine *how* and *why* particular procurement methods are selected by a public sector client in Western Australia (WA). There is a need by a WA public sector client to formalize its procurement method selection process to improve the transparency, accountability and probity of decisions.

1.1 Procurement selection

Clients who are experienced are able to select a procurement approach that has worked for them before, or which they know will be suitable taking into account prioritised objectives and their attitude to risk (Mortledge *et al*., 2006). Inexperienced clients, on the other hand, will need to seek advice from experienced professionals to assist them through the process. Morledge *et al*. (2006) states that the selection of an appropriate procurement strategy has two components:

1. *Analysis* – assessing and establishing priorities for the project objectives and client attitude to risk.
2. *Choice* – considering possible options, evaluating them and selecting the most appropriate.

The efficient procurement of a building project through the choice of the most appropriate procurement strategy has long been recognised a major determinant of project success (Bennett and Grice, 1990) and a failure to select an appropriate procurement approach as the primary cause of project dissatisfaction (Masterman, 1996). The selection of a procurement method is more than simply establishing a contractual relationship as it involves creating a unique set of social relationships whereby forms of power within a coalition of competing or cooperative interest groups are established. Differing goals and objectives and varying degrees of power within a project team are often the underlying conditions for triggering adversarial relations (Love *et al*., 2004).

In an attempt to overcome the adversarial nature of construction, partnering, whether it is *strategic* or *project*-specific in nature has been used as a mechanism for stimulating collaboration between parties so as to attain mutual goals (Li *et al*., 2000). Yet, in Australia the use of partnering has had a "lengthy and somewhat chequered history, principally due a number of parties attempting to exploit the concept in a rather cynical way" (Morledge *et al*., 2006). The authors do not consider partnering to be a procurement method *per se* as it is often used as an 'add on' to pre-existing construction contract forms and the fundamental transactional nature of the contract remains the same. In most cases the partnering agreement is separate from the legal contract and the partnering charter that is established is little more than an informal statement of intent to cooperate. While partnering in part fills a gap in current practice (if used as an add-on), it is no more than a form of programmatic Band-Aid (Howell *et al*., 1996) unless it embedded within part of the procurement strategy. If partnering is to be used by clients' then formal relational based contracts must be used and address issues such cost reimbursement, performance based fees and incentives, and seek the inclusion of key subcontractors in the agreement.

The concept of alliancing is now considered a way of procuring projects and has been used successfully by the private and public sector (Hampson *et al*., 2001). Davis (2005) catalogued thirty-four Australian relationship style projects with an average value of $150 million. Specific noteworthy examples are the National Museum of Australia project with a total budget of A$155.4 million (Walker and Hampson 2003), the WA21 Alliance project in Western Australia with a total budget of A$150 million (Whiteley 2004; Whiteley 2004) and Sydney's Northside Storage Tunnel project having a total budget exceeding A$460 million. Recognising the merits and limitations of alliancing and the potential of such a procurement strategy for effectively delivering certain project types, the Victorian Government states that "alliance based methods should only be considered in the delivery of complex and high-risk projects, where risks are unpredictable and best managed collectively" (Victorian State Government, 2006).

2. PROCUREMENT ASSESSMENT CRITERIA

A primary issue that is often raised within the construction industry relates to what clients want in order to be satisfied with their buildings and the means by which those buildings have been procured. Consequently, it is important to evaluate the clients' criteria, their importance and then seek performance to match the criteria. All clients require their buildings to be completed on time, within budget and to the highest quality. Conventional procurement selection criteria are based around the concepts of time, cost and quality (Rowlinson, 1999). While the use of such criteria can be used as a guide to assist decision-makers with an initial understanding of the basic attributes of a particular procurement system they *should not* be used as a basis for selecting the procurement method. This is because of the underlying complexity associated with matching client needs and priorities with a particular method (Kumaraswamy and Dissanayaka, 1998).

2.1 Determination of Selection Criteria

Several studies have used the NEDO (1985) criteria (or modifications) in an attempt to develop a procurement selection framework (e.g., Love *et al*., 1998; Tucker and Ambrose, 2000). Kumaraswmay and Dissanyaka (1998) and Luu *et al*. (2003a) undertook an extensive review of the normative literature and identified key criteria that were considered by clients when selecting a procurement method. Luu *et al*. (2003a) state that the use of a limited number of factors such as those identified by NEDO (1985) may give rise to the selection of a sub-optimal procurement system. Since the selection of procurement system is influenced by *client characteristics* (Moshini and Botros, 1990), *project characteristics* (Ambrose and Tucker, 2000), and the *external environment* (Alhamzi and McCaffer, 2000), procurement selection criteria representing the constraints imposed on the project should be considered before a decision is made.

The major challenge for clients when selecting a procurement method is identifying the criteria for the project, but the question is that if projects are different in nature and clients' needs are constantly changing due to internal and external demands, would the same criteria be applicable for all projects? Any weighting given to criteria will invariably change as would the criteria type. The selection of an appropriate procurement method can be effective in mitigating the risks inherent in a project. Hibberd and Basden (1996) suggest that a contractual arrangement should initially be selected so as to take into consideration how risk would be transferred between parties, therefore determining the nature of the procurement method so as to fulfil the client's objectives. Noteworthy, the contract itself will assign and allocate the risk and responsibilities of parties involved in a project.

3. TOOLS AND TECHNIQUES FOR PROCUREMENT SELECTION

Despite the difficulties associated with procurement method selection a number of structured methodologies, tools and models have been developed. The approaches developed range from simple (Franks, 1990) to highly complex (Luu *et al*., 2005). It is important, however, that selection is done logically, systematically, and in a well-organized manner by the clients' principal adviser (Love, 1996). The range in choice of procurement system is now so wide and projects are becoming so complex that the selection process needs to be carried out in a disciplined and objective way within the framework of the clients overall strategic project objectives (RICS, 2000). A summary of the development of procurement selection tools can be seen in Table 1.

Table 1. Procurement selection systems (Adapted from Sidwell *et al*., 2001a)

Author	**Year**	**Description**
NEDO	1985	Procurement path decision chart. Use of a rating system using client's priorities for nine criteria
Skitmore and Marsden	1988	Use of multi-attribute utility analysis based on NEDO with a rating system and weighting of client priorities
Brandon *et al*.	1988	ELSIE – A computer expert system based on project characteristics and client requirements. Subjective and contained a limited number of procurement options
Franks	1990	Simple rating system of criteria against a limited number of procurement options
Bennett and Grice	1990	Based on NEDO's and Skitmore and Marsden's model using MAUA. Enables client's to weight specific criteria multiplied by a set of utility ratings for various procurement options
Moshini and Botros	1990	PASCON-An expert system similar to ELSIE.
Lui	1994	Organisational behaviour-based model utilising an act-to-outcome process governed by organisational goals, which are subject to moderators and determine performance relationships
Chan *et al*.	1995	Utilises the Bennett and Grice model, but uses a different procurement category developed for the Australian construction industry
Griffith and Headley	1997	Use of weightings to assess criteria and procurement options for small building works. Simple and easy to use.
Kumaraswamy, and Dissanayaka	1998	Weighting of priorities and ranked using the rank agreement factor. The matched against various procurement options. This was developed into a
Kumaraswamy, and Dissanayaka	2001	computerised expert system. Not able to update system database.
Love *et al*.	1998	Based on Skitmore and Marsden's model, and tested widely throughout Australia.
Ambrose and Tucker	2000	MAUA based model that includes three dimensions. Complex to use.
Alhamzi and McCaffer	2000	Allows users to choose from a reduced number of prescribed strategies and alternative contract types. Sue of weighting/ranking systems juxtaposed with

		AHP. Very complex system to arrive a procurement option.
Construction Industry Institute	2001	Project delivery selection workbook. Suitability matrix. Rates critical project goals by level of importance, scores each goal and ranks the most critical metrics. Limited options and prescribes optimum project delivery system
SRD Consulting	2000	Suitability matrices developed for Qld Dept of Main Roads. Scoring and rating to pre-determine optimum project deliver system
Cheung *et al*.	2001	Use of MAUT and analytical hierarchy process. NEDO criteria used. Utility factors corresponding to various procurement strategies established. To cater for individual project characteristics, the relative weightings of the selection criteria are assessed using AHP.
Chang and Ive	2001	Transaction-cost-based procurement selection technique. Use of MAUA and alignment with procurement route with attributes of the construction transaction. Client selects procurement option based on their particular project context rather than on generic solution based on preferences.
Luu *et al*.	2005	Case-based reasoning – capture and reuse of experiential knowledge from previous projects for procurement decision-making. Project characteristics, client characteristics and external environment taken into account.
New South Wales Department of Commerce	2006	Weighting of client priorities and procurement method to achieve the priorities. Simple to use but too many criteria

Each of the methods presented attempts to cross-reference project variables with existing procurement systems that are available in the marketplace. As a result, Sidwell *et al*. (2001b:p.24) state that this “shoe-horns one-off projects and their particular parameters, priorities and external conditions into off-the-shelf delivery systems”. Many of the procurement selection systems developed (e.g., NEDO, 1985; Skitmore and Marsden, 1988, Moshini and Botros, 1990; Ambrose and Tucker, 2000; Cheung *et al*., 2001) ignore an array of factors, are limited in their options available for consideration, are conditional and not widely applicable, and simply not user friendly (Alhazmi and McCaffer, 2000). While all the systems identified in Table 1 have their merits they tend to be prescriptive and not recognise the complexity associated with the selection process. Often there are many stakeholders that need to be involved in the selection process and decisions are dependent upon the interaction of many variables that incorporate a high degree of subjectivity and intuitive judgement (Morledge *et al*. 2006). Many of the systems developed have not been tried and tested in practice over a period of time so as to determine if the method selected was able to produce a successful outcome for the client. There are, however, examples where systems have been developed and tested for one-off projects (e.g., Al-Tabtabi, 2002).

4. RESEARCH APPROACH

Considering the sheer number of criteria and procurement selection methods that clients’ are confronted with the challenge for selecting an ‘appropriate’ procurement method is a daunting process. In examining *how* and *why* public sector clients in WA select a procurement method, a triangulated research process, which encompasses focus groups, case studies, and a questionnaire survey, has been adopted. The research approach and subsequent findings from two focus groups that were undertaken with 18 senior project and policy managers are presented hereinafter.

4.1 Focus Groups

Focus group interviews were used to gather information relating to the feelings and opinions of the participants in a non-threatening environment (Krueger and Casey, 2000). Convenience sampling for selecting participants was used as it is deemed to be the most common method of selecting participants for focus groups. Essentially, participants were selected for their familiarity with the project procurement selection process of their organisation. Two equal groups of nine were used for each focus group. This was because it has been revealed that an ideal focus group should contain between 6 and 12 participants (Stewart and Shamdasani, 1990). During the interview participants were given freedom to discuss issues, listen to their peers, provide reflective comment and arrive at a shared understanding of collective experiences regarding procurement use and selection. Whilst working with the group the researcher(s) appeared to be ‘genuinely naïve’ and avoided leading questions so as to allow corroboration to naturally occur. The questions presented to participants were ordered in terms of their relevance. The focus group discussion revolved around *five* questions:

1. What project types/ factors do you consider in selecting a procurement method?
2. What procurement methods are you familiar with? For each what are their individual characteristics? What are their advantages/disadvantages? Which characteristics/advantages/disadvantages do you find most important in selecting a procurement method?
3. What is the most common procurement method used by your agency? Why?
4. What is the process followed for assisting government in selecting a procurement method. What is good about this process? What improvements could be made?
5. What forms of procurement method would you like to see more use of? Why?

Each of the focus groups that were undertaken lasted one and half hours in duration. Notes were taken and the findings from that were derived presented to participants to check for accuracy, and reliability.

5. RESEARCH FINDINGS AND DISCUSSION

5.1 Factors considered in Selecting a Procurement Method

The New South Wales Department of Commerce (2006) states that an appropriate procurement method for a project will depend on several project characteristics including; the factors that impact upon its delivery and desired risk allocation. As a result appropriate selection will provide value for money, manage risk and meet project objectives. Similarly, findings from the focus groups revealed the following criteria: *project value, project complexity, project type (standard/novelty), location (regional/local), stakeholder integration, political considerations, client needs, and industry culture*. The factors identified formed part of an *implied* process in determining a procurement strategy for each project procured by the client. The focus attendees could not identify formal policy or technique used for procurement selection. The process of procurement method selection for the public client being examined is based on the intuition and experiences of those responsible for its selection. It was observed from discourse during the focus groups that the underlying culture (i.e. beliefs structured as a hierarchy of values) of the organization had an important influence in procurement selection process: *uncertainty avoidance*. Such cultures "shun ambiguous situations" (Hofstede, 1991:p.116) and in this context any alternative consideration from the default Traditional Lump Sum (TLS). The key decision-makers who had extensive industry experience with a particular procurement method were more likely to select a method that had worked for them in the past, rather than take the perceived risk of choosing an unfamiliar method (See Morledge et al., 2006). This observation is in-line with Morledge *et al*. (2006) and the DISR and NatBACC (cited in APP 1998).

5.2 Procurement Method Familiarity

Procurement systems can be classified as: traditional (separated); design and construct (integrated); management (packaged); and collaborative (relational). Each of the aforementioned systems has an array of methods associated with them. Participants had familiarity and limited experience with several procurement methods and cited *traditional lump sum (TLS), design and construct, novation, design, manage and construct, public-private-partnerships, and package deals* (used only for housing). Despite participant's limited experience they had considerable knowledge of global procurement trends and emerging methods which have been used in the United Kingdom such as Heathrow Terminal 5. Examples where these emerging methods could be considered were in remote locations of WA were the scarcity of resources has necessitated a more *collaborative* approach to procurement in lieu of the more commonly used traditional lump sum method. Smith *et al*. (2002) have suggested that in regional areas *coopetition* in congruence with an alliance framework should be used as a form of procurement strategy with local small-medium-sized firms so they can compete with metropolitan contractors.

5.3 Process used by Public Sector in Selecting a Procurement System

Traditional lump sum (based on AS 2124 contract type) was the most commonly used to deliver projects. It was estimated that approximately 95% of projects delivered by the agency in the last yen years had been procured using TLS. Discussion within the focus group sessions left little doubt that not only was this method the most common, but also the default option for the agency. Participants revealed that they would only contemplate an alternative procurement method when:

- circumstances were perceived to be 'abnormal', for instance to obtain something beyond their budgetary constraint; or
- a minister, the WA Department of Treasury or the like suggested a system of procurement other than the default TLS; for instance, when treasury introduced a *new* Public-Private-Partnerships process; or
- in association with *non-standard* or *non-profile* projects where the procurement options would be discussed or negotiated with clients of the agency; sometimes using a recently launched 'business case navigator' as a referral tool.

Reasons for the popularity of TLS identified by participants included*: policy; ability to deal effectively with risk (cost, time, quality); familiarity and acceptance within the local industry; satisfies public accountability; provides maximum client control over the project's outcome; and provides cost certainty*. Rowlinson (1999a: p.49) has argued that the concept of cost certainty is a "fallacy in the context of traditional approaches that are based upon full drawings and bills of quantities (BoQ)". This approach should provide a client with a firm, fixed price for construction but in practice very few projects are actually completed within the tendered price (Rowlinson, 1999a; Love, 2002). Complete drawings and BoQs are generally not available when a projects goes to tender. Rowlinson (1999a:p.49) therefore asks why do clients' continue to use this method when it can be argued that it leads to: a lack of flexibility; a price to pay in terms of claims-conscious behaviour; and the fallacy of cost certainty.

5.4 Perceived Effectiveness/Improvements of the Selection Process

While no formal process was in place for project procurement selection, participants suggested that the benefits of the current way of doing things enabled:

- *value for money;* it provides time and cost predictability and therefore represents the lowest risk to meeting time and cost requirements;
- better quality control; it provides better design outcomes and therefore represents the lowest risk to meeting quality requirements;
- familiarity; it matches their culture, skill set, systems and processes;
- industry familiarity; they are aware that TLS will be predominately used;

Participants acknowledge the need for a formal selection process for reasons associated with transparency and accountability in the decision-making process. It was perceived, however, that the local market did not have the skill and experience to deliver projects using non-traditional methods, particularly *construction management* and *management contracting*. Participants suggested that their organisation could improve the procurement method selection process by addressing:

- the need for a more comprehensive and sophisticated procurement selection process for high profile projects, such as arenas, stadiums and convention centres; and
- the need for a shared and 'agreed' general understanding of the definitions of all procurement systems.

Despite the need for improvement in the way in procurement methods are selected, it was suggested by participants that any improvement to the existing system could be destabilising as decision-makers were comfortable with the *status quo*. The continual use of TLS by the public sector may stifle technological innovation in WA, particularly the design and constructability of public sector buildings. Other States within Australia are actively pursuing alternative forms of procurement and this has put increasing pressure of the WA State Government to examine other forms of procurement. Particularly, procurement methods that participants suggested that they would like to see more use of were PPP's, construction management, and design and construct in conjunction with an alliance agreement. Though, it was suggested that alliances would only be considered by participants for complex or large infrastructure projects. While WA has been slow to adopt alternative forms of procurement compared to other States such as Queensland, New South Wales and Victoria, it is essential they learn from their previous experiences with regard to the use of methods used and how they justified their selection.

6. CONCLUSION

A plethora of tools and techniques have been developed to determine an ideal procurement method for a specific project. Yet, no specific techniques have gained widespread acceptance, particularly by the public sector organisation involved in this research. While forms of ranking and weighting of specific client priorities against the attributes of a particular procurement method are used by public sector agencies in New South Wales and Queensland, WA has used a more informal and intuitive approach based on the personal experience of the decision-maker. Because of an innate culture of uncertainty avoidance, traditional lump sum methods are the norm and default unless a specific request is made by a Minister or the Department of Treasury or another agency is made. Moreover, it was perceived by those involved in the focus groups that the marketplace within WA does not have the management experience to effectively embrace alternative forms of procurement. The research identifies a need to develop a pragmatic framework that public sector clients in WA can use to select an appropriate procurement. A procurement framework should be able to guide the decision-maker rather than provide a prescriptive solution, which the author's consider an appropriate strategy to undertake. Learning from previous experiences with regard to procurement selection will further provide public sector clients with knowledge about how to best deliver their projects.

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PROMETHEUS AND BOB: UNDERSTANDING, MEASUREMENT AND IMPLICATIONS OF EMOTIONAL INTELLIGENCE

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Abstract: Emotional intelligence (EI) is a new and growing area of behavioral investigation, which is considered to be positively related to occupational success, satisfaction, emotional health and adjustment. Furthermore, individuals who posses a high degree of EI are able to significantly influence team and organizational performance. In construction, there is a real need to examine how individuals, teams and the structure of projects influence behavior if the improvements being sought within the industry are to be realistically achieved. Potentially EI, in conjunction with other assessment tools, could be used by construction organizations to significantly improve the performance of project managers and site management teams. This paper defines the concept of EI and provides a critic of the popular EI tests. Implications for the construction industry are also discussed.

Keywords: Emotional intelligence, individual, teams, project performance, construction.

1. INTRODUCTION

During the last fifty years the construction industry has been criticised for its poor performance when compared to that observed in other industrial sectors (e.g., Emmerson, 1962; Banwell, 1964; Latham, 1994; DIST, 1998; Egan 1998; Tang, 2001). Efforts to redress this problem have led to the widespread transfer of innovative management tools and techniques (e.g., supply chain management, lean construction, alliances) from more technologically advanced industries to construction. As part of the transfer process, construction researchers have sought to adapt these aforementioned tools and techniques to a construction setting. These resulting hybrids are then proclaimed and marketed as being panaceas to project procurement problems. Yet, despite this research activity there has been little evidence that the diffusion of such hybrids have formed an *integral* part of most construction firms operations, particularly in Australia, Hong Kong and the United Kingdom. As a result, it would appear that the problems identified by the Banwell report in the 1960s are still prevalent within the industry today. Surveying the literature (CIDA, 1993; Winch, 1996; Chan and Kumaraswamy, 1997; Kumaraswamy, 1997; Love, 2002; Flyvberg *et al*., 2002) provides an insight into frequent cost overruns, delays, and underperformance in terms of quality, which seem to be ubiquitous within the industry. A perennial problem faced by construction professionals, educators and researchers is what needs to be done to improve project performance?

Historically, construction research has tended to focus upon the factors of process, product and more recently the environment and legislation, through the lenses of technology, economics, management, and operations management (Koskela, 2000). In fact, Koskela (2000) has argued that there is a dearth in construction management theory and has suggested academia and industry embrace a transformation-value-flow approach founded on the concepts embedded within lean production. In a similar vein, Koskela and Howell (2002) have also stated that the underlying theory of project management is obsolete and that an alternative theory should be founded on developments in operations management because of the sympatric symmetry that exists between these concepts. Developments in operations management have typically focused on process efficiency (optimisation) (Holweg, 2007; Sprague, 2007) and placed emphasis on "technicist solutions, quantitative methodologies, and a strong reliance on instrumental rationality" (Hodgson and Cicmil, 2006:p.9). It should be acknowledged that a generic theory of construction management has not been forthcoming, but the field has yet to mature. However, operations management is not the panacea to industry's problems as it provides no *scope* for theory generation with respect to psychological (individual) and sociological (team) considerations (Love *et al*., 2002), which are fundamental to procuring projects successfully. Processes can be readily optimised using, deterministic, heuristic and stochastic tools and techniques to determine 'best practice' (e.g. Love *et al*., 2002; Edwards *et al.*, 2004) and law like predictions. Yet, the behavior and performance of individuals and teams have eluded any valid prediction or optimisation.

Many advances within the field of construction management have been made under the auspices of the 'operations management' paradigm, but improvements in the industry's performance have been marginal over the last decade or so. This has led a number of researchers within the construction management community to actively examine how field of *organizational behavior* can contribute to improving the overall performance of projects (e.g., Bresnen *et al*., 1986; Rowlinson *et al*., 1993; Loosemore, 1998). Organizational behavior seeks to: "investigate the impact that individuals, groups and structure have on behavior within organizations for the purpose of applying such knowledge towards improving an organization's effectiveness" (Robbins *et al*., 1998:p.10). It is suggested that greater examination and understanding of *how* individuals and teams influence organizational behavior will lead to improvements in project performance and the industry as a whole.

Goleman (1998) has proposed that individuals who posses a high degree of emotional intelligence (EI) can positively influence both team and organizational performance. Since this assertion, the concept of EI has become increasingly popular within the business fraternity, particularly human resource management. Often, EI is considered to be synonymous, though mistakeably, with having simply good social skills (Sunindijo and Hadikusumo, 2005; Goleman, 2006) such as good interpersonal and communication skills. Such skills have been identified as being fundamental for construction managers, as they deal with an array of people at various levels such as clients, consultants, subcontractors and suppliers on a daily basis (Love *et al*., 2002). EI however, extends beyond simply possessing social skills. If taken out of context, then EI is a danger of becoming another 'academic fad', particularly its determination and measurement (e.g., Sunindijo and Hadikusumo, 2005). With this in mind, the concept of EI is defined and a critique of the popular tests that have emerged to date is made. This paper concludes with suggestions for possible areas of application within construction academia and industry.

2. WHAT IS EMOTIONAL INTELLIGENCE (EI)?

Contrary to the claims of Goleman (1995 and 2006) EI is not a new concept in science as evidence of it underlying our 'general' intelligence has been noted by several prominent psychologists such as Binet (1886), Wechsler (1939; 1981), and Kaufman and Kaufman (1983). In fact, it has been repeatedly noted by several researchers that traditional measures of IQ fail to explain cognitive ability (e.g., Kaufman and Kaufman, 1983; Smith, 2002). The distinction between intelligence and knowledge in the area of cognition (i.e. IQ) is evident, where generally, psychological research demonstrates that IQ is a reliable measure of cognitive capacity and is stable over time (Wechsler, 1981). In the area of emotion and the distinction between intelligence and knowledge is unclear. It has been suggested by Bradberry and Greaves (2005) that EI is dynamic and an individual can readily improve their so called 'emotional capacity'. Contrastingly, Mayer (2006) argues that EI is stable process and is an innate skill that cannot be taught or learnt.

Thorndike (1920) used the term 'social intelligence' to describe the skill of getting along with other people. Gardner (1975) formulated the idea of 'multiple intelligences as identified eight intelligences including *personal intelligence*, and *interpersonal intelligence*. Notwithstanding, the concept of EI was first introduced by Salovey and Mayer (1990) and since then has been popularised by several best-seller books (e.g., Goleman, 1995; Goleman and Cherniss, 2001; Goleman *et al*., 2002; Goleman, 2006). Statements such as "EI may be the best predictor of life success, re-defining what it means to be smart" (Time, 1995) and "we've known for years that EI improves results – often by order of magnitude" (Goleman *et al*., 2001:p.42), have created an explosion of research activity in a new and fuzzily-defined activity (Mayer *et al*. 2002:p.5). Accordingly, Carmeli (2003) has revealed that managers who are deemed to be 'emotionally intelligent' out perform those who have a lower EI. Goleman *et al*. (2001) have further claimed that EI can predict leadership effectiveness. Several academic's have taken issue with this largely unsubstantiated claim and stress that EI cannot predict leadership effectiveness beyond IQ or the 'big five' personality traits (e.g., Antonakis, 2003; Anotonakis, 2004).

An examination of the literature reveals that there is no consensus on an operational definition of EI. For example, Goleman (1995:p.34) defines EI as "abilities such as being able to motivate oneself and persist in the face of frustrations; to control impulse and delay gratification; to regulate one's moods and keep distress from swamping the ability to think; to empathize and to hope". Goleman (1995) essentially defines EI by exclusion (i.e. represents all those positive qualities that are not represented by general intelligence). In fact, many of the qualities identified by Goleman (1995) are personality traits and as a result there is a natural tension between his definition and others that have been propagated in the literature. For example, Mayer and Salovey (1997:p.) define EI as the "ability to perceive emotions, to access and generate emotions so as to assist thought, to understand emotions and emotional knowledge, and to reflectively regulate emotions so as to promote emotional and intellectual growth". In this instance, Mayer and Salovey (1997) have couched EI as a form of cognitive ability (where processing of emotional information is tantamount), which has lead them to construe EI as the capacity to reason about emotions. In contrast, Bar-On (1997:p.14) depicts EI as "an array of non-cognitive capabilities, competencies, and skills that influence one's ability to succeed in coping with environmental demands". Conceptually, this definition is not that far removed from Golemann's in that it invokes clusters of established personality traits. Emotional intelligence research has traditionally focused on individual differences, something akin to traditional IQ, or has been associated with personal ability (Caruso *et al*. 2001). More recent 'innovative' work has sought to examine how 'emotionally intelligent teams' can be measured and developed (Day and Carroll, 2004; Jordan and Troth, 2004).

2.1 Measures of Emotional Intelligence

The most popular measures of EI, from an individual perspective are, Bar-On EQ-i (Bar-On, 1997), Emotional Competence Inventory (ECI) (Boyatzis *et al*., 2000), EQ Map (Orioli *et al*., 2000), and the Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT), (Mayer *et al*., 2002). With the exception of the MSCEIT, the aforementioned tests are based upon self perception reporting tests were an individual is asked to endorse a series of descriptive statements using a rating scale. Self perceptions can however, be inaccurate and vulnerable to response bias, social desirability and deception. Thus, it is questionable whether items asking participants to self-appraise their 'own ability' is indeed a valid measure.

Tests such as the Bar-On EQ-i, ECI and EQ Map that assess non-cognitive traits, appear to measure constructs associated with individual well-being or dimensions of individual difference that relate to personality rather than intelligence (Matthews *et al*. 2002). Dwada and Hart (2000) have demonstrated that the big five personality constructs developed by Costa and McCrae (1992) (i.e. *neuroticism*, *extroversion*, *openness*, *agreeableness* and *conscientiousness*) have a significant relationship with the Bar-On EQ-i measure of EI. Likewise, Derkson *et al*. (2002) confirmed this finding and suggested that the Bar-On EQ-i and other self rating tests measure something else other than intelligence.

Mayer and Cobb (2000) and Mayer *et al*. (2000) have argued that a psychometric test of intelligence must meet three important criteria. First, the proposed intelligence must reflect ability (in this case emotion-related capabilities) rather than behavior. Therefore, EI should be capable of reflecting cognitive performance rather than non-intellectual attainments (Bowman *et al*., 2002). Second, it must share similarities with, but remain distinct from other established intelligences. Third, it must characterize an individual's experience and age. Noteworthy, the MSCEIT has been subjected to extensive psychometric testing, and besides being reliable and valid, is distinct from existing personality dimensions (Matthews *et al*., 2002). However, akin to other tests, MSCEIT is still deemed to have its flaws (Roberts *et al*., 2001). The test itself attempts to objectively measure the following salient features:

- *emotional perception* i.e the ability to correctly identify how people are feeling;

- *emotional facilitation* i.e. the ability to create emotions and integrate feelings into the way one thinks;
- *emotional understanding* i.e. the ability to understand the causes of emotions; and
- *emotional management* i.e. the ability to figure out effective strategies that use your emotions to help achieve a goal, rather than being used by one's emotions.

In combating the problems associated with self perception report tests, Mayer *et al*. (2002) use performance based measures similar to those found in traditional intelligence research works to legitimise their EI test. Definitive details about the structure, design and scales of the MSCEIT can be found in Mayer *et al*. (2002). However, it should be noted that tests such as the MSCEIT should be administered by trained personnel familiar with the principles of testing, psychometrics, human behavior and psychopathology. Alternatively, a qualified psychologist can be used, as they have the skills to analyse and interpret the output produced. Moreover, the EI test results should be used in conjunction with other assessment methods when evaluating potential employees, staff or project teams.

3. CONSIDERATIONS FOR CONSTRUCTION PRACTICE

Being emotionally intelligent involves being actively able to identify, understand, process and influence one's own emotions and those of others to guide feeling, thinking and action (Mayer and Salovey, 1997). Individuals who posses a high degree of EI are able to make informed decisions, better cope with environmental demands and pressures, handle conflict in an effective manner, communicate in interesting and assertive ways and make others feel better in their work environment (Bar-On, 1997; Mayer and Salovey, 1997, Goleman, 1998). For construction project managers' who are constantly confronted with solving disputes and general problems during pre, during and post construction, an ability to formulate satisfactory solutions is essential.

Individual moods and emotions, emotion sharing processes, and team affective composition may all be modified by the affective context (i.e. emotion norms that govern emotional expression) in which a project team is situated (Hackman, 1992). Isen and Daubman (1984) have demonstrated that positive affect predicts better creativity and greater cognitive flexibility. Construction project managers who have a positive mood toward problem solving will invariably evaluate things more positively than those who have a negative mood (Mayer *et al*., 1992). Negotiations, for example, between a contractor and a client's representative (with respect to a claim) can be highly emotional charged situations for both parties, especially when substantial financial investments are at stake. The negotiation process is fraught with emotion, and emotional relationships and contingent interactions can all impact the outcome (Baron, 1993). Thus, when entering negotiations or solving problems on-site with team members or subcontractors it is important that construction project managers are cognisant that their emotional standing can influence their mood and those around them.

Emotional intelligence and leadership

Bresnen *et al*. (1986) and Rowlinson *et al*. (1993) have suggested that the construction project managers' leadership style can influence a project's outcome. Similarly, Nam and Tatum (1997) have stated that *effective* leadership is fundamental for innovation in construction. Two leadership styles dominate the construction management literature *charismatic* or *transformational*. Transformational leaders provide a vision that followers accept and believe in, they inspire and motivate their followers and stimulate their followers intellectually (Bass, 1998). The components of transformational leadership bear a resemblance to the key components of EI. To engage in transformational leadership, leaders need to have clear emotional self-awareness, which is similar to the EI concept of understanding (Bass, 1998). A charismatic leader, on the other hand, tries to obtain follower compliance. It is generally used in a manipulative and emotionally demanding manner when subordinates are subject to exploitation. It is suggested that a construction project managers, who are deemed to be emotionally intelligent, should be able to *positively* utilise charismatic leadership skills to regulate their own and others' emotions and use emotional information for decision-making to achieve creative and positive outcomes. However, George (2000) and Caruso *et al*. (2001) have suggested that EI is an important catalyst of leadership, irrespective of the style adopted, as it enables leaders to: articulate team goals and objectives; instil enthusiasm to team members; empathise with team members; establish cooperation, trust, and identify; and encourage flexibility.

Emotional intelligence, stress and coping behaviour

Researchers within the field of EI suggest that intelligence increases developmentally. Alternatively, Horn and Hofer (1992) and Roberts *et al*. (2000) argue that some when cognitive abilities such as *fluid reasoning* decline, others such as *acculturated knowledge* improve providing a negative correlation. There is no general consensus on this issue but different developmental trajectories could be examined for different components of EI such as those identified within the MSCEIT. For example, Goleman (1998) suggests that EI moderates the direct effect of stress through the *coping behavior* of the individual. Job stress arises when an occupational situation has demands, constraints and opportunities that are perceived to threaten (or to exceed) a person's personal resources and coping abilities (Love and Edwards, 2005). During make-or-break moments in a project, an individual's ability to be flexible and adaptive to stress and change, to consider new information (whilst resisting self protection) and responding quickly (and as appropriate) is crucial for project managers and team members. A combination of the stresses imposed on construction project managers and a lack of social support (Love and Edwards, 2003) poses a danger that feelings of frustration and resentment are temporarily repressed only to manifest in periodic angry outbursts (Hochschild, 1983). Such feelings result, in part, from the constant requirement to monitor one's negative emotions, and to express positive ones. If unchecked, or if not given a healthy expressive outlet, can lead to emotional exhaustion or burnout (Krumel and Geddes, 2000).

The phenomenon 'burnout' has been shown to have serious effects on construction staff and organisations (e.g., Lingard, 2003). Kruml and Geddes (2000) have shown that individuals experience stress when they fake emotion, thereby demonstrating a potential link to burnout. Further, inhibiting emotion also can lead to aversive physiological and psychological outcomes. This occurs through a complex process that weakens out immune system. Adverse health outcomes that can result from non-expression of negative emotion include serious disorders such as hypertension and cancer (Grandey, 2000). Working on a construction project is stressful and construction organisations need to provide internal social support to their employees throughout a project's life cycle. Construction project managers and their site management team should be better educated about how they can better manage their 'emotions' as this will contribute to better project outcomes.

Emotional intelligence and project teams

Team based research in construction has generally focused on identifying task processes that distinguish the most successful teams (i.e. the need for participation, commitment, cooperation, goals, and so forth). The underlying assumption appears to be that once these processes are identified they can be imitated by other teams with similar effects. The circumstance that contributes to team success is the condition that enables task processes to emerge and cause members to sincerely engage them. For this to happen a team needs to create emotionally intelligent norms that support the behaviours for building trust, group identity and group efficacy (Druskat and Wolff, 2001). The composition of a project team is normally different for each construction project and therefore the norms developed are impossible to replicate; this renders the notion of best practice an impossible task to attain. Assessing an individual's and team's EI, before a project commences can provide project managers with important psychological features and enable them to identify strategies to improve their team's effectiveness (Fernández-Aráoz, 2001). There maybe specific projects that require individuals or teams to posses high EI because of their economic importance or political sensitivity. Thus, adopting formal training and off-site training programs can improve EI but only when *sustained* changes in interpersonal and inter-group relationships within the parent organization are made. Changes within the parent organization should then provide the foundation for improving inter-organizational relations and establishing the 'norms' in project teams as well as ensuring that the change is sustainable.

4. CONCLUSION

The perennial problem of poor performance seems to continually plague the construction industry despite monumental efforts of both academics and practitioners; it is a Gordian knot that strangles the sector and to-date the riddle remains unsolved. Introducing new management tools and techniques, adopted from more technologically advanced industries, has not significantly reversed the observed trend. One could therefore conclude that innovation and technology transfer and/or adoption *per se* is ineffectual and that greater attention ought to be given to members of the project management team. After all, the capability of the individual determines whether any tool or technique is successfully implemented. In acknowledgement of this obvious, yet much overlooked fact, psychologists have explored the concept of organizational behavior and an individual's EI. Both explore the complex interrelationship that exists between individuals within a project or organization and the impact of these individuals upon company competitiveness. Psychologists have pointed to the many benefits associated with EI research work, yet the concept remains largely unexplored in a construction context. This notable absence is perhaps partly due to a similar absence of construction psychologists but also a general unwillingness of industry to focus on organizational behavior; the industry seems infatuated with process efficiency under the banner of the operations management paradigm. Given previous tools and techniques adopted and the scarcity of consequential benefit associated with them, practitioners may be understandably suspicious of the *latest academic fad*. From the evidence presented in the literature, it is suggested that if construction organizations focused on selecting construction project managers who were highly emotionally intelligent using the MSCEIIT (as it is deemed the most trustworthy and reliable measure, as well as provide training them on *how* to use such a skill, for their projects) then industry and academia may see a significant enhancement of the effectiveness of decision-making, creativity, cognition, etc. This improvement could in turn manifest itself as innovations that contribute to improved project performance. Unless the management of individuals and teams are scrutinised in greater detail (in order to develop improved organizational structures for delivering projects) then the improvements in construction efficiency that are being sought will only remain marginal.

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DEGRADATION PATHWAYS FOR PYRENE BY SONOCHEMICAL TREATMENT.

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Abstract: A discussion is presented concerning the structure, sources and health hazards of polycyclic aromatic hydrocarbons (PAH's), the subsequent fate of these PAH's in the environment and the use of power ultrasound as a useful means in the degradation of these materials. Thus a novel waste treatment approach to clean-up contaminated waterways or waste from commercial processes is examined at a fundamental and practical level. Reaction pathways are simulated for the treatment process, based on reported research and our own findings to date. The selected PAH, pyrene is postulated to form a number of other PAH's and phenol compounds during degradation, hydrolysis and re-formation (eg naphthalene and naphthalene phenols, phenanthrene and phenanthrene phenols, benzene and benzene phenols). Continued and future work is presented in the context of a long-term research programme towards just one solution to this toxic chemicals in the environment problem.

Keywords: degradation, photochemical, polycyclic aromatic hydrocarbon, pollution, power ultrasound.

1. INTRODUCTION

Polycyclic aromatic hydrocarbons (PAH are fused rings of carbon and hydrogen and can be visualised as two or more fused benzene rings in linear, angular or cluster arrangements. PAH's generally occur as complex mixtures (for example, as part of combustion products such as soot), not as single compounds. PAH's usually occur naturally and are contained in asphalt used in road construction. They can also be found in substances such as crude oil, coal, coal-tar-pitch, creosote, and roofing tar and are found throughout the environment in the air, water, and soil. They can occur in the air, either attached to dust particles or as solids in soil or sediment.[1]. In the natural environment they can be degraded by natural sunlight but there is a possibility of accumulation if degradation is not forthcoming, leading to dangerous levels being realized. As a result of this, methods of decreasing the amount of PAH in the environment or subsequent disposal of these pollutants are required. The increase in PAH may eventually lead to the environment being so polluted that its ability to cope may be severely compromised, e.g. in waterways; animals, and plants may have their growth cycles severely compromised[2]. Discharges of PAH's into the aquatic environment are regulated by European Union directive 76/464/EEC[3], this has now been recently been updated by directive 2006/11/EC[4]. The selection of the polluting PAH compounds is based on the criteria of toxicity, persistence and bio-accumulation and relates to the pollutants on list 1 of the European Union directive in respect to inland, surface, coastal and territorial water on pollution caused by dangerous substances[5].

1.1 The sources and health implications of PAH pollution:

PAH molecules are both aromatic and unsaturated in nature, are very reactive and therefore have increased levels of toxicity associated with them, ranging from hazardous through to carcinogenic.

One of the more toxic PAH's is Benzo(a)pyrene (B[a]P) which is a known carcinogen. Many of the other PAH are known irritants but the carcinogenicity of them has not been fully investigated. PAH cannot be characterised by a threshold, in that no safe exposure level can be defined[6], but an expert panel for air quality standards has erred on the side of caution in setting the air quality standard.

Benzo(a)pyrene has been chosen as the marker for total mixture of PAH's in the UK. The level recommended by the panel is 0.25 ng/m^3 measured as an annual average. This is calculated by taking the recorded level of B[a]P each day for the past year, summing it, and dividing by 365[7]. PAH sources may be from either point source such as a chimney vent or tar pit, diffuse sources such as underground storage tanks, pollutant leachate from landfill sites are other examples. The PAH sources can be divided into anthropogenic and natural sources[8], as listed in tables 1 and 2

Table 1:Anthropogenic sources of PAH[9]

soot from combustion
cigarette smoke, this is a major source of a variety of toxins with one of the main ones being PAH's
car exhaust
wood burning
oil processing
oil storage (leakage and subsequent leaching into soil)
forest clearances for logging
stubble burning in agricultural fields
Incinerators
barbecuing, smoking or charring foods

Table 2: Food products that contain low level PAH

roasted coffee
roasted peanuts
refined vegetable oil
grains, vegetables
fruits

There are also products made from coal tar that may contain PAH, these include cosmetic products such as makeup and shampoos

Natural sources include tar pits where the PAH both vent to the atmosphere or leach into the surrounding soil. Forest fires ignited by lightning strikes, underwater hot vents and volcanic activity can release large quantities of PAH into the atmosphere

Health implications that occur from exposure to the PAH appear through various routes and can have an acute or chronic effect[10]. PAH`s can be easily taken into the body[11] by inhalation of gases that contain them and this can lead to irritation of the lungs and possible lung cancer.

Ingestion of foodstuffs in which PAH have been deposited for instance from soot, liquids, leads to stomach irritation and possible stomach cancer. The last route for human exposure is through skin absorption by contact with PAH`s that have been deposited on a surface, this has the possibility of skin irritation and skin cancer.

The PAH, although not always carcinogenic, can still be irritating to the mucous membranes (eye, mouth), also to the skin (rashes blisters) and the stomach (nausea and vomiting).

As PAH`s are not easily degraded in the environment they are a species that have the inherent ability to accumulate in the body and in the environment, this makes PAH's especially dangerous to both humans and the environment.

The PAH species Pyrene ($C_{16}H_{10}$) is the focal compound used in experiments, a relatively stable PAH which like other PAH's it has limited solubility in water (~7.2 x 10^{-4} mmol/L[12]), but still has carcinogenic properties associated with it.

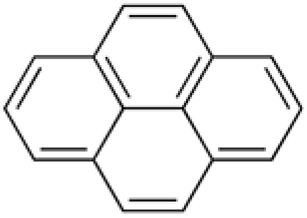


Fig: 1 Structure of Pyrene.

The pyrene molecule should theoretically be able to be broken up into smaller molecules using ultrasound (some of which may also be carcinogenic) i.e. phenanthrene, anthracene and phenol, as well as various long chain hydrocarbons.

These molecules may then reform back into other PAH's as well as the possibility of dioxins and a host of other chemical products, due to the aqueous nature of the matrix. Fig 2 illustrates some of the potential reaction pathways under ultrasound conditions.

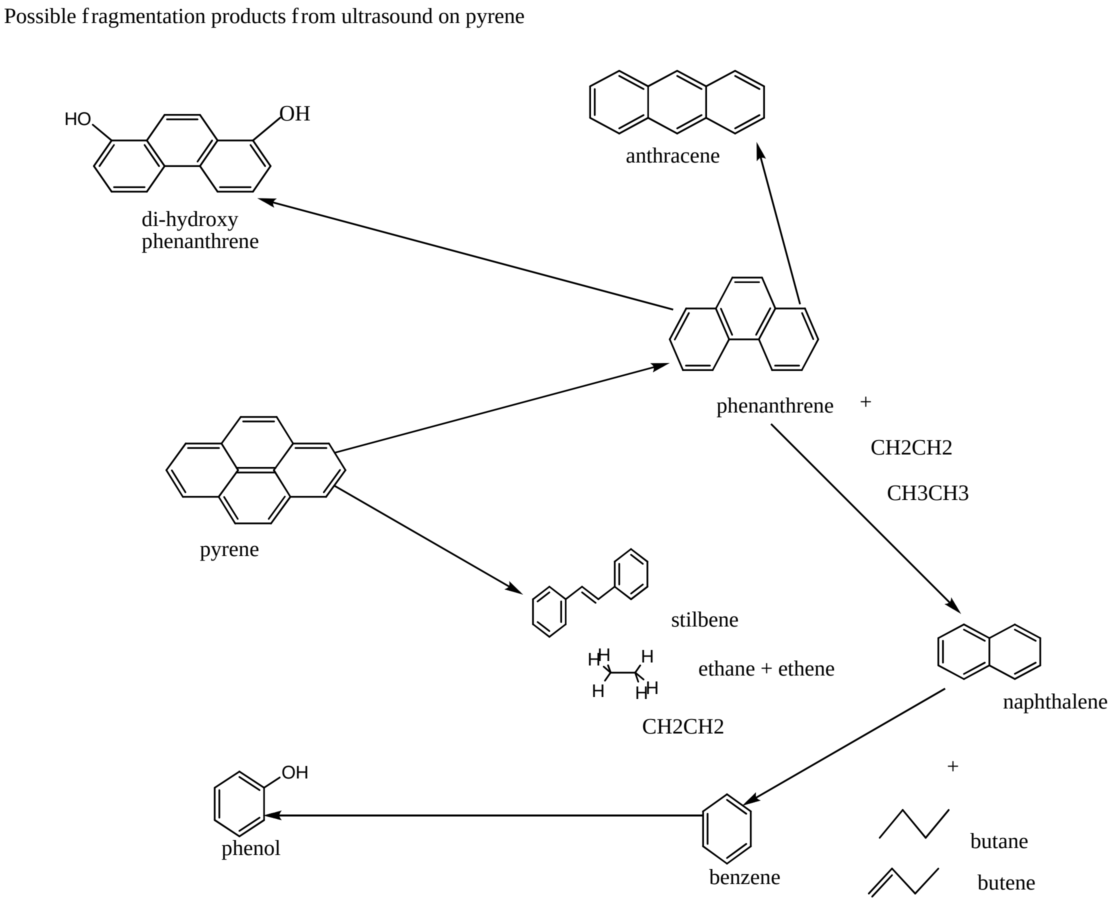
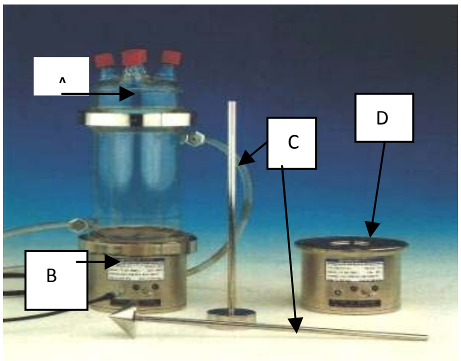


Fig 2: Possible fragmentation products from ultrasound on pyrene

1.2 The theory of Ultrasound and Sonochemistry.



A: sonotower

B: transducer

C: deflectors

D: transducer (not connected)

Fig 3: L3 transducer and sonotower

In power ultrasound, also known as a mono-energy treatment system[13], there is only one type of energy being irradiated into the sample. The other types of energy that can be applied to induce chemical change in a compound are electrochemical energy, thermal energy, and radiological energy.

The sono effect was characterized by Sir John Thornycroft and Sidney Barber at the start of the 20th century[14]. The phenomenon of ultrasound produces cavitation as sound and is transmitted through a fluid in the form of a wave, with alternating compression and rarefaction cycles. During the rarefaction period of the cycle a large negative pressure is developed, strong enough to overcome the intermolecular forces that hold the molecules together, literally tearing the molecule apart to form various fragments and new molecules. These new molecules can be composed of compounds and mixtures such as epoxides, various radicals, phenols; other smaller aliphatic and aromatic species and long chain hydrocarbons.

Ultrasonic cavitation produces micro bubbles which have a relatively short life span, almost instantaneously collapsing, producing incredibly high temperature. Inside the micro-bubble estimated temperatures in the region of 5000 K and high pressures in the region of 1000 atmospheres are said to exist[15].

The extreme conditions evolved from cavitation collapse contribute to the ability for bond fission to occur causing degradation of the solid, liquid and gaseous vapours in the bulk medium, due to the shockwave that is generated by cavitation collapse. These conditions provide the mechanisms to promote and accelerate recombination and fractionation of the molecules. It is possible to ‘tune’ the frequency of ultrasound used to target bonds within specific molecules and therefore cleave the bond, forcing the break-up of molecules in a known and quantifiable manner.

It is expected that in the future study of pyrene the degradation compounds obtained from the procedure can be identified and quantified.

Other PAH species such as anthracene, phenanthrene, phenol and naphthalene are possible fragmentation/recombination products. These compounds are easily identified by using known standards and comparing HPLC elution times and fluorescence peaks with the standards run on the HPLC and fluorescence spectrometer.

2. EXPERIMENTAL

The frequency of the ultrasonic transducer used was set at 42 kHz with a power maximum of 50 W_{real}. The sample was irradiated with the ultrasound for a set time in this case 15000 seconds, and this was achieved using a L3 communication sono tower with the power driven by a Cesar RF power generator.

0.003 g of pyrene was weighed out using the 'Ohaus plus' analytical balance. The pyrene was dissolved in 1000 cm^3 pesticide grade water giving a pyrene solution for analysis of 3 ppm. 500 cm^3 of this was transferred to the sonotower for treatment using the 42 kHz L-3 transducer, with samples taken every 20 minutes for analysing using the f4500 Hitachi fluorescence spectrometer and the Varian 9012 HPLC.

The column that was used for the HPLC analysis was a Phenomenex envirosep-pp, 135 x 60 mm, specifically designed for polyaromatic hydrocarbon analysis. The solvents used were pesticide grade acetonitrile, pesticide grade water in a ratio of 80:20 actetonitrile/water. The peak heights were plotted against time, the photon counts plotted against time and temperature against time. Significant changes in the peak height at certain positions on the base line indicated a change in the chemistry of the pyrene, with either degradation or recombination of the molecule a possibility.

Pyrene was also sonicated using the ultrasonic bath with lower power output than the sono-tower (~20kHz) with samples taken at periods of 30 minutes and analysed using the same fluorescence instrument and HPLC techniques; the results plotted for photon count versus wavelength.

The pyrene was also irradiated using the tower system with samples taken at 30 minute intervals and analysed using Varian 9012 HPLC with combined Varian fluorescence detector. A wavelength scan was obtained using the the f 4500 Hitachi spectrophotometer, providing additional information on peak heights.

The results from analysis were then tabulated and graphed and provide evidence for possible degradation pathways for pyrene at 5.0^o C. This is a repeat of a similar experiment but at a lower temperature for a comparison of reaction routes and temperature, the comparison can be seen in the results. The HPLC results showed a number of peaks as well as the main pyrene peak. This is indicative of a number of different compounds in the mixture after sonication.

These plots were overlain against each other so that any discenable difference was easily noted. It was found that over time the photon counts were seen to increase with time, indicating that the sample was further dissolving up to a maximum level.

Further work requires to be done confirming the generated PAH species obtained or postulated from ultrasonic irradiation, the results should be compared with standards or to other methods to either prove or disprove the degradation products (see fig.4).

Table 3: Ultrasonic bath (~20 kHz) at 20^{o}C.

Time Sonicated	Photon counts
0	2151801
30	1598381
60	2069249
90	1759224
120	2088930
150	1881169

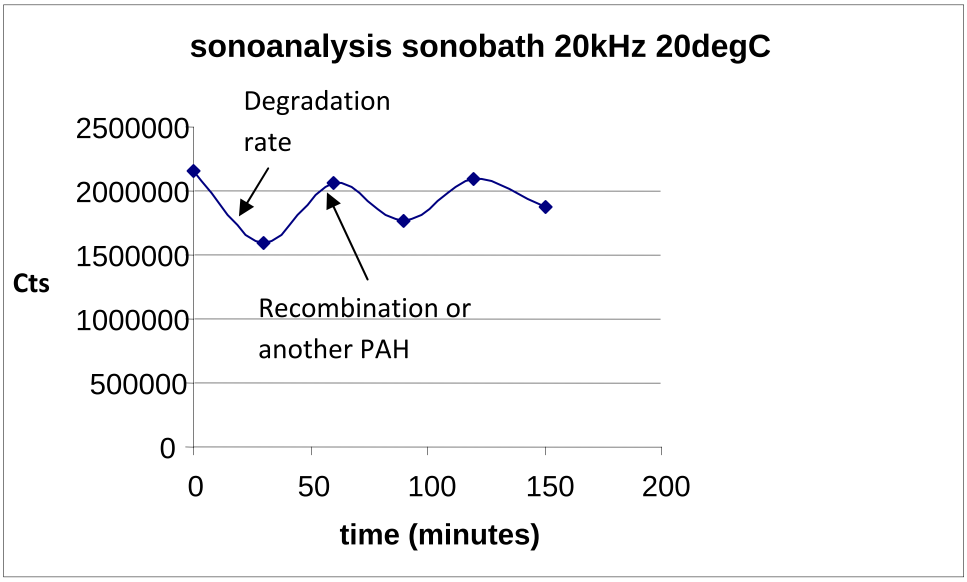


Fig: 4: Sonoanalysis using the 20kHz sonobath

The graph shows at 0 minutes the photon count value of 2151801, which is the 3 ppm model pyrene at the start before the commencement of sono treatment.

After 30 minutes of low level ultrasound the photon count has dropped to 1598381, this gives a degradation rate of 18447 counts per minute.

After 60 minutes the photon count has increased back to 2069249, giving a recombination rate of 46404 counts per minute over the 30 minutes. This may be either reformation of the pyrene or recombination to a different PAH.

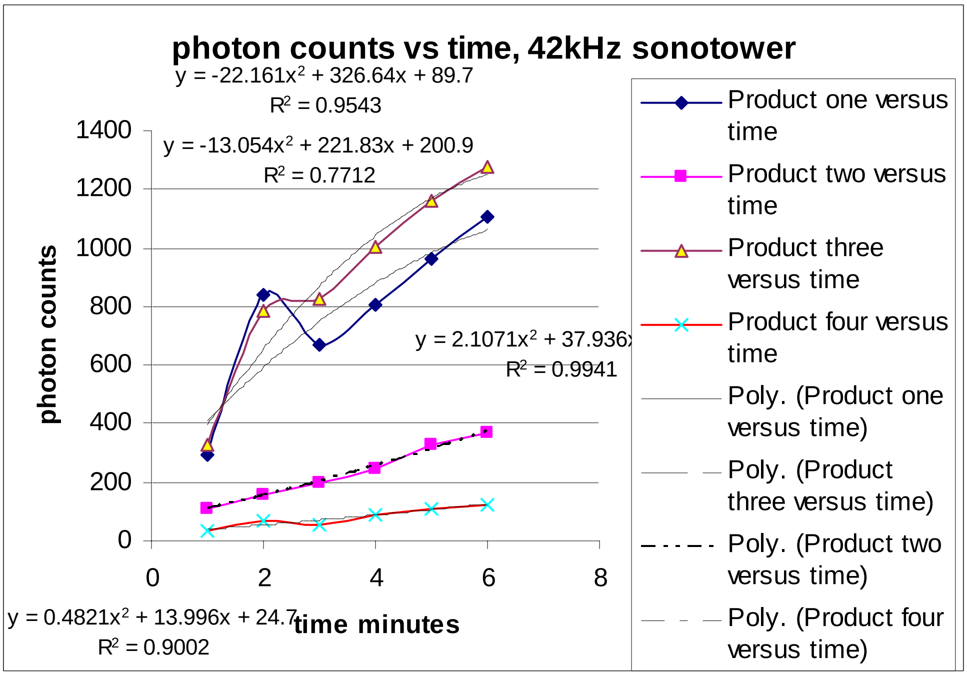
After 90 minutes of ultrasound exposure the photon count has fallen to1759224, which is a decay rate of 10334 counts per minute over the 30 minutes, showing another change, whether further degradation or recombination, into a further PAH.

After 120 minutes the photon count increases to 2088930 giving a reaction increase of 10990 counts per minute of either recombination or the formation of different PAH species.

The effect of sono treatment on the pyrene molecule shows both degradation and reformation of the model pollutant with ultrasonic exposure time. The results using the HPLC and fluorescence spectra. . The peak heights obtained from the HPLC analysis scans showed a decrease in heights between samples indicating a change in the 3 ppm pyrene solution (Fig.5).

Table 4: Ultrasound degradation at 5.0 to 7.0°C.

Time sonicated	0 mins	30 mins	60 mins	90 mins	120mins	150mins
Product one	291	842	669	808	961	1105
Product two	109	158	199	247	325	368
Product three	331	787	829	1001	1159	1274
Product four	34	71	55	90	112	124



Fig, 5: Graph of photon counts versus ultrasonic treatment time using the sono-tower at 5.0 to 7° C, 42 kHz ultrasonic transducer.

Product one = unknown analyte one.

Product two = unknown analyte two.

Product three = unknown analyte three.

Product four = unknown analyte four

From the graph it can be seen that of the four peaks observed, peaks two and four would appear to vary little but there is actually there is a ~380% increase obtained over the treatment time further analysis would yield the identities of these compounds, the graphs has also had a polynomial fit trend lines added and R^2 values of 0.9941 and 0.9002 obtained respectively. Peaks one and three however, have the most pronounced change over time, ranging from over 291 for peak one and 331 for peak three, climbing to a maximum of 1105 and 1274 respectively this also is a ~380% increase over the analysis time again a polynomial trend line was again applied and R^2values of 0.7712 and 0.9941 respectively obtained. Further analysis using known standards of any from the hypothesised compounds from fig 2 and fig 6 may yield the identity of the molecules.

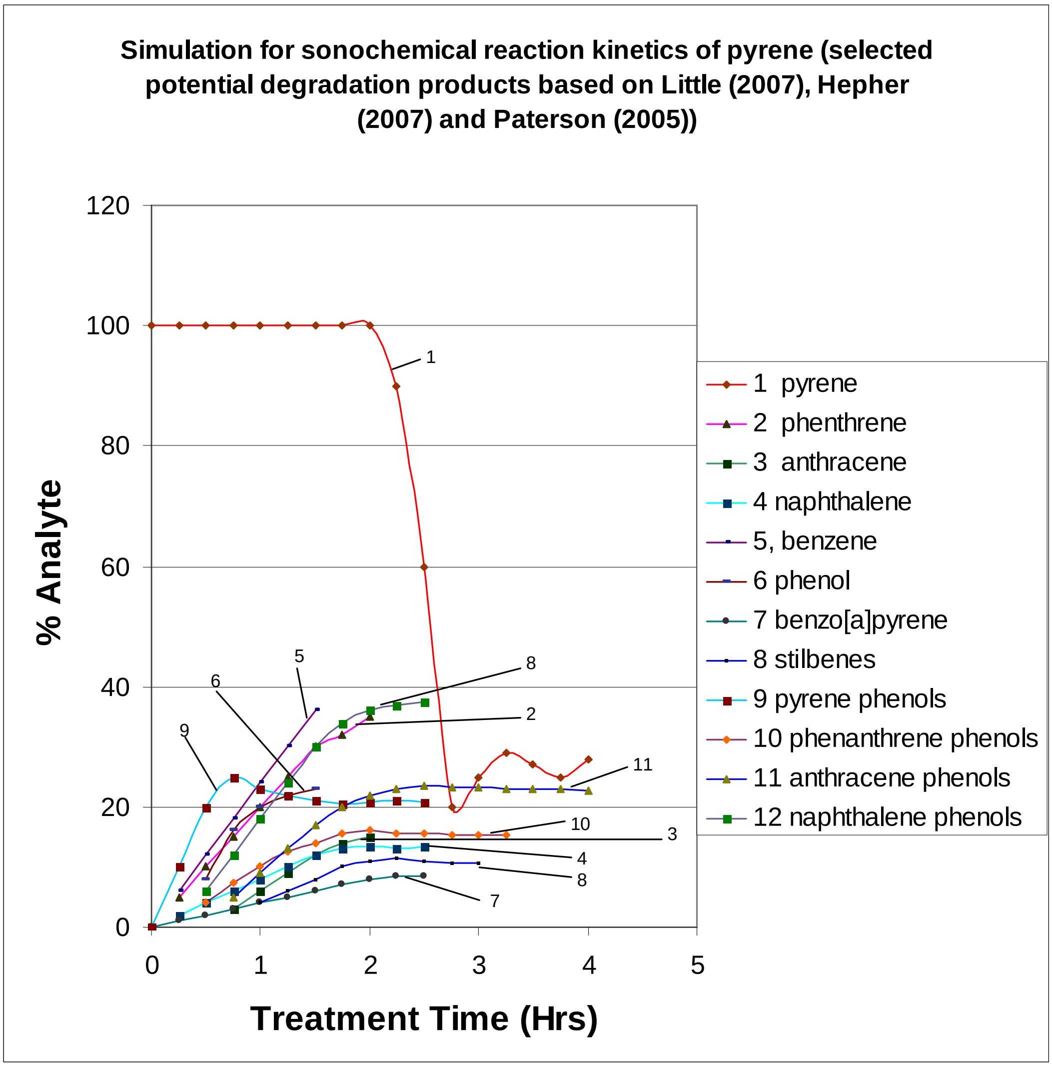


Fig 6: Graph for simulation data of the degradation of pyrene using ultrasound

It is suggested that the initial concentration of pyrene is100% ie a saturated solution with excess pyrene also undissolved. With the introduction of ultrasound the hypothesis is that the pyrene will be 'broken up into smaller molecules, this is suggested by the various compounds that are proposed. These compounds are simulated compounds but are perfectly feasible in the experiment; the various compounds could be confirmed by the use of stock standards of the various compounds and comparison with the experimental results. One of the main compounds of interest in the simulation would be the B[a]P (number 7) as it is one of the most carcinogenic of the PAH's[16]. Other compounds may also be worth investigating such as phenanthrene, benzene, phenol etc. Fig 2 and fig 6 show two possible degradation pathways for pyrene but these are only two possible theories, there may be others. Further research into the phenomena of the ultrasonic degradation of pyrene would yield more concrete results and confirm if the simulation was correct..

3. CONCLUSION

The sono treatment of pyrene can be complicated with the formation of several products ranging from phenanthrene and anthracene through to lesser PAH's, long and short chain hydrocarbon, fragments and radicals. Due to the aqueous nature of the matrix involed phenols were found after sonication due to the breaking of the water molecules to H and OH radicals; as the radicals are very active they could readily combine with aromatic fragments to form phenols. This was confirmed by comparison a standard scan of phenol using both the fluorescence spectrometer and the HPLC with fluorescence detector, and comparing the results with the original experiment.

Other fragments recombine to form smaller PAH's and epoxides. This can be confirmed by the use of a known standard solutions of phenol, phenanthrene, anthracene, naphthalen and benzene, with comparison between these standards and the results.

The degradation and recombination of the molecule is evident from the various treatments as they show a marked change in the photon counts. The primary investigation in this work involves pyrene. It must be explained that the purpose of this discussion is not to fully explain the mechanisms of the products after sonication but to study the effect that ultrasound treatment has on the sample and to provide an ideal simulation model of the process.

Fig 4 shows the effect that low level ultrasonic treatment has on the sample via the photon count on the HPLC analysis. It shows that there is a marked difference over time for the counts with the possible degeneration and recombination of the molecules over the treatment time.

Fig 5 shows the effect of using the 42 kHz sono tower at low temperature and fluorescence analysis; the data shows that over the six experiments there is a change in amount of sample with time. This is shown graphically with separate peaks increasing with time. This concurs with the hypothesis of degradation and recombination of the pyrene into different molecules. The results could be reinforced by the running of standards for comparison.

There is evidence that the use of sonochemistry may be beneficial to the degradation of trace levels of PAH's changing them into a variety of compounds, see Fig 4, with the treatment showing recombination and possible alternative PAH's being formed. Further analysis of these molecules can determine the nature of the products and provide information on possible sustainable methods of disposing of, or reusing the pollutant species of in an environmentally friendly manner.

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A MODEL FOR DIGITALIZING THE CONSTRUCTION MONITORING PROGRESS

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Abstract: Traditional computational techniques have failed construction industry because of the sheer number of information interfaces and complex relationships. The growing needs for better monitoring and control of construction projects, together with rapid technological progress, have lead to identify the problem of automatically updating project progress reports. This research focuses at trends and predictions of the construction industry especially during the construction stage for implementing information technology tools and presents a model namely Automated Construction PROject Monitoring (ACPROM®) system. This system integrates information from 3D CAD drawings, 2D digital images and updates the planned work schedule automatically. A pilot study carried out to test the validity of ACPROM® system, to explore the technical issues related to the integrated use of CAD and digital images within the house building sector of the Malaysian Construction Industry. This research paper describes the development of a real-time monitoring model capable of measuring the construction project progress by simulating the digital photographs and AutoCAD drawings. The system enables the management staff at the owner's representative (consultant) and contractor's to follow development at the construction site in real time. The use of the ACPROM® can help resident engineer, construction manager and site engineer in monitoring and evaluating project performance and progress reporting. This system abridges the monitoring and controlling the construction work by implementing the information technology techniques.

Keywords: 3D CAD, Construction Management, Expert System, Photographs, Progress Monitoring.

1. INTRODUCTION

The proliferation of mega projects that transcend traditional boundaries, cross cultures, and span disciplines has increased the need for more rigorous evaluations of the projects and their management Kumaraswamy (1993). Project progress monitoring and control is one of the most important tasks of construction project management. However, the construction industry relies heavily on written reports to document the actual physical progress. Due to the language ambiguity and the fact that details are usually omitted during writing, it is difficult to reconstruct a complete picture of what actually occurs during construction. To develop the actual physical progress reports are time consuming, data are not well organized, flexible or easily accessible. McCullouch (1997) reported that an average 30-50% of the time of field supervisory personnel spent recording and analyzing site data. Additionally, inspection information is often provided in useful format or timely basis and in practice little has been done to address this problem.

The need has long existed for tools to stream line the job of systematic evaluation and monitoring for management of construction activities. Chin (1997) mentioned that computers are increasingly become a central component of project information systems however, manual paper-based information flow on construction projects dominates. Progress of construction work is required to be monitored and compared with planned schedule in order to identify and measure these differences. There are few integrated systems which are used to monitor and report on the progress of the work. Some of them rely on information related to activities while others are based on work types. This paper contains a review of commonly used monitoring system and their characteristics and proposes new framework model for evaluating and monitoring the construction project progress.

An integrated project progress monitoring and evaluation system called Automated Construction PROject Monitoring (ACPROM) system has been developed to assist project managers in developing the actual physical progress reports. ACPROM calculates the percentage of progress by integrating the digital images and AutoCAD drawings and plots the actual progress bar chart. Project monitoring data are stored in a database with input provided from AutoCAD drawings and Digital images from construction site as construction progress. The percentage of progress are calculated by integrating the information from 3D CAD drawings and 3D Model from digital images and compared with the as-planned schedule of work and as-built schedule bar chart plotted in Microsoft project.

2. BACKGROUND AND LITERATURE REVIEW

The construction industry has been criticized for slow adoption of emerging technologies. O'Connor and Yang (2004) mentioned that this trend has been changing in recent years. Greater demands for more cost-effective and schedule-efficient projects have led to new project delivery process, many of which exploit technologies that serve to either automate or integrate tasks. Researchers have identified the effects of automation and integration technologies. Griffis et al (1995) studied the impacts of using three dimensional (3D) computer models on cost, schedule duration and rework metric and concluded that projects using 3D Models experienced reduction in cost growth, schedule slip and rework.

This section provides a brief overview of studies reported in the literature review relating to automated digital construction monitoring and evaluation. The commercial software packages related to this topic are also listed. Chin (1997) developed an integrated construction information framework, named ICIM (Integrated Construction Information Model) to support effective as-planned and as-built information management throughout the life-cycle of a construction project. The validity of ICIM was developed by using an object-oriented programming language and database management system.

Wang (2001) developed the expert system integrating construction schedule with CAD drawing (ESSCAD), mainly with knowledge-based system programming technique and software integrating techniques, which can automatically interpret the CAD drawings of a building and extract data of its building components, breakdown the project into activities, determine the logic dependencies among activities, estimate the work quantities and durations of activities, finally generate a primary construction schedule for the project. Abeid *et al.* (2003) described the development and implementation of PHOTO-NET II, an automated real-time monitoring system for construction projects programmed in a Delphi environment. The system links time-lapse digital movies of construction activities, critical path method (CPM) and progress control techniques. This system accepts the digital images taken from multiple cameras store them in chronological order and links them to a database that contains schedule information; the progress graph has been developed showing planned versus actual schedules.

Chau *et al.* (2004) developed a prototype 4D visualization model that links three dimensional geometrical schedule data and implemented with a view to overcoming problems incurred in conventional construction planning methods and in incorporating practical site management features. This prototype model has been developed on a personal computer under the contemporary Windows platform. Visual C++ is the programming development environment for the construction processor as well as for the user interface. The results indicated that 4D visualization model will have strong potential in construction planning and management process. Dzeng *et al.* (2005) proposed an automatic review system called Network Review Assistant (NRA), which helps practitioners to review schedules. The NRA generalized rule forms to represent the schedule critique knowledge collected from the industry. The NRA was developed using Visual Basic Application and Micro soft Access 2000. The MS project, open plan and P3 scheduling software allow users to export schedule files in NRA. The NRA was evaluated by comparing the review results of two test schedules generated by human reviewers and NRA. It has been found that NRA reduces review time, and provides more accurate review on finding activities and related pay items not conforming to standards, and reminding users of important but often omitted activities.

Pappa, *et al.*, (2002) implemented the photogrammetry techniques for Gossamer Spacecraft Structures and described that the science of calculating 3D object coordinates form images is a flexible and robust approach for measuring the static and dynamic characteristics of future ultra-light-weight inflatable space structures. Close-range Photogrammetry, a flexible and robust technology with demonstrated potential for measuring Gossamer-type structure was used by Pappa *et al.* (2000). Greco (2001) described Photogrammetry is one of techniques for obtaining reliable measurements from photographs and other type of images. Chant (2000) mentioned that by using close-range Photogrammetry instead of taking traditional contact measurements, the photos were converted into AutoCAD models using PhotoModeler pro version software.

In the highly competitive construction industry, these systems are good for solving a specific problem, but the scope is limited. From the related research it has been cited that studies have been conducted to develop the integration model for a project and the ideas for developing automated real-time monitoring systems are rapidly growing with the advancement in the information technology. From the literature it has been cited that very few have given concern to develop the actual physical progress bar chart by simulating the images with CAD drawings.

3. A FRAMEWORK FOR THE PROPOSED MODEL

As illustrated by the preceding discussion, numerous studies have focused on information flow throughout construction projects monitoring, and a number of computer programs have been developed to support this area. However we have not found a thoroughly comprehensive treatment of the construction site photographs and drawings of construction projects, particularly as they relate to computer support tools. Furthermore we are interested in examining how issues of project monitoring fit within a larger context of integrated project management systems and standard data models for representing and exchanging all forms of project progress information among all project participants. The research reported in this paper took a step towards this objective by attempting to simulate the 3D Model from digital photographs and 3D AutoCAD drawings of super structure concrete elements specially beams and columns.

This system focuses some areas which are not covered by other existing systems mentioned above; a major objective of the system was to serve as a focal point for collecting and analyzing data about project physical progress and flows for integrated computer systems rather than create a new class of software application. Several researchers have addressed different aspects of development methodologies for monitoring system (Dzeng *et al.* (2005); Chau *et al.* (2004); Kang *et al.* (2004); Cheung *et al.* (2004); Abeid *et al.* (2003); Saad (1999)). On the basis of these researchers' recommendations, a framework model is proposed as shown in Figure 1. The model includes four phases: Input data requirements, Data process procedure, output and action. Each phase of the proposed model includes different steps and procedures and identifies its final product.

Phase I (Input the data):
In the phase I, user input the initial project information. This carries the general information regarding the project title and its' position in the management of the project. By pressing the submit icon, user needs to add the data of Planned bar-chart, 3D CAD drawing and 3D coordinates values in txt format from digital images. The uploaded information will be processed in the phase II of the proposed framework.

Phase II (Process the uploaded Data):
During the phase I, as the user browsed the information related to planned bar chart in Microsoft project file, 3D CAD drawings in AutoCAD file, 3D coordinates values from digital images in txt format, that information is processed by developing different algorithms to formulate it as automatic process. The algorithm is developed for detecting 3D coordinate information automatically from 3D CAD drawings and develops a database and algorithm to capture the information from planned schedule of work activities. The information from the digital images is also restored in the database automatically. The database developed from CAD drawings are called Primary database and from digital images are called secondary database. Once the database has been uploaded, the simulation process will start which will calculate the actual progress of work by simulating the 3D coordinate values in percentage. The result of simulation process will be viewed in the Microsoft project bar chart as an Output of the process.

Phase III (Output result):
During the phase III, the output result of simulation process will be viewed. Microsoft project will show the comparison of planned schedule and actual progress of work.

Phase IV (Action):
Base on the information gathered at phase III, phase IV suggests the action or any remedial measure to overcome the problems related to construction. The scope of this research is limited up to phase III and to suggest an appropriate action which is carried out in further studies.

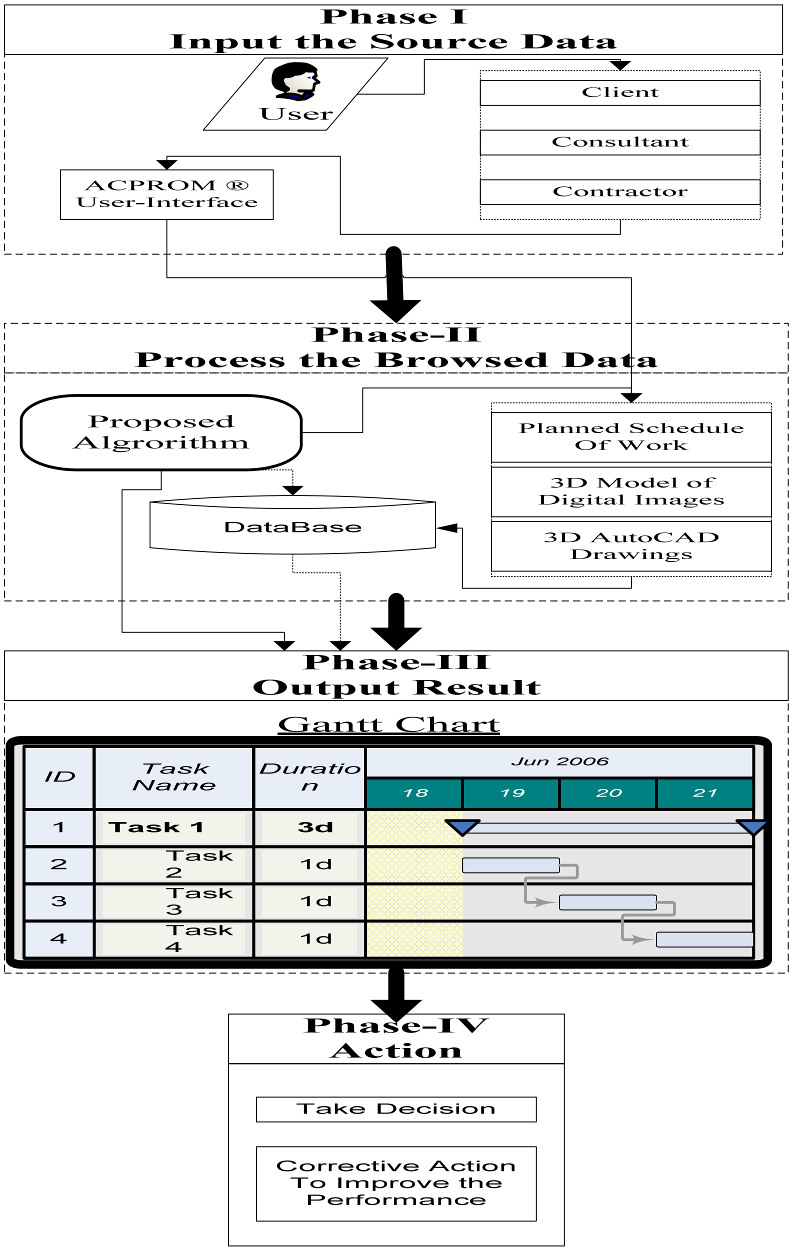

Figure 1: Framework model for Automated Construction Project Monitoring

4. WHAT IS AUTOMATED CONSTRUCTION PROJECT MONITORING (ACPROM) MODEL?

The objective of developing Automated Construction PROject Monitoring (ACPROM) model is to systematize the construction monitoring and evaluation of a project. ACPROM is implemented using object oriented concepts and event driven programming. The object oriented concepts were utilized in the graphical user interface of constructing the ACPROM processes. Graphical interfaces were created in the Photogrammetry and PhotoModeler environment and then exported into Visual Basic TM (event driven programming). Relational Data base was implemented using Micro Soft Access TM engine to store project related information. The simulation concept of ACPROM model is currently being used to test and check the validity.

Automated Construction PROject Monitoring (ACPROM) Model is a software package in the window environment, which is under development at Construction Technology and Management Center (CTMC), University Technology Malaysia (UTM) that integrates the digital images captured from small-details concrete structure elements at construction sites, AutoCAD drawings for the these structural elements and standard scheduling tools such as a Micro Soft Project. A prototype simulator is being developed using visual basic programming language in Windows programming environment that provides user with the ability to create self contained windows applications. The visual programming features provide strong links to the Visual components Library classes of the Window System.

The proposed Model is intended to be a user friendly application that is easy to access by different project team members. The main objectives and the scope of the system are as follows:

(a) To enable computer system to solve the problem intelligently by emulating the human brain.
(b) To reduce the amount of time spent recording, preparing and posting reports.
(c) To improve the tracking and control of the project and activities status.

Digitalizing the construction phase is the recent demand of the Malaysian Construction Industry and for the developing countries, where monitoring the project progress is carried-out by traditional method of capturing the photographs and placing these into monthly progress reports. Malaysian construction industry which is the second largest industry to implement the Tele-Construction strategies and this study is one part of that approach. The major object of developing this model is to link between existing method of evaluating and monitoring the physical progress of construction scene with modern technology by developing an Artificial Intelligence to emulate the human brain.

5. COMPONENTS AND STRUCTURE OF ACPROM SYSTEM

The basic theory for developing the model is to extend the traditional approach to represent the dynamic and simultaneous construction operations by incorporating inter-relationships between hierarchical processes of evaluating and development in the field of Information technology. With the continued development of easy-to-use computer software and improved graphical presentation media, many of the practical problems associated with formal scheduling mechanics have been overcome. Some of the function involved in project management, especially those concerned with project monitoring and evaluation (developing the actual physical progress bar chart) were virtually impossible to execute with any great speed before computers were used (Levine 1989). The rapid growth in the availability and power of microcomputers, coupled with their continuously decreasing cost, has made it possible for construction managers to effectively and efficiently analyze the massive amounts of data necessary to monitor and control the progress of the many interrelated tasks together to make a construction project. Taking into account characteristics and functions of ACPROM, it was programmed with knowledge-based system programming method. Being a typical expert system, Figure 2 shows the basic components for the model. The ACPROM consists of AutoCAD, Photogrammetry techniques, Database management system, Knowledge base system, ACPROM simulation to formulate the user interface.

This system demonstrates the computer vision integrate 3D CAD drawings of the project to produce construction as-built schedule. Raynar and Smith (1994) defined computer vision as to take 2D images or photos as input and produces descriptive information as output. The actual construction is represented by the digital images of the construction scene and AutoCAD represents the original structural drawings of the elements. The scope of the research is to develop a vision or integrating system for processing images of the construction scene by simulating with AutoCAD drawings. Figure 3 shows the process flow diagram of the ACPROM system which links the digital images, CAD drawings and Planned Bar-chart. Event-oriented programming (Visual Basic 6.0) is used to integrate the information from images and drawings to calculate the actual physical progress of the work and to show the actual progress of the work.

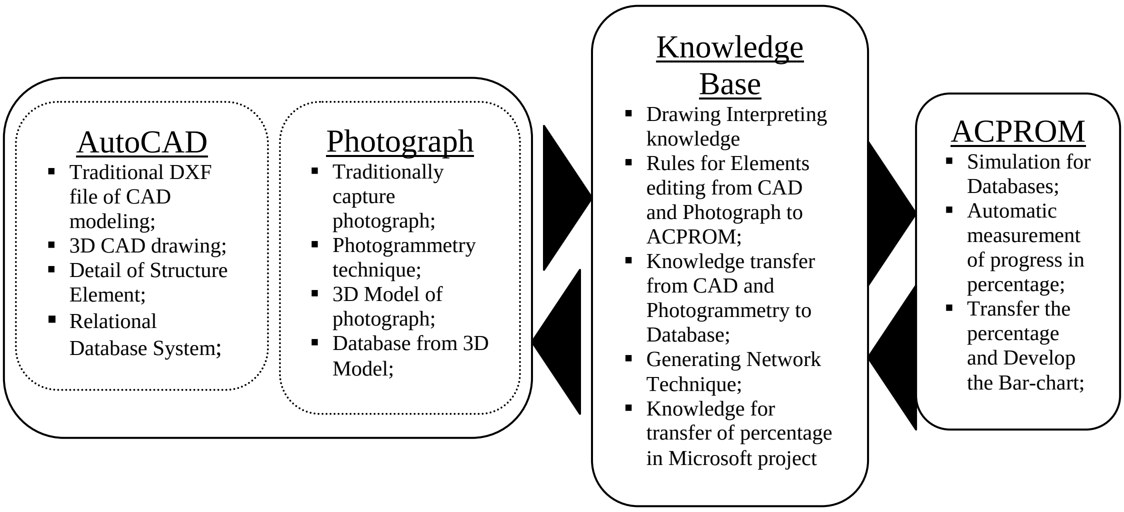

Figure2: Components of Automated Construction PROject Monitoring

6. ACPROM TESTING

ACPROM currently supports the management and collection of as-built information on components, construction drawings, and related multimedia information such as a construction photographs and video clips. Taking advantage of relationships between entities, ACPROM accesses desired construction information from 3D Model of digital images and 3D CAD drawings. The ACPROM will be operated through a user interface, to which access is via the set-up domain of the prototype. By installing the system, the user can access the various built-in functions.

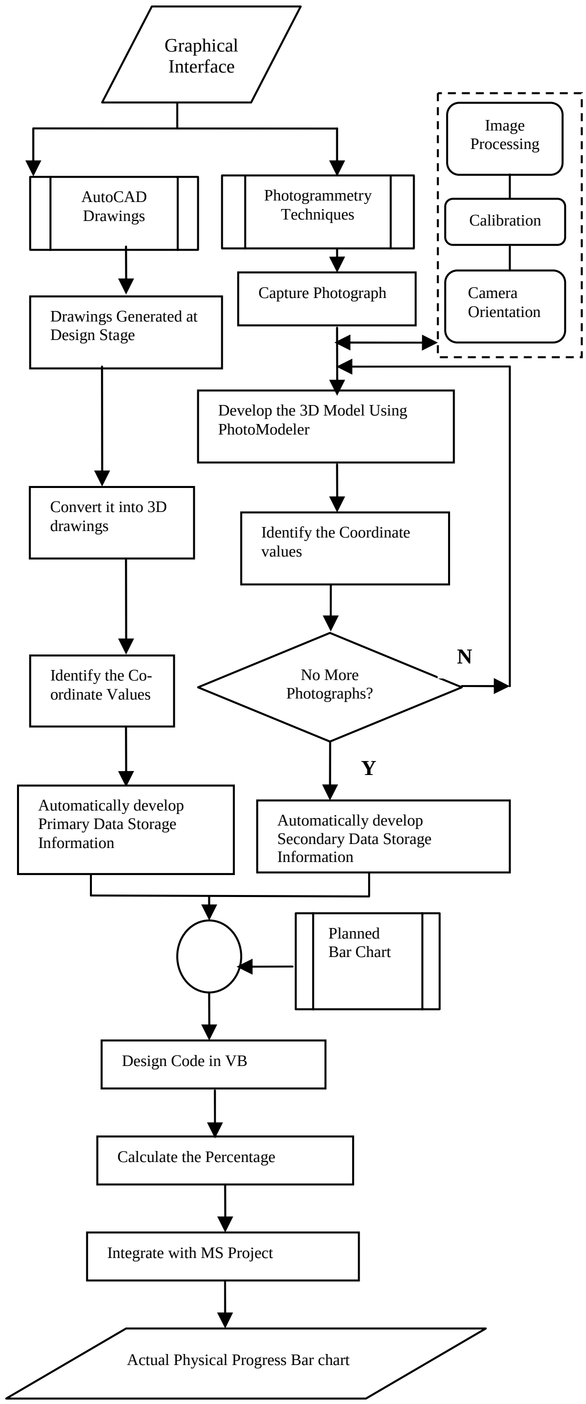

Figure 3: Process Flow Diagram of ACPROM

6.1 Data browsing and Simulating Process

The user can easily browse and insert the specific project detail information regarding the planned bar-chart in Microsoft project as shown in Figure 4. Once the MS project file is uploaded, ACPROM will automatically detect the information for beams and columns for the construction of project. The users also reconfirm the planned start date and finish dates and input the progress updating date. Once the elements selected and dates are described, next step is to browse the 3D coordinate information obtained from digital photographs in tabular format. This table should be in *.txt format and developed with the help of PhotoModeler pro version. Similarly the 3D AutoCAD drawing of the project is browsed to detect 3D coordinate values automatically. The coordinate values from digital photographs and from AutoCAD drawings will be stored automatically in two different databases.

After successfully uploading the initial information, next phase is to start simulation process. It will initially check the start date and finish date and then consider updating date as base line to show the project physical progress up to that date. Figure 5 shows the output of simulation process and result report page smartly connected with the Microsoft project which shows the result of simulation process by updating the planned schedule of work by clicking on view icon on result page and actual project physical progress bar chart will be shown.

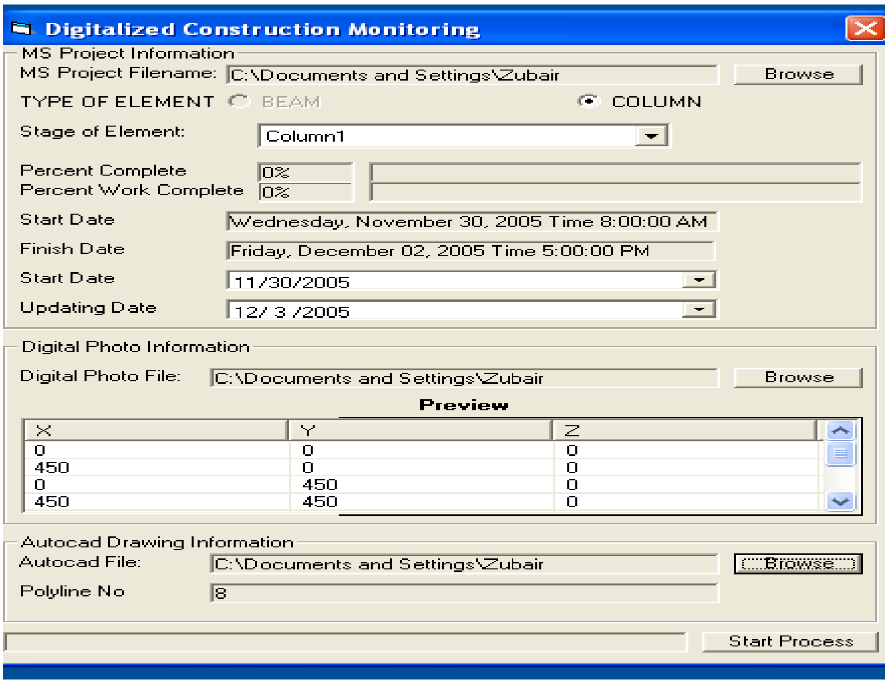

Figure 4: Sample Screen with Data browsed.

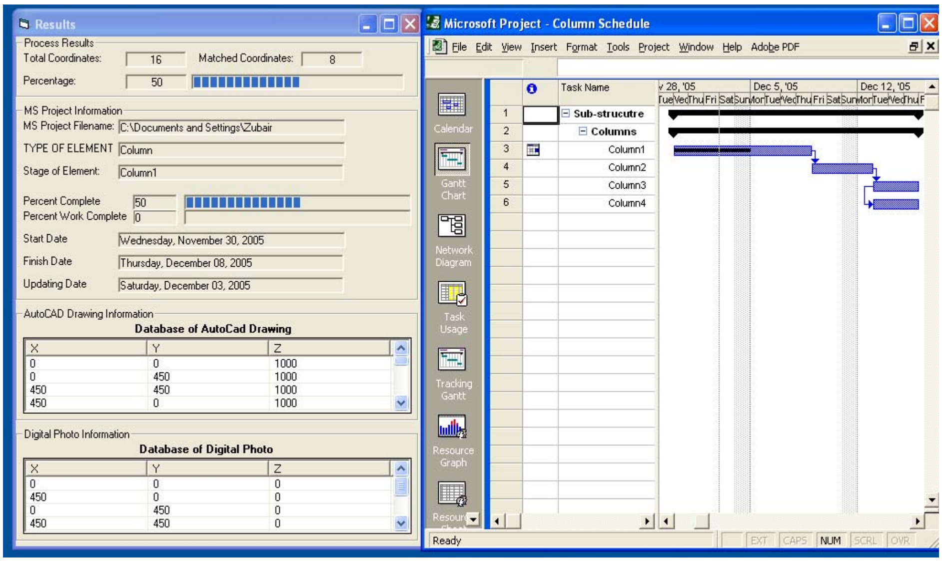

Figure 5: Sample Screen of Result Interface for Pilot Study.

7. PILOT STUDY (A CAR PARKING CONSTRUCTION PROJECT FOR LARKIN MAIN MOSQUE)

In order to test the effectiveness of ACPROM model, a pilot study for the construction of car parking at Larking Main Mosque was conducted. The main object of pilot study was to explore the technical issues related to the integrated use of CAD and digital images within the house building sector of the Malaysian Construction Industry. The construction of columns was tested to check the validity of the system. The images were captured for the column1 after the formwork removed by using Nikon 8700 digital camera. Figure 6 shows the 3D static shape of the column1, which was developed by marking and referencing points in one image with their corresponding points in the other images. This procedure is called referencing the points. Input data was browsed and uploaded in the ACPROM model as instructed on the interface. Initially planned bar chart, 3D CAD drawings, and 3D coordinate values from digital photographs were uploaded as input data. By pressing the processing, it start simulating the information from drawings and digital images and upload the actual progress in Microsoft project as shown in Figure 5.

8. DISCUSSION

The ACPROM model streamlines the job of construction monitoring and progress reporting. From management point of view this system assists the contracting parties (Client, Consultant, and Contractor) to easily develop the progress report. More importantly, the use of ACPROM enables the project manager to easily calculate the percentage of progress without any trial and error method or by guessing. This system also helps the executive for the public works while sitting in the office one can easily know the accurate physical project progress.

The smooth functioning of ACPROM relies heavily on the digital photographs and the database system developed from photographs and AutoCAD drawings. Pappa *et al.*

(2002) discussed the guideline for placing the cameras at convergent viewing angels, and the zoom lenses should be settled properly, either minimum or maximum zoom setting (focal length), any changing in the zoom or focus setting require new camera calibration data. During the acquisition of images for the Larkin Mosque Car Park construction project at Johor Bahru, Malaysia, camera's zoom settled on maximum. Images were captured with convergent angles so that all the information of the images should be captured.

As such, ACPROM users need to be equipped with PhotoModeler software, AutoCAD 2000 and Microsoft project to develop the reliable database and output result. Despite the costs involved for initial purchasing the output result will be more useful and liable forever.

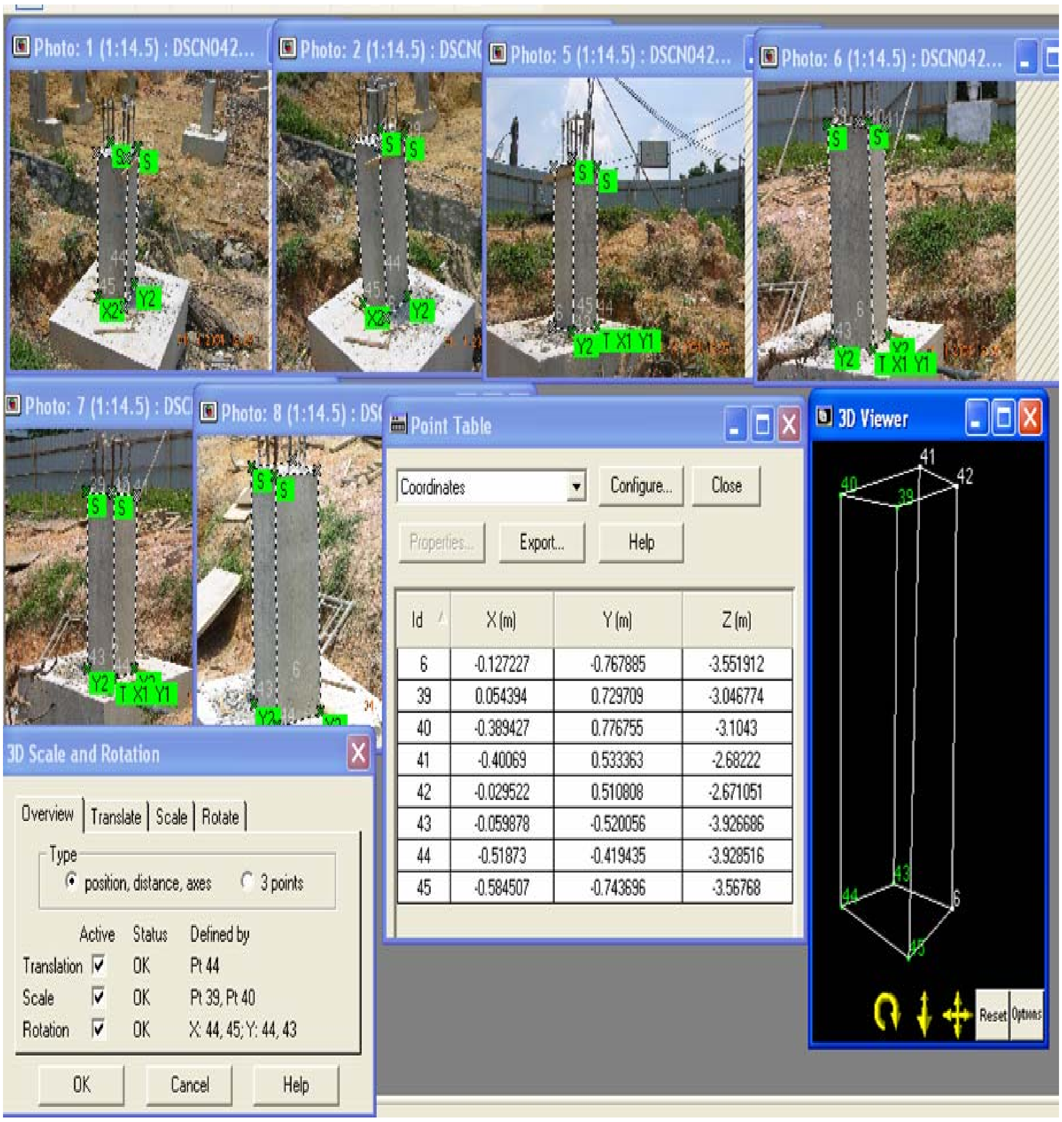

Figure 6: Sample screen for Marking, Referencing and Developed 3D Model.

9. CONCLUSIONS

This paper summarized the experience at CTMC, UTM, for developing a prototype software model ACPROM, for monitoring the progress of construction work. ACPROM will help the professionals to implement the Information Technology in line with the National Information Technology Agenda for the Malaysian Construction industry.

This study attempts to overcome the limitations of the previous research development in the field of project progress monitoring and controlling. The ACPROM model developed by using the Relational Database Management System (RDBMS) and demonstrates the possibility of integrating the information from digital images and 3DCAD drawings and allowing the superintendents to systemize the construction monitoring, evaluation and reporting the actual physical progress more precisely. The prototype software described in this paper is capable of communicating the digital images, AutoCAD drawings and Microsoft Project scheduling and proposed system suitable for remote or off-shore projects.

The application of ACPROM model for monitoring the actual physical progress enables project management teams to better track and control the schedule of work on the case study. Regular and accurate reporting on project progress offers a continuous vital diagnosis of the project status, enabling different project team-members to make proper decisions on any necessary corrective actions to safeguard the project and ensure its completion. ACPROM will minimize the paperwork, provide timely update, and ensure a safe and easy method for document storage and retrieval.

This system enables the project managers to remote diagnosis of construction problems in real time, enhancing communication between site superintendent and the office staff, and providing another source of information to the parties involved in contractual agreement regarding on-site activities. The integration of digital images and drawings will enable construction manager to develop progress reports in a more consistent and accurate way. The more accurate as-built project schedule will be transferred to the facility managers for taking timely decisions. The authors’ believe that by implementing the latest technologies in the field of construction, especially during the execution phase could minimize the potential problems and encourages lesson-learned and innovation.

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IMMIGRANT CONSTRUCTION WORKERS AND ECONOMIC LEAKAGES

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Abstract: The paper draws on a study of economic leakage in the national income model made by construction immigrant workers via remittances in Malaysia. The aim of the study is to investigate current issues and challenges derived from utilising immigrant workers in the Malaysian construction industry and its impacts on the Malaysian economy by looking at measures taken by the Malaysian government to control them. Initial results reveal that there are no measures specially designed to control the economic aspects associated with immigrant workers. Moreover, it has been reported that they have a high tendency to export their wages to their country of origin. This creates a disturbance at macro economy level known as economic leakage. It is proposed that looking at economic modelling and immigrant workers' management could lead towards developing a framework to control the economic leakages in the national income model. However, there are considerable challenges in identifying what and to what degree economic modelling measures consider immigrant workers. To address this, a review of economic modelling at macroeconomic and microeconomic level and measures via rules and regulations taken was undertaken. A discussion is included on the future research direction for the development of economic modelling and government measures to control economic leakage.

Keywords: economic modelling, economic leakage, immigrant worker, remittance.

1. INTRODUCTION

The construction industry possesses a unique character which distinguishes it from other sectors. The product of the industry is mainly large in size, very much dependent on the government as a client, requires high capital investment, has a unique nature, utilises a variety of construction technologies, occupies a unique arrangement of project organization, requires long duration and involves time lags as well as special structure (Ofori, 1990). Further more, it has a high dependency on labour, more so than many other industries especially manufacturing. This makes construction a good sector to influence demand and supply levels and particularly the employment rate, in the economy in general (Hillebrandt, 2000).

However, the industry suffers from labour shortages due to its nature known as '3-D' job (difficult, dirty and dangerous) (Manning, 2001). It has been proved to be one of the barriers to attracting local workers to join the workforce (Ofori, 1990, Dainty et. al, 2005). Therefore, it is not a surprise to find a high percentage of immigrant workers in construction projects.

The employment of immigrant workers in industrialised and developing countries has increased over the last decade (Mughal and Padilla, 2005). Their presence has helped to reduce shortages in the labour market especially in the construction industry

(Narayanan and Lai, 2005). Coupled with the benefits of engaging immigrant workers to the industry are drawbacks like overdependence on unskilled immigrant workers and consequent reduction in quality of buildings and infrastructures. Social problems like increases in crime and high percentage of remittances also occur due to the inflow of immigrants. It is claimed that the legislative actions for controlling the problems are not effective (Mughal and Padilla, 2005; Manning, 2001) and thus can not be relied upon solely to control immigrant workers. There are attempts to reduce the usage of labour-based technology with capital-intensive technology for example the IBS (Industrialised Building System). However, it still fails to remove the existing problem (Dainty et. al, 2005). Moreover, there is a need to use both the technology and human capital concurrently to achieve the best profit to nation's economy and the construction industry itself (Hillebrandt, 2000).

This research is shaped by the recognition that leakage via remittances made by immigrant construction workers has created a disturbance in the Malaysian economic cycle especially in the country's real and money cycle (Harvey, 1988). This has thus affected the function of the construction industry to provide the multiplier-accelerator effect to the economy (Abdullah, 2004 and Hillebrandt, 2000). It presents the current situation with respect to economic leakage as a result of remittances made by the immigrant workers in Malaysia and forms the first part of research required in order to develop a framework to support the integration of economic modelling and management of immigrant workers. It begins with reviewing the current practice of immigrant worker's management especially the problems that emerge and actions taken. A review of the potential use of economic modelling to control the high percentage of remittances that cause the leakages was also conducted to generate a better understanding of the economic theory.

2. PROBLEM IDENTIFICATION

The construction industry has not been able to fulfil its potential as an industry that could influence the level of the demand and output as well as economic multiplier due to its high usage of workers. This is due the current scenario in the industry whereby much of the employment created has been passed on to the immigrants who are willing to work at minimal wage and in poor conditions (Narayan and Lai, 2005). In addition, their presence in the industry has driven down the wages received by the local workers (Ofori, 2000).

The utilisation of immigrant workers has also led to a high percentage of remittances. Taking Malaysia as an example, about £72M was exported by immigrant workers every month in 2006 (Rosli and Kumar, 2006). Remittances of this sort are made by the immigrant workers in many other developed and developing countries like America and UK (Lafayette County, 2006 and Thieme and Wyss, 2005). This scenario creates a disturbance to the national income in the macroeconomic model known as leakage.

The need to control the economic leakage caused by immigrant workers is crucial as their number in the Malaysian construction industry is very high and they have high tendency to remit their wages. This scenario could dampen the function of the construction industry as economic multiplier-accelerator.

Much literature discusses issues such as the attempts to reduce the high dependency on immigrant construction workers, protections, optimising benefits of organised labour migration and the importance of remittances. However, little research on the need to control the percentage of remittances made by the immigrants to help stimulate the labour receiving countries was found. There is therefore a gap in knowledge and hence a study investigating the economic aspects of remittances is beneficial.

3. OBJECTIVES AND METHODOLOGY

The aim of this paper is to investigate current issues and challenges derived from utilising the immigrant workers in the Malaysian construction industry and the impacts of utilising them on the Malaysian economy. It presents the current situation with respect to economic leakage as a result of remittances made by the immigrant workers in Malaysia and forms the first part of research required in order to develop a framework to support the integration of economic modelling with the management of immigrant workers. A review on the potential use of economic modelling to control the high percentage of remittances that cause the leakages was conducted to generate a better understanding of the economic theory.

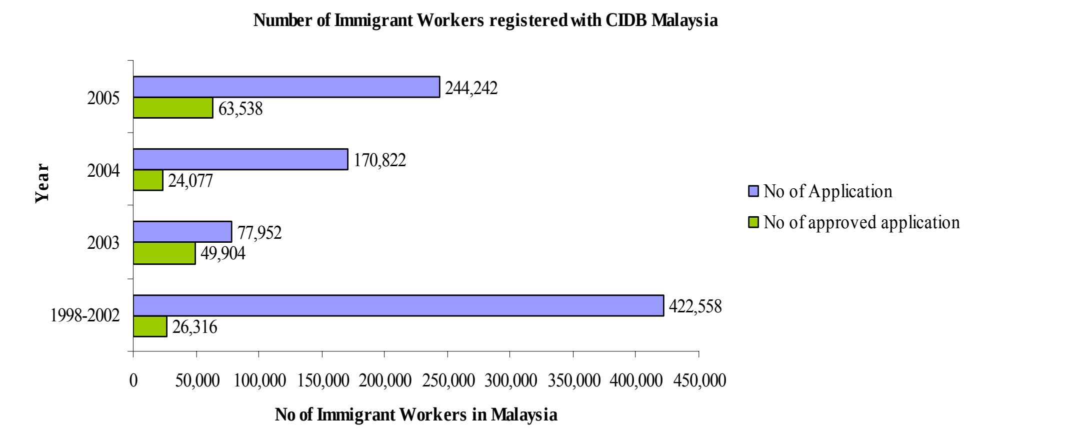
Another review of the current practices of immigrant worker's management especially the problems that emerge and action taken was also conducted. An interview with the director of the foreign workers division from the Immigration Department of Malaysia has been carried out to develop a better understanding of the management of immigrant workers in Malaysia. The outcome of the interview is presented and supported with other information from several administrative and survey sources concerning immigrant workers.

4. IMMIGRANT WORKERS IN MALAYSIA

The use of immigrant workers started in the 1970s when the Malaysia government initiated the New Economic Policy. The policy welcomed influx of labour especially from India to address the labour shortages particularly in plantation sector (Narayanan and Lai. 2005). The inflow of immigrants during this period is a result of "pull" factors especially the critical labour shortages suffered by the Malaysian government.

4.1 Analysis of Management and Measures of Immigrant Workers in Malaysia

This section presents the analysis of the management and measures currently applied to immigrant workers collected from the Malaysian Immigration Department and the Malaysian Construction Industry Development Board. Data on the current numbers of legal and registered immigrants are presented. The statistics reflect the high percentage of dependency of the Malaysia labour market on immigrant workers. Giving Malaysia as an example, the proportion of the immigrant workers to local workers in the workforce is increasing from 1:10 in 1995 to 1:8 in 1997. It then recovers to 1:13 in 2000 (8th Malaysian Plan, 2001). As per 2005, there are 63,538 registered immigrant workers works in Malaysia with another 244,242 waiting for working permits (CIDB, 2006). The figure shows the increasing numbers of immigrant workers applying for job and their preference to work in Malaysia. The following Figure 1 shows the numbers of registered immigrant construction workers in Malaysia.



Source: Construction Industry Development Board of Malaysia,

Figure 1: Number of immigrants construction workers registered with Construction Industry Development Board, Malaysia

It clearly shows that the numbers of immigrant applying for working permit increases from the year 2003 despite of the development growth in Malaysia. However, it shows that in 2004, there have been some attempts to reduce the numbers of immigrant workers in the Malaysian construction industry and to control the numbers of existing approved immigrant construction workers.

4.2 Analysis of the Regulations and Mechanisms Applied to Control Immigrant Workers

In line with their objectives to control the inflow and outflow of the immigrants in Malaysia while maintaining the workers market, the Malaysian Immigration Department has implemented a number of policies and regulations such as limiting the sectors immigrants can work in, limiting countries of origin, requiring work permits, limiting work durations, imposing levies, requiring visas and appointing foreign workers through listed outsourcing companies (Malaysian Immigration Department, 2007). Most of the Malaysian policies outlined are developed in common with nearby neighbourhoods such as Brunei and Singapore. The regulations are as stated in the Malaysian Immigration Act 1959/63 and Malaysian Passport Act 1966. However the measures concentrate mainly on safety and monitoring the inflow and outflow of immigrant, permits and penalties for those who disobey the rules (Malaysian Immigration Act 1959/63 and Passport Act 1966, 2006).

Table 1 below shows the overview of the measures taken so far by the Malaysian government to control legal immigrants in Malaysia. Most of the measure emphasise the need to combat illegal immigrants.

Table 1: Measures taken to control immigrant workers in Malaysia

Year	**The regulations/attempts made/measures**	**Purpose**	**Effects/Remarks**
1968	The Employment Restriction Act 1968	To evict several thousands Indian workers from plantations	No remarks stated on the slackness of the action. A general measures.
1970s	Immigration Law (1957)	To control foreign workers in Malaysia	Received rejections from employers due to critical workers supply in Malaysia.
1984	The Medan Agreement - MoU by Malaysian and Indonesian government (basically the very 1st attempt made)	To establish new recruitment procedures. Subsequently similar agreement signed with other countries (eg. Bangladesh, Philippines, & Thai)	Laxity of enforcement failed to stop the inflow of workers. The measure is more on controlling the numbers of immigrants in Malaysia.
1989	Proses Pemutihan Pendatang Tanpa Izin (Program for the Regularisation of Illegal Immigrants)	To regularize the status of already employed Indonesians in agriculture	Failed due to the time and expense involved for the execution of measures.
1990	A ban to all Indonesian workers	To control the inflow	Failed due to pressures from employers as it affects the workers supply especially in construction industry.
1991	New measures to grant legal workers with equal wages and benefits while protecting the rights of citizens to employment	To control the inflow	No remarks on the slackness of action
1992	Levy to foreign workers	To register all illegal migrants	Seen as the 1st time a serious and concerted drive to register all illegal immigrants particularly in plantation, construction, and domestic sector. This the only measures seen to control on economic aspects but only at the point of entry and appointment of new jobs among the immigrants. Deported over 10000.
1993, April	A ban to unskilled immigrant workers	Attempt to raise the skill level of incoming workers	Revoked during the tedious management and lack of enforcement.
1994, Jan	Another ban imposed to all sectors excluding manufacturing		No remarks or further elaboration on the efficiency of the ban nor the slackness of the action
1997	Total ban on all recruitment	To control the inflow due to financial crisis	No remarks on the causes of the removal
2002, August	A stop on employing Indonesian in Construction sector due to series of riots caused by them followed by massive repatriation	To control the riots	The result of the repatriation, 400,000 illegal workers was sent home. Created major disturbance to the construction sector which forces the Government to rescind order. The ban was shortly taken back.
No specific time stated	Amended Immigration Act particularly on larger fines, a jail term, and mandatory whipping for both the illegal and employer		Carried out sometime after rescind order by the government. Shown a dramatic improve at lower scale

The limitation of approved sectors to work within does not apply to the construction industry as all immigrants from all the approved countries could be employed (Malaysian Immigration Department, 2007). Moreover, when there is a limitation stated in other sectors such as the approved sub sectors, none exist for construction industry.

From the analysis, it clearly shows that all the current measures were taken towards controlling the number of entrants and security to Malaysia. There seems to be no restrictions made to control the percentage of remittances made by them. This needs to be addressed to harmonize the attempts taken to overcome the labour market in Malaysia as well as the economic cycle especially when the Malaysian government has invested a large amount in the construction industry with the aim to stimulate its economy.

5. ECONOMICS OVERVIEW

Many definitions have been given for economics. Must focus on either the problems the economist deals with or the methods that economists use in dealing with these problems (Bronfenbrenner et al., 1987). According to Case and Fair (2004), economics is “the study of how individuals and societies choose to use the scarce resources that nature and previous generations have provided. Economics is a behavioural, or social, science. In large measure it is the study of how people make choices. The choices that people make, when added up, translate into societal choices”. This suggests that economics study is about studying the human behaviour upon making choices with limited resources.

There are two major divisions of economics namely the microeconomics and macroeconomics. The former deals with the behaviour of decision makers in the economy whereas the latter concentrates on the aggregate of economic activity. Both need to be understood and dealt with careful consideration as each component compliments the other. Microeconomic models represent the decision of the individuals including firms, on what, how and when to produce. Macroeconomics on the other hand deals with the level of inflation and the rate of unemployment (Bronfenbrenner et al., 1987) and concentrates more on aggregate demand and production.

5.1 The Function of Economic Modelling

Economic modelling was constructed by economists to study the behaviour of economic units by looking at how an economy produces, exchanges and consumes goods. There are different types of economic modelling subject to the economic unit concentration all uniquely designed to achieve its objectives by looking at its variables (Kogiku, 1968). An economic model can aid government in planning, monitoring and making changes in its economy in accordance to its economic goals (Case and Fair, 2004; Harvey, 1988) especially when the function of the government is to excel in economic prosperity (Glazer et al., 2001) in order to win support from voters to win in the next elections.

5.2 Government and its Function in Economy

Keynesian theory, through expansionary fiscal policies, supports the idea that government can stimulate the national economy and weather an economic slump via government consumption and gross investment in infrastructure and public buildings. Significant capital is required to build buildings and infrastructure (Case and Fair, 2004; Hillebrandt, 2000). By so doing, it generates further investment from other sectors namely the manufacturing, mining and many more.

5.3 Multiplier and Accelerator Effect

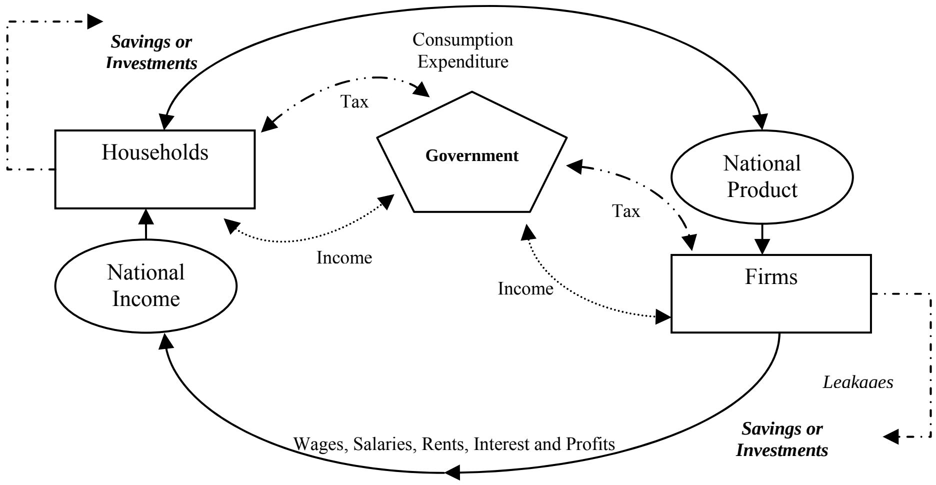
The multiplier effect is very much related to macroeconomic modelling used by a government to control the percentage of unemployment. A high rate of unemployment reflects a poor government administration. The multiplier model reflects an expenditure made by a government by injecting a certain amount to build capital in the form of infrastructures and public buildings. By offering tenders to construction firms, it creates construction projects that later require human capital and thus creates job opportunities (Case and Fair, 2004; Friedman, 1975).

By creating employment, it triggers the microeconomics section by providing job opportunities among the workers and construction projects among the construction firms. They then spend their income and capital to fulfil their everyday needs and business. This will multiply other economic sectors to fulfil their demands for commodities and building materials (Hillebrandt, 2000).

In other words, a small change in one sector of an economy could result in a great change in the national income and product (Bronfenbrenner et al., 1987). In addition, an accelerator effect occurs in consequence of a multiplier in which any increase in the output or consumption of goods due to an increase in demand for commodities, is likely to result in a demand increment for investment goods (Case and Fair, 2004, Hillebrandt, 2000 and Harvey, 1988) such as the production of machinery.

5.4 The Function of Microeconomic Modelling

Income hypotheses by Keynesian, Friedman, Modigliani, Brumberg, Ando and El-Mokadem concur that there is a correlation between income and consumer's expenditure known as the consumption function ((El-Mokadem, 1973; Case and Fair, 2004). Hence, the combination of the wages received and the spending pattern will help to identify the percentage of remittance made and later provide some idea for controlling and reducing the remittances.



Sources: Compiled from Case et. al, (2004); Bronfenbrenner et. al, (1987) and Harvey,(1988).

Figure 2: The circular flow within the financial markets, governments and foreign markets and the leakages in an economy

6. RESEARCH STRATEGY

Although regulations and mechanisms have been developed and implemented to control the immigrant workers in Malaysia there's still room left for malpractices either committed by the immigrants themselves, the employers or the recruiting agencies. From all the regulations and mechanisms applied currently, there is no single regulation designed purposely to control economic leakage. Although the foreign worker needs to apply for a work permit, pay for a visa and levy, it is still considered a small amount compared to the amount of money being sent to the worker-exporting countries. An improvement in managing the leakages can be achieved by integrating macro- and microeconomic modelling (Thieme and Wyss, 2005) especially on the hybrid of the consumption function of the immigrants and the existing measures particularly the rules and regulations used by the Malaysian government. Macroeconomic and microeconomic modelling is central to this management as it facilitates a form of control in the leakages by the immigrants through the wages received by imposing certain policies such as tax and interest rates (Case and Fair, 2004).

In attempts to control the leakages, government influence and interference can be used to manipulate firms and consumer spending habits (Friedman, 1975). One of the measures is increasing the bank's interest rate to encourage households to save money as well as firms. Thus, by putting more money in the bank, it enables the bank to loan the money to firms who seek to expand their business. This in conjunction with imposing certain percentages of taxation and setting up minimum wage levels enables the government to manipulate the spending pattern of the consumers (Case and Fair, 2004 and El-Mokadem, 1973). This can be address by incorporating economic theory at macro and micro level and managing of immigrant workers as explained earlier. It is hope that the level of leakages made via remittances can be reduced and the relationship between the worker-sending and worker-receiving countries strengthen as both countries benefit.

7. CONCLUSION

This paper has presented a brief overview of the importance of economic theory especially the government influence on the economy through its capital spending. The multiplier-accelerator effect was also explained along with the importance of integrating economic theory at macro and micro level with the management of immigrant workers to form a framework to control the level of leakage. Literature suggested it was now impossible to stop the in-flow and out-flow of immigrant as the world border had become 'invisible'. There are countries, especially the less developed countries, who rely on the exchange rate from the remittances made by their citizens working abroad and likewise there are also workers from developed countries who work in developing or less developing countries. As the weaknesses of the existing measures in the form of laws and regulations are revealed through further research a new approach involving both worker-importing and worker-exporting countries will be developed. Although the research is in its early phase, it is clear that by adapting the existing economic theory particularly the integration of macro and microeconomic modelling and problems involving the management of immigrant workers is in a proactive approach rather than trying to solve the problem in a reactive manner. This action will not only reduce the percentage of remittance but it will also improve and enhance the function of the construction industry as a multiplier-accelerator industry. The development of the problem will be addressed through on-going research.

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FACILITIES MANAGEMENT KNOWLEDGE IN PFIs PROJECTS

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Abstract: The paper draws on an exploratory study of facilities management (FM) service providers of major Private Finance Initiative (PFI) projects. The aim of the study is to investigate current issues and challenges and the areas of knowledge applied during the operation and maintenance stage of PFI's project cycle. This will lead to an identification of the gaps in knowledge and practice. Initial results reveal FM's knowledge facilitates the effectiveness of managing services with regards to better understanding and integrating approaches from both operational and management level. However, there are considerable challenges in disseminating FM knowledge to the operational level teams. Thus, the need for a review of the FM's approach on operational strategies is necessary. A discussion is included on the future research direction for the development of a FM's knowledge framework to meet the needs of PFI projects.

Keywords: FM practice, knowledge dissemination, operational strategies, PFI.

1. INTRODUCTION

In emergence of the Public Finance Initiative (PFI) procurement system, the private sector has a primary role in delivering services. Under this contractual arrangement, the private sector company obtains the finance, builds the project, owns and operate it for a defined period usually 20-30 years. Typically it involves complex contracts which are capital intensive in the early stages and involve payment on commencement of service and performance at the later stage.

PFI involves the integration of construction processes over the project life-cycle (Dixon, 2005). The post-construction stage is mainly concerned with operating and maintaining the services. Moreover the operational and maintenance phase is more important in most of PFI project because this is where service and payment is created (Akbiyikli, 2006). Thus, the inclusion of facilities management practice becomes significantly importance in executing PFI projects. In general, facilities management (FM) in the construction business can be seen as a key function in managing the buildings and infrastructure, support services and working environment to support the core business of the organisation in both the long and short term (Chotipanich, 2000).

Facilities management in PFI contracts involve the integration of planning, design, construction and management of facilities that results in focusing on effective delivery of services in the operations phase. The integrated construction processes in PFI contracts involve information and knowledge flows. Processes and practices developed within PFI-FM project organisations could generate knowledge and require FM organisations to manage it.

This research is shaped by the recognition that knowledge relating to the managerial and operational practices in FM organisation brings an impact in the implementation of construction project performance. The operation and maintenance period of PFI projects is more uncertain in terms of risk and impact to the project. Thus, this research aims to improve FM process in PFI projects through identifying areas of FM knowledge applied during the operation and maintenance stage. Accordingly, this paper provides an opportunity to address the initial findings from an exploratory study on practical problems and challenges in FM's current practice during the operation of PFI facilities. It provides an insight into the industry and practitioners with a view to providing a clear focus for continuing research.

2. OPERATION AND MAINTENANCE IN PFIs PROJECT

The operation and maintenance period can be generally classified as a period of uncertainty in the construction project. PFI procurement is concerned with the whole life cycle project, typically 25 to 30-years. In contrast, for other types of procurement, the whole life cycle of the project including operation and maintenance period takes up only 2 to 5-years. PFI shifts the normal practice of existing facilities management approach towards new PFI-FM approach. These new approaches are geared to produce a high level of services performance as stipulated in the contract. Figure 1 illustrates the relationship of FM in construction project life cycle.

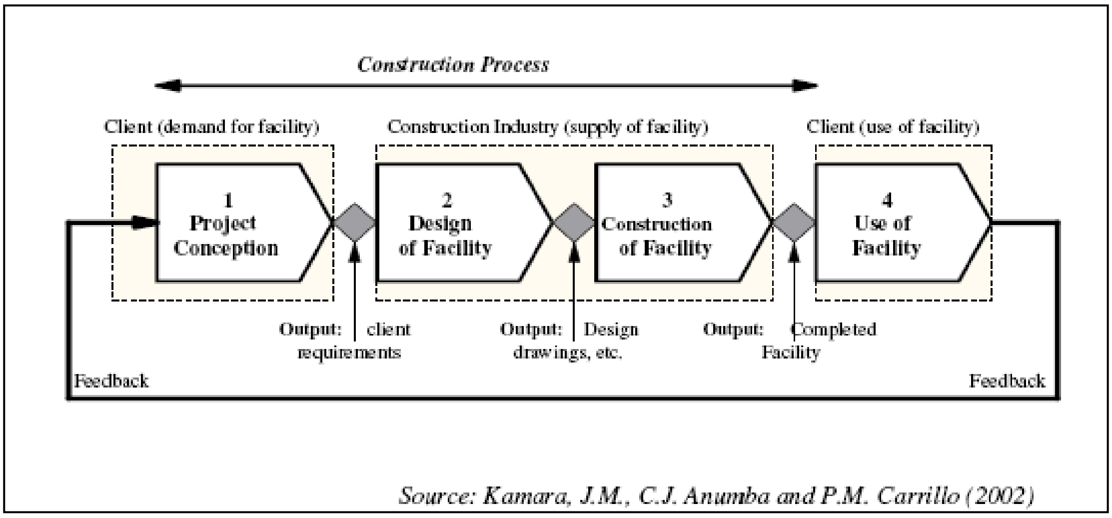

Figure 1: Relations of FM in construction life cycle

The effect of life cycle stages on organisational effectiveness has long been recognised (Cameron et. al., 1983). Each project cycle implies a different amount of effort as well as different tasks and actors. Nutt (2000) noticed that FM served the organisation differently at different stages in its life-cycle. He added that the involvement of facilities management not only takes place in the operational stage, but apparently are considered at all stages, even as early as at the bidding stage. However, the operational and strategic FM functions needs to be carried out throughout the project phases. This requires substantial amount of knowledge and skills.

In positioning the FM function at the earlier stages of the PFI contract arrangement, can lead to better information and knowledge flows of the built facilities. It can be done through the influence of facilities design towards its operation and maintenance (El-Haram, 2002). Further, a study by Moore and Finch (2004) on facilities management in South East Asia provided an interesting insight into the importance of management ability and knowledge of managing facilities. In their study they found the need to have a good understanding of FM is essential in order to cope with challenges and issues of complex projects.

Throughout the PFI construction project life cycle, there are two significant domains involved. These are construction project management and facilities management. Construction project management involves the organisation of the project structure and its implementation towards the completion of project. Subsequently later involves the facilities management function. Once the facility is completed, it involves operating, maintaining and monitoring of the services for the next 30-years. Figure 2 illustrates the inclusion of facilities management function across project life-cycle.

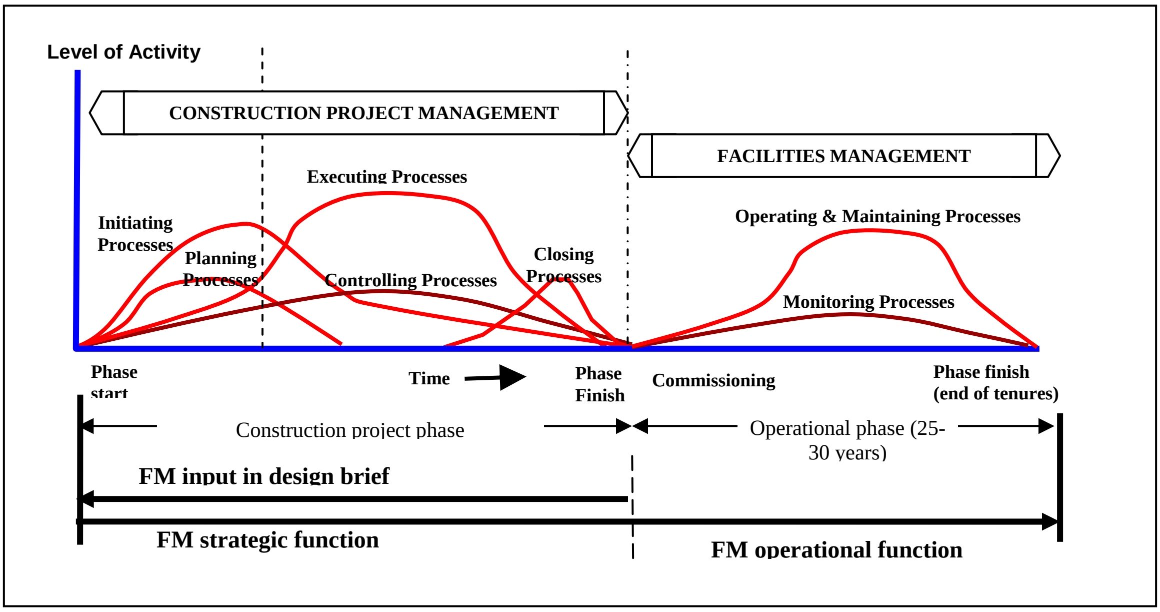

Figure 2: Inclusion of Facilities Management function in PFI project life-cycle

The facilities management team has to shift and adapt a different management approach away from traditional contracting to a wider view (Payne, 1997), more proactive, liberal and dynamic view (Zhang, et. al., 2001). The adoption of applicable knowledge management processes can assist facilities managers and their organisation to incorporate and exploit knowledge into PFI-FM practices. Several researchers (Wong and Aspinwall, 2006; Gray, 2001; and Liao, 2002) has described an importance of having knowledge management in practice. They considered knowledge management as a strategy for improving organisational competitiveness and performance. These are aligned with the nature of PFI contract which is geared by services performance. In the PFI-FM context, knowledge of managing facilities, processes and approach for dealing with problems, and management of day-to-day operation help the facilities manager to be effective, both in operational and managerial level.

3. RESEARCH OBJECTIVE AND METHODOLOGY

The research undertaken for this study is part of an on-going doctoral study that aims to identify areas of knowledge applied during the operation stage of PFI project. The justification for undertaking this research was based on the need to improve facilities management knowledge processes in PFI projects. This was expected to lead to improvement and address gaps and opportunity on PFI-FM's knowledge practice.

The objectives of the research are outlined below:

1. To understand and examine industrial practice in PFI-FM with a view to ascertain the underlying problems, challenges and potential areas necessary for improvement.
2. To review the implementation of facilities manager's knowledge at operational level and strategic managerial level in pursue of efficient services delivery.
3. To investigate the integration of knowledge management approach with facilities management at operational and strategic level.
4. To develop and evaluate a framework to enable organisations to manage services delivery and performance efficiently.

This paper addresses the first objective only. By improving the facilities management knowledge during the operational stage in PFI projects, the resultant effect on the project performance through efficient services delivery will be notable.

3.1 The Semi Structured Interview

This research was based on semi-structured interviews with facilities manager those involved in PFI projects. Semi-structured interviews were conducted using a set of questions designed to gather as much information regarding current practices and challenges of FM in PFI and information used in operating the services. From this finding, it is essential to make a judgement of the challenges and aspect of facilities management practice that can be improved.

Semi-structured interviews were chosen as they provide a thorough, focused and trustworthy means of information gathering, face to face with the interviewee (Mitchell, 1998). It is noted by Guba and Lincoln (1981) that the semi-structured interview offered a means to extend and amplify meanings that might be lost through other techniques of data collection. Moreover, according to Nachmias and Nachmias (1996), an interview method is a suitable means of data collection where questions are designed to elicit answers pertinent to the research. Further, the semi-structured interview is an ideal method to continually check the credibility of the information collected by constantly questioning the interpretation (Kvale, 1989).

The selection of the interviewees was primarily obtained from the British Institute of Facilities Management (BIFM) database. BIFM is the UK's leading professional body in facilities management. Fifteen respondents were identified to take part in this initial study. All of them were contacted through post to request their assistance in this study. As a follow up, reminders by telephone and e-mail were made. However, amongst the group of fifteen, only four were willing to be interviewed.

Table 1 displays the profiles of the respondents. A series of semi-structured interviews was conducted with stakeholders in key PFI projects. Four interviews were conducted with senior ranking professionals, suggesting that all of them had considerable practical experience in PFI project, both at technical and managerial levels. Their experience in the industry ranges from ten years to over twenty-five years.

Table 1: Respondents' detail

Respondent	Project Scope	Organisational Role	Individual Position
S1	PFI School (S)	FM Service Provider	Project Director
H1	PFI Healthcare (H)	FM Service Provider	Estates Facilities General Manager
H2	PFI Healthcare (H)	FM Service Provider	Resident General Manager
H3	PFI Healthcare (H)	Project Company (SPV)	Monitoring Officer / Asst. General Manager

No other personal details were collected because within the objectives of the study there was no intention to relate the data to individuals, but to take their output as a whole. All interviews were recorded to allow for the verification and transcription for subsequent analysis. All interviews were conducted face to face on the interviewee's own premises. The length of the interviews was approximately one hour.

4. RESEARCH FINDINGS: IMPLICATIONS FOR FM SERVICE PROVIDERS

An analysis of the interviews produced several findings and some gaps and areas for further research, which will be discussed in this section. For the purposes of this paper, it focuses specifically on operational and service delivery issues. In line with the report by Partnerships UK (2006), it is reported that less attention is paid to the operational phase of PFIs project compared to the procurement phase. More attention needs during operational phase due to ensure smooth tasks on services and to meet the service performance as outlined in the contract. Further, it leads FM service providers delivering the services at their highest level. All respondents have identified a number of themes that considered as issues and challenges to them. Many of which are interrelated. The challenges identified within facilities management practice in PFI projects can be grouped under five main themes: services performances; communication; FM input and knowledge retention. Later, it provides a future framework to describe a major part of these research findings.

4.1 Meeting Services Performance

In PFI projects, meeting demanding performance requirements and managing stakeholder expectations are two key challenges in managing and operating facilities. During the interviews, all service providers' representatives confirmed that view. Two respondents (H1 and H2) stated that it is difficult to meet the standards requirement and expectation from the stakeholder if they need to manage and operate the services where no proper facilities available. H1 drew an example from his previous experience in managing a PFI refurbished hospital. In that particular project, new facilities and demolition works were carried out on the same site. Whilst demolishing work was carried out on an accommodation block, all patients were required to move to a temporary building. Therefore, as the service provider in charge in cleaning and maintaining services, keeping services at a high standard for the building that was not fit for purpose, posed severe challenges and require significant attention.

There was concerned amongst those interviewed that the rigorous performance review done by the project company considered delivering services according to specification without compromising the standards. Thus, performances penalties then become operational issues to the delivery of services by the service providers. Accordingly, performance reviews systems also do not provide incentives. Penalties are given if failure occurs, however no rewards are given for operating the facilities in a successful way. Hence, it is proposed by one of the respondents that more qualitative assessment of performance with the option of contract negotiation in the operational phase is needed to address this challenge.

4.2 Communication as a means of quality improvement

A limitation of the current practices in implementation of communication and level of knowledge required by operational and managerial level are highlighted by all respondents. In practice, there are many challenges and issues involved. One of the examples given by H2 stated that there was a constant change in legislation and requirements imposed by the legislative authority especially in PFI health projects. Due to the absence of direct contractual relationships between FM service providers and the authority, it may affect the FM service providers in delivering the services related to the proposed changes. All FM service providers' representatives believe that it is a challenge and a gap exists for them. The services provider's managers acknowledge that an improvement in communications and relationships is needed.

Further, it also recognised that through long term services arrangements, good relationships with the project stakeholder, design and build team and project company are necessary. These may not be best addressed through the contract. Instead, good knowledge transfer, understanding the impact of performance and trust between the parties need attention. To achieve this, good communications systems and relation with FM supply chain are needed. Since there is difficulty in obtaining any information from the Special Purpose Vehicle (SPV) company, they agree that the FM service providers should be involved at SPV level in relation with service performance improvement. Thus, any potential challenges and threat can be managed through the consideration of strategic decision making by the management team.

In terms of commencing and delivering new services, there was a general view by all respondents that specific knowledge and information was required. Moreover, each project phase involves different tasks, different knowledge and skills required by facilities managers. Contract documents, method statements and specifications are those primary sources mentioned by service providers to acquire knowledge of PFI schemes. H2 stated that in the PFI-FM context, it is all about 'know-how' knowledge.

H1 added that by referring the contract document, it helps both the operational team and management team to draw a clear understanding of the content and awareness of their business scope. The contract document also communicates the required services to deliver, mode of software intended for use, the number of operational staff required for each task, tasks to be done and level of services performance needed. In assessing the justification of this selection, one of the respondents (H1) responded that by referring to the documents gives them a clear understanding of what standards to achieve. Thus, by ignoring the contract leads to a lack of understanding of the operational scope. Consequently, the decision and content of information made should be disseminated to the operational level. However, there are difficulties in order to communicate to the operational team. H2 added that this situation largely happens at operational level where the team involved are not commercially aware of the business needs. The main reasons are because operational team are involved in day-to-day operation, isolated and based on-site. Thus, in such circumstances, they are not aware and lack of understanding the impact of their works towards the organisation business aim and strategies.

Clearly as stated by one respondent (H3), the successful delivery of services through a PFI scheme depends on a number of factors, including clarity at the contract stage. This shows that PFI directly affects the facilities management practice from the beginning of the contract. Inability to understand the contract will result in the failure in services performance. Consequently, the companies have to take the challenges in defining and providing the maintaining and operating services coupled with consideration of facilities management knowledge in order to cope with its facilities' performance.

4.3 Needs of FM input at design stage

In terms of service delivery, the quality of the finished building may affect the quality of the service's performance. Whilst FM involvement at the initial stage aims to contribute proper consideration of the operation of new facilities, there is still a gap to address where finance becomes a constraint. According to the general manager (H2) from a service provider involved in the design stage, there is little input taken into consideration during the design of the facilities. In addition, the facilities manager has to justify the significance of their input towards the cost savings in the future.

4.4 Knowledge used and retention

There is evidence that high levels of staff turnover relate to knowledge retention. Therefore, the questions on how organisations retain their knowledge workers were asked of all respondents. Succession planning and staff continuity are two elements highlighted by two managers interviewed. They strongly believe that valuable knowledge from their staff should not disappear from the project throughout the operational stage of the contract. Through proper succession planning, a level of individual knowledge content is not only retained but could be enhanced. However, since all PFI projects managed by respondents are in an early stage of operation, it cannot be confirmed that knowledge lost due to staff turnover is a significant challenge to them at the moment. It observed that the crucial knowledge for the operational and maintenance of project is varied and crucial throughout the life of facilities.

5. DISCUSSION AND FUTURE RESEARCH DIRECTION

From the literature and interviews undertaken, it was deduced that facilities management is about supporting the business of an organisation and using its essential requirements as a driver for facilities improvement. In managing the services over a long time period, there are inevitable challenges in facilities management practice. However, most of the projects managed by the respondents are still in the relatively early phases of their operations.

Apart from the challenges outlined, FM's knowledge facilitates the effectiveness of managing services with regards to the better understanding and integrated approach from both operational and managerial strategy. In addition, contractual matters, business and commercial operation and technical capabilities are those areas of knowledge that require attention by both managerial and operational level. Effective communication helps organisation to understand each other's requirements and working practices, which can lead to fewer misunderstanding. By applying that, it facilitates the effectiveness of managing services.

The need for a review of the FM's approach on operational strategies is necessary and will be addressed through the on-going research. This can be done through assessing and establishing effective communication requirements, knowledge management tools and as well as examining the structure of organisation. This research can be done through a form of qualitative research method based on detailed surveys and case studies involving PFI construction sectors. It requires the building of theory and description within the context of practice itself. These theories are then tested through carefully designed instruments (questionnaire) administered to relevant respondents. This method would involve surveying project groups and finding out their knowledge management practices, the nature of knowledge used or required, the tools and models used for sharing knowledge and the gaps existing in current practices with a view to introducing better alternatives. As such, the method is 'problem driven' in response to practitioners' perception of where knowledge flows exist and shares throughout the facilities management practice.

6. CONCLUSIONS

This research constitutes a preliminary attempt at gaining an understanding of the facilities management practice in PFI contracts. It also draws attention to the knowledge of facilities services' providers during the operational stages of PFI project. The data presented here have practical relevance as it is from current practices and approaches. To sum up, the results revealed that numerous challenges faced by the FM management level at operation and maintenance stage in PFI's project. The result also identifies areas require for further research. These deal with issues such as improvement to current PFI procurement contract arrangements, company's facilities management (FM) approach on operational strategies and facilities management's supply chain.

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A CONCEPTUAL FRAMEWORK FOR ASSESSING RISK IMPACTS ON CLIENTS' CASH FLOW

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Abstract: The need for a reliable prediction of client's cash flow cannot be overemphasized. Undoubtedly, a prior knowledge of project cash flow requirements helps the client to anticipate his likely future financial commitments and to pro-actively plan for them as well. Different researchers have made efforts to provide simpler and quicker techniques to assist both the client and contractors in forecasting their cash flow. However, risk in construction has been identified as one of the inhibiting factors in achieving the desired level of accuracy of contractor's and client's cash flow forecast. This paper presents part of an on-going research aimed at assessing the impacts of risk on construction clients' cash flow forecast. Based on a review of risk and cash flow management theoretical concepts as well as empirical evidences from previous studies, this paper attempts to develop a conceptual framework for assessing the impacts of risk on construction clients' cash flow forecast. It is the intention that the conceptual framework will assist in developing a model which considers risk factors in forecasting clients' cash flow. It is expected that the outcome of the research will provide a more reliable prediction of client's cash flow as likely changes to client's cash flow pattern due to risk occurrence are expected to be evident from the eventual model envisaged in the research.

Keywords: cash flow, client, conceptual framework, risk.

1. INTRODUCTION

Cash flow prediction for all stages of construction is of great importance so as to prevent unsavoury incidence of insolvency. Lowe and Lowe (1988) asserted that the construction client should have an idea of future financial commitments and the expected interest rate accrued from borrowed capital. According to them, this information will enlighten them to know where, when and how to source for fund for the project right at the inception stage.

Cash flow prediction at inception stage is necessary because it gives clients the opportunity to identify the interest on short term borrowing during the conception and construction phase of the project and enable the clients to plan and attempt to optimize his financial position by borrowing short-term finance at the most advantageous rates. Therefore an approximate forecast is needed at the conception phase (Lowe and Lowe, 1988). Also, clients will enjoy the importance of cash flow prediction during the construction phase as it ensures availability of working capital in a sufficiently liquid form to meet all contractual obligations and enables the clients to select a suitable program of project which avoids overspending or significantly underspending. Therefore preliminary estimate and more accurate forecast will be needed (Kaka and Price, 1993).

Odeyinka (2003) submitted that an accurate forecast of construction cash flow has been a difficult issue due to risks and uncertainties inherent in construction projects. In the case of complex projects, the problem of uncertainty and ambiguity assumed even greater proportion because of the difficulty in predicting the impact of expected changes on construction progress and consequently on cash flows (Boussabaine and Elhag, 1999).

Different methods have been adopted by different researchers in modelling construction cash flow forecast but their accuracies were questionable because of failure to consider risks and uncertainties inherent in the construction process. Most researches that dealt with risks and uncertainties however focused on risk impacts on contractors' cash flow forecast but this paper aims at developing a conceptual framework for assessing risk impacts on construction clients' cash flow.

2. PRINCIPLES OF CONSTRUCTION CASH FLOW FORECASTING

Construction is a business in which success for a client is measured by the ability to complete project on time and within budget. Cash flow forecasting is an indispensable tool for construction companies, and is essential for their survival at all stages of the project. A cash flow forecast is a detailed projection of the timing and amounts of cash inflows and outflows for a specified time period, generally covering one year broken down into weekly or monthly time periods (Tremel, 2006). It records receipt and disbursements when the money is received or paid.

The need for a reliable method of forecasting the cash flow of capital expenditure on building schemes is an obvious one. The need is even more apparent in time of capital scarcity and where several projects compete for resources (Hudson, 1978 and Peters, 1984). Cash flow forecasts may be used as a basis upon which to arrange project finance, they can assist in monitoring the progress of the work and serve as a cost control tool during the construction phase by providing a valuable early warning system to predict possible insolvency and enables preventive measures to be considered and decided on in good time (Ashworth and Hogg, 2002; Hwee and Tiong, 2002).

Cash flow forecasting can be viewed both from the client's perspective and the contractor's perspective. For contractors, it provides information regarding the amount of capital required, when it will be needed and the amount of interest that needs to be paid to support an overdraft and the evaluation of different tendering strategies (Kaka, 1996; Hwee and Tiong, 2002). On the other hand, cash flow forecast for the clients, carried out by his professional advisers provides information on when payments are due and an indication of how much is due, so that he may make the appropriate financial arrangements to meet the contractual obligations accordingly (Kaka, 1996; Hwee and Tiong, 2002). The contractor undertakes a relative small number of discrete but complex operations and is required to finance at anytime the difference between the cumulative contractual value of work done less retention monies and the cumulative cost of doing the work. Projection of cash requirements will ensure availability of adequate funds to pursue construction programme and an optimum utilization of its funds to minimize the amount of time that any funds must be tied up in unproductive uses (Hwee and Tiong, 2002).

2.1 Construction Clients' Cash Flow Concept

According to Cooke and Williams (2004) developers and other construction clients are responsible under most procurement methods to provide the capital investment required for construction projects to go ahead. This money according to them may be borrowed from banks, provided by shareholders’ investments or generated from profits, or a combination of all three. According to Cooke and Williams (2004), the developer or construction client has a different view of cash flow from the contractor because their cash position is always negative until sales income or revenue from the completed building is forthcoming. Fig. 1 shows the concept of construction client’s cash flow. The left side of the Figure shows the money in (or positive cash flow). This, according to Kenley (2003) and Cooke and Williams (2004), is derived from a number of sources including housing development deposits, sales from completed developments, rental income and production revenues. The right side shows the money out (or negative cash flow). This, according to Cooke and Williams (2004) includes land purchase, interest on borrowings, planning and legal fees, professional fees, infrastructure costs and building costs. Since the cash position of client is always negative for most part of the development, this study will focus on the negative cash flow.

Under the normal conditions of construction contracts, the client is obliged to pay the building cost to the contractor in monthly installments. The amount of each installment is based on the value of construction work actually produced in the previous month and forecasts are needed in advance of the likely value of these payments (Skitmore, 1992). The anticipated client’s cash flow forecast is usually prepared by the client’s cost adviser (quantity surveyor) in conjunction with the contractor since it will be greatly influenced by the intended programme of work. By using the work values contained in the bill of quantities, monthly incremental amounts including a proportion of the preliminaries are calculated and from these calculations a cumulative expenditure curve can be plotted against time (Kwakye, 1997; Ashworth, 2002 and Honoabu, 2005).

2.2 Risks Factors in Construction Clients’ Cash Flow Forecasting

Various authors describe risk in different ways. Risk is described as the chance of exposure to the adverse consequences of future events, the probability that an adverse event occurs during a stated period of time (Edwards and Bowen, 1998). Risk in construction, according to Perry and Hayes (1985) is an exposure to possible economic loss or gain arising from involvement in the construction process and it is a variable in the process of construction project whose variation results in uncertainty as

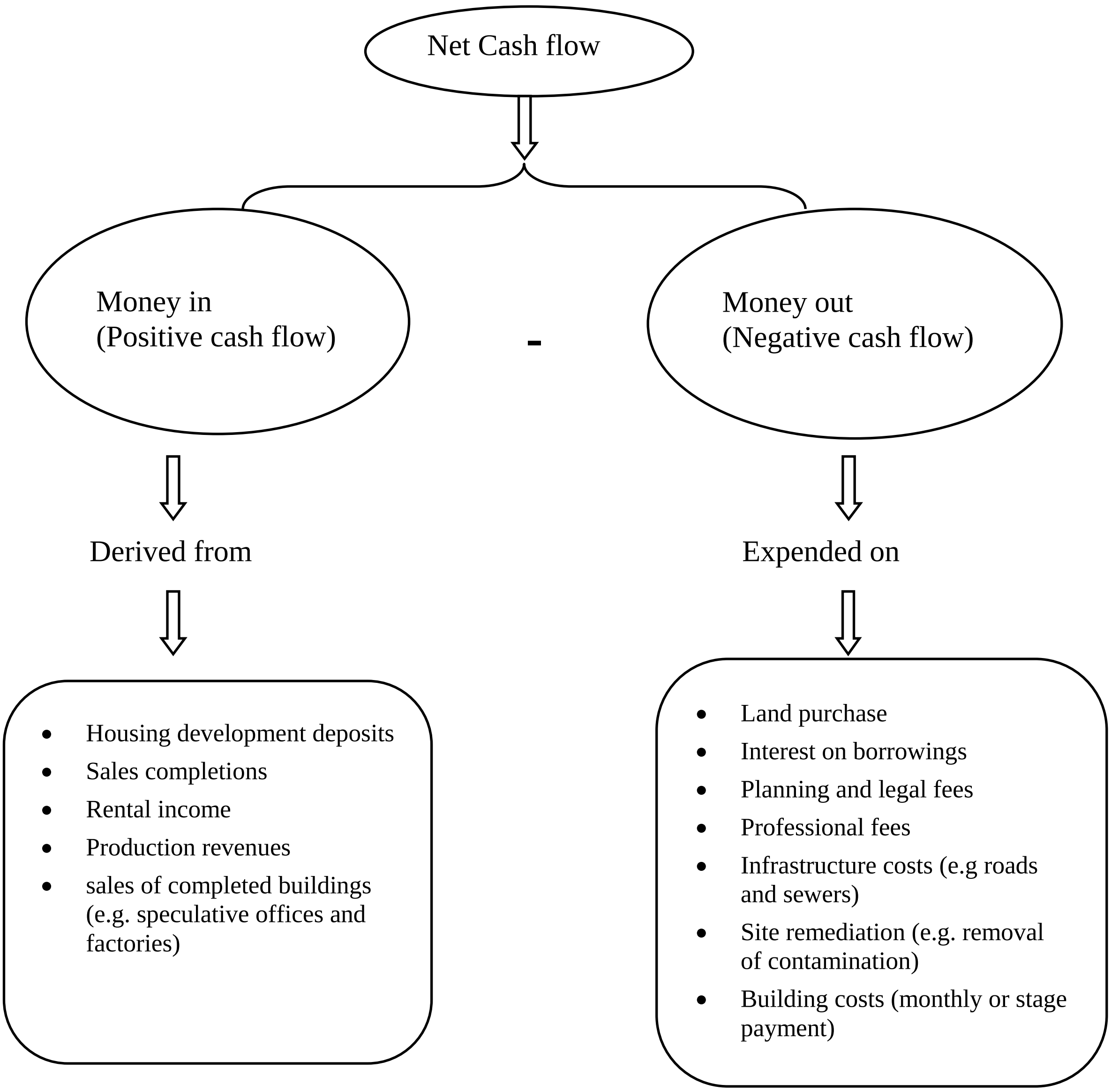

Fig. 1: Client's cash flow concept

to the final cost, duration and quality of the project. Risk and uncertainty are inherently present in construction projects and associated with specific events or activities, which can be individually identified (Perry and Hayes, 1985; Smith, 1999; Ashworth and Hogg, 2002). A risk event implies that there is a range of outcomes of the event and each outcome has a probability of occurrence which may require some degree of subjective judgment because there is usually insufficient objective data for assessing risk due to the nature of construction projects. Fong (1987) agreed that it is generally recognized that those within the construction industry are continually faced with a variety of situations involving many unknowns, unexpected, frequently undesirable and often unpredictable factors. These factors according to Lockyer and Gordon (1996) include timing schedule slippage of the project task, technological issues, people- oriented issues, finance, managerial and political issues. Fong (1987) acknowledged that one of the challenges to optimum construction is risk and uncertainty inherent in construction projects due to evolving information and newer conditions through the project life cycles, organization and environment. Risks occur at various project stages as one of the silent day-to-day realities and arise from the nature of the industry itself. Risks are caused by evolving and emerging conditions through project life cycles and project environmental circumstances, physical, economical, social and political circumstances with resources available and the threat of variability, instability, lack of knowledge of events and activities and lack of appropriate technology to handle the events and activities (Laufer and Coheca, 1990; Ashworth and Hogg, 2002).

Peters (1984) and Kenley and Wilson (1986) maintained that individual variation between projects' cash flow profile is caused by a multiplicity of factors. Low accuracy of predicted cash flow according to Sidwell and Rumball (1982) include lack of consideration of building type, design characteristics, external environmental influences, individual contractors pricing characteristics and weather conditions. Peters (1984) and Calvert (1986) however identified other factors to include mode of payment, quality and reality of project programme, method of assessing interim payment, level of required information, retention, currency of data, delay in honouring architect instruction and overestimating. Lowe (1987) grouped the factors responsible for variation in project cash flow under five main headings of contractual, programming, pricing, valuation, and economical factors. Under these generic factors are other factors such as delayed payment, time schedule slippage, inclement weather, variations, fluctuations in interest rate, fluctuation in foreign exchange, etc. Some of these factors were also identified by many authors (Kaka and Price, 1993; Kaka, 1996 and Khosrowshahi, 2000). The identified risk factors have been reported to affect cash flow profiles as well as significantly impacting on cash flow modelling (Odeyinka and Lowe, 2000; Odeyinka, 2003).

2.3 Construction Client's Cash Flow Forecasting Models

Many researchers have developed cash flow forecasting models for the use of both construction contractors and clients. Those developed for the use of construction clients include those of Hudson (1978), Sidwell and Rumball (1982), Peters (1984), Lowe (1987), Lowe and Lowe (1987), Lowe and Lowe (1988), Kenley and Wilson (1989), Khosrowshahi (1999) and Skitmore (1992).

Hudson (1978) developed a mathematical model commonly known as the DHSS formula for the expenditure profile using data from the hospital buildings. The model based on mathematical equation to forecast the value S-curves and construction duration. Sidwell and Rumball (1982) tested the predictive ability of Hudson's (1978) model to predict client's expenditure pattern and found out that the ability of the formula to forecast expenditure profiles could be influenced by a number of variables. Therefore, according to them, the use of standard formula is bound to present problems due to variables in construction projects. Berny and Howe (1983) attempted to improve on the Hudson's (1978) approach by establishing project expenditure budgets and forecasts for a broad spectrum of construction contracts by combining a cubic and exponential equation so as to take account of cost overruns.

Peters (1984) investigated into the causes of inaccurate cash flow forecast in clients' organization and identified the client-based problems and project-based problems as they affect both the projected and the actual cash expenditure. He therefore suggested a solution of ‘cost and schedule integration’ as the most obvious choice to establishing project cash forecasts. He however agreed that overall success of cost and schedule integration depends essentially on various factors including risks. Lowe and Lowe (1987) developed clients’ cash flow forecasting model for public sector department using computer based Monte Carlo simulation approach and concluded that the accuracy of an expenditure programme remain uncertain. Lowe and Lowe (1988) ascertained that the accuracy of the approaches based on simple computer models or mathematical formulae used for preliminary estimate is questionable. According to them, it is thus clear that any attempt to utilize a mathematical or computational model to produce an advanced estimate is liable to be inaccurate. They afterward developed an expert system based model which took care of both qualitative and quantitative information taking into consideration various factors responsible for variations in the modelled and actual cash flow profile. However, the predictive ability of the expert system is unknown.

Skitmore (1992) applied the DHSS formula to four types of completed construction projects to assess the effect of different building type groups. According to him, various approaches are considered in attempting to predict the best parameter values based on the known characteristics of the project. He found out that the best parameter values offer a ten fold improvement over the published values based on the project types. The result showed that the inclusion of the project type grouping significantly improves the predictive power of the models and is approximately 25 percent better than the DHSS formula with Hudson's parameter values. Honoabu (2005) developed a model each for building and civil engineering projects and found that lack of substantial curvature in the trend lines established for the projects suggests that a quick prediction of the cash flow can only be obtained by just spreading the contract sum uniformly over the contract sum. This is considered unrealistic considering the nature and the mode of construction of any project. Good cash flow prediction, according to him, is primarily founded on the preparation of good initial estimate.

Various researches reviewed on clients’ cash flow forecasting revealed the inaccuracy of the developed models. This is largely due to risk factors inherent in construction which ultimately impact cash flow forecast. Few works (Odeyinka and Lowe, 2001 and Odeyinka 2003) have been recorded on impact of risk in relation to cash flow forecasting. Odeyinka (2003) attempted to model the variation between predicted and actual cost flow due to inherent risks in construction by examining risk variables impacting contractors’ cost flow using multi linear regression and Artificial Neutral Networks (ANN). He found that the models developed from the archives data and employing the ANN back propagation algorithm performed better than others in related studies.

3. A CONCEPTUAL FRAMEWORK FOR ASSESSING RISK IMPACTS ON CLIENTS’ CASH FLOW FORECAST

Fig. 2 shows a conceptual framework for assessing risk impacts on client’s cash flow forecast. As shown in the Figure, the research concept adopted commenced with the identification of risk factors impacting client’s cash flow forecast. The risk factors will be identified from cash flow literature and from discussions with construction clients and their representatives. Following this, a method will be devised to determine significant risk factors from the identified risk factors. As shown in Fig. 2, the next stage will involve determining the extent of cash flow risk occurrence on the forecast cash flow. This will involve using the significant risk factors earlier determined. In addition, the exercise, which will utilize cash flow data from diverse projects, will be segregated into differing project groupings such as client type, project type, procurement type and project duration. Odeyinka and Lowe (2000, 2001) found that a more accurate modeling of cash flow forecast that takes risks and uncertainties into consideration would need to consider differing project groupings. Skitmore (1992) also found that segregating cash flow data into differing project groupings significantly improves the predictive power of developed models.

For each of the classified project groupings, the variation between forecast and actual cash flow will be determined. Kaka (1996) and Odeyinka (2003) found that high variability exists between the forecast and actual cash flow within 30% and 70% completion period. This insight will assist in determining the variation between forecast and actual cash flow at 30%, 50% and 70% completion periods as well as when the project is completed. In addition, the extent of risk occurrence responsible for the observed variation between the forecast and actual cash flow will be determined. These two pair of data sets will then be modeled to determine the impacts of risks on clients' cash flow.

The next step requires testing and validating the predictive ability of the model. This will require curve fitting of the developed model using the logit transformation technique which was found to be reliable and fast (Kenley and Wilson, 1986 and Kaka and Price, 1993). The technique of logit transformation was used by Kenly and Wilson (1986) to fit data using the principles of regression analysis. It is the simplest of the sigmoid transformations and allows the S-curve to be represented in linear form. The linear equation according to them is found by a logit transformation of both the independent and dependent variables.

4. CONCLUSION

This paper examines the concept of construction client's cash flow forecast with specific emphasis on risk impacts on clients' cash flow forecast. It concludes that the cash position of the construction client's cash flow is different from that of a contractor. This is because the cash position of the construction client is always negative for most part of the development period. This led to the development of a cash flow concept for the construction client. This concept informs the direction of the study that the study needs to concentrate on the negative cash flow side since the cash position of the construction client will be negative for most part of the development period.

The paper further concludes that previous studies indicated a disparity between the modelled and actual cash flow forecast. This is largely due to risk factors which are inherent in construction and which inevitably impact cash flow forecast. Some risk factors found from cash flow literature as impacting cash flow forecast were grouped under the headings of: contractual, programming, pricing, valuation, and economical factors. Under these generic factors are other factors such as delayed payment, time

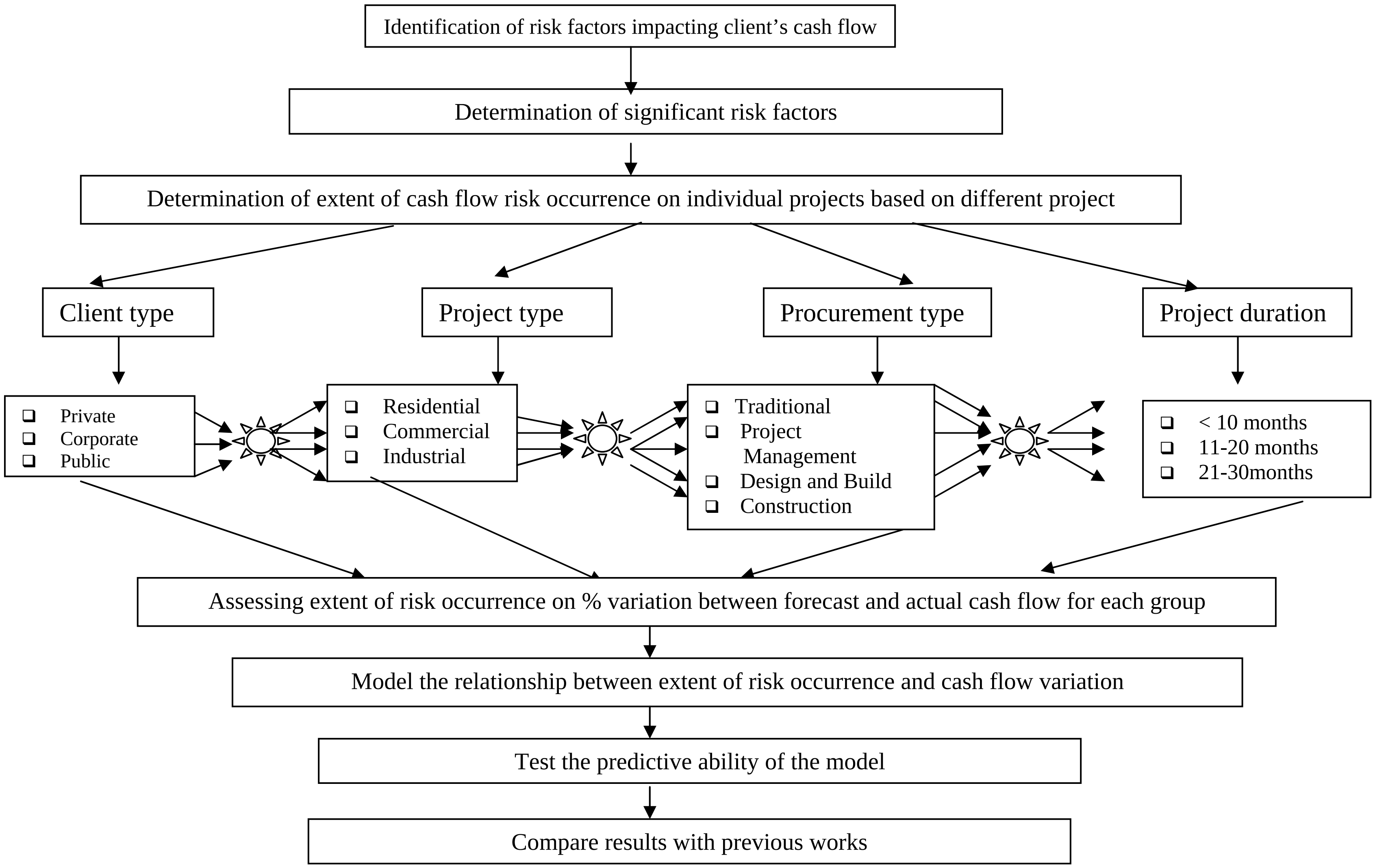

Fig 2: A Conceptual framework of risk impact on clients' cash flow forecast

schedule slippage, inclement weather, variations, fluctuation in interest rate, etc. It is the intention of this research to devise a method to determine significant risk factors from the host of risk factors obtained from cash flow literature.

The developed conceptual framework provides a step-by-step approach to realizing the research aim of assessing risk impacts on clients' cash flow forecast. Starting with identification of risk factors impacting clients' cash flow forecast, the conceptual frameworks proceeds to devise a method to determine significant risk factors. Following from this, the extent of client's cash flow risk occurrence on various projects will be assessed. The assessment will be based on various project groupings such as client type, project type, procurement method and project duration. In addition, the variation between the forecast and actual cash flow at 30%, 50%, 70% and 100% completion will be evaluated. At the end, the two pair of data sets will be modeled to determine risk impacts on clients' cash flow forecast.

It is anticipated that the model to be developed will assist the construction client in pro-actively managing their cash flow in the face of risk occurring. This is because when the identified risks are occurring on a construction project, the likely impacts on cash flow can be pre-determined and this has the potential of helping a construction client to know the likely impact of the risk occurrence and thereby anticipate an early response strategy rather than waiting till the end of the project when nothing can be done.

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AFFORDABLE HOUSING: OBSTACLES OF DELIVERY THROUGH OFF-SITE CONSTRUCTION

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Abstract: Reports of Housing crisis have been recorded world wide. This crisis presents itself in the form of shortage of housing supply; deteriorating state of existing housing stock; increase in tenancy rate and housing cost. Also the effects of cross-border immigration; ever increasing population; and obsolete strategy for housing delivery have further exacerbated the shortage of housing stock. All these result in cumulative effect of the need for Affordable housing, hence the build up of affordability need. Various strategies developed by experts to address this problem resulted in limited impact. One of such strategies is delivery of Affordable housing through off-site construction which is challenged by many obstacles.

This paper investigates the obstacles challenging the use of off-site construction. It also investigates the strategic framework within which off-site construction is being used to increase delivery of Affordable Housing. The use of benchmarking is considered as part of this strategic framework. The authors are utilising in-depth grounded theory and participatory observation techniques to develop benchmarking system to tackle this issue of needs.

Findings are analysed using the framework of benchmarking to justify the need for a coherent system of delivery using off-site construction to improve the delivery of Affordable housing. Using Department for Business Enterprise and Regulatory Reforms' (formerly DTI) template, a comprehensive system for benchmarking is being developed. This system aims at benchmarking Affordable housing with major focus on continuous improvement of delivery process and product.

Keywords: Affordable Housing, Affordability Pressure, Benchmarking, Housing crisis, Off-site Construction.

1. INTRODUCTION

Despite efforts to forestall inadequate supply of housing worldwide, the pressure for need has lately escalated, thereby attracting greater attention. The need for increased delivery of decent and standard affordable homes within sustainable and inclusive communities or environments is globally becoming inevitable. Department of Community and Local Government, (2006) defines a decent home as a home that: meets the current minimum standard for housing; and is in a reasonable state of repair; has reasonable modern facilities; and provides a reasonable degree of thermal comfort. Research has shown that increased quality Affordable Housing could be delivered by offsite construction without compromising any of the parameters.

Offsite Construction is a term used to describe construction found within the spectrum of applications where buildings, structures or building parts are manufactured and assembled remotely from the building site prior to installation in their final position Gibb and Pendlebury (2006). The evolution of this practice was traced to 18th century in the UK when Georgian architecture arose from disciplines of 'design for manufacture'. In the days of transportation, some prefabricated huts were shipped to Australia from the UK. Gropius and Wachsman emerged from the design schools of Continental Europe in their exploration of the pre-war 'BAUHAUS' (concept of manufactured building). Most of the impacts of their exploration were felt in the USA in the post world war II development era to address the dire need of housing caused by effect of the World War II Housing Forum, (2006). This concept however fizzled out shortly after taking off under similar circumstances as in previous attempts. While focusing on Affordable-housing sector and those governmental bodies with initiatives for quicker and more efficient means of house building Mayer, (2005) argued that whereas off-site construction offers many benefits, it must be managed carefully to maximise value and minimise risk.

Housing crisis has recently been widely reported across various nations. In England, there were recent predictions of housing crisis (Department of Community and Local Government, 2006; and Stewart, 2002). In Kate Baker's recent estimate of housing needs, an additional (17,000 per year)of social housing units above existing provision was recommended in England while considering several significant factors in appropriating this figure for current needs at (48,000 per year). Though, this figure is still considered insufficient in housing supply, Wilson and Anseau (2006). Meanwhile, in United States of America (U.S.A.) corresponding evidence has highlighted that, 'a chorus of voices appears to proclaim unanimously that America is in the midst of an affordable housing crisis' Glaeser and Gyourko, (2003). Globally, the issue of housing crisis is gradually becoming endemic and catastrophic.

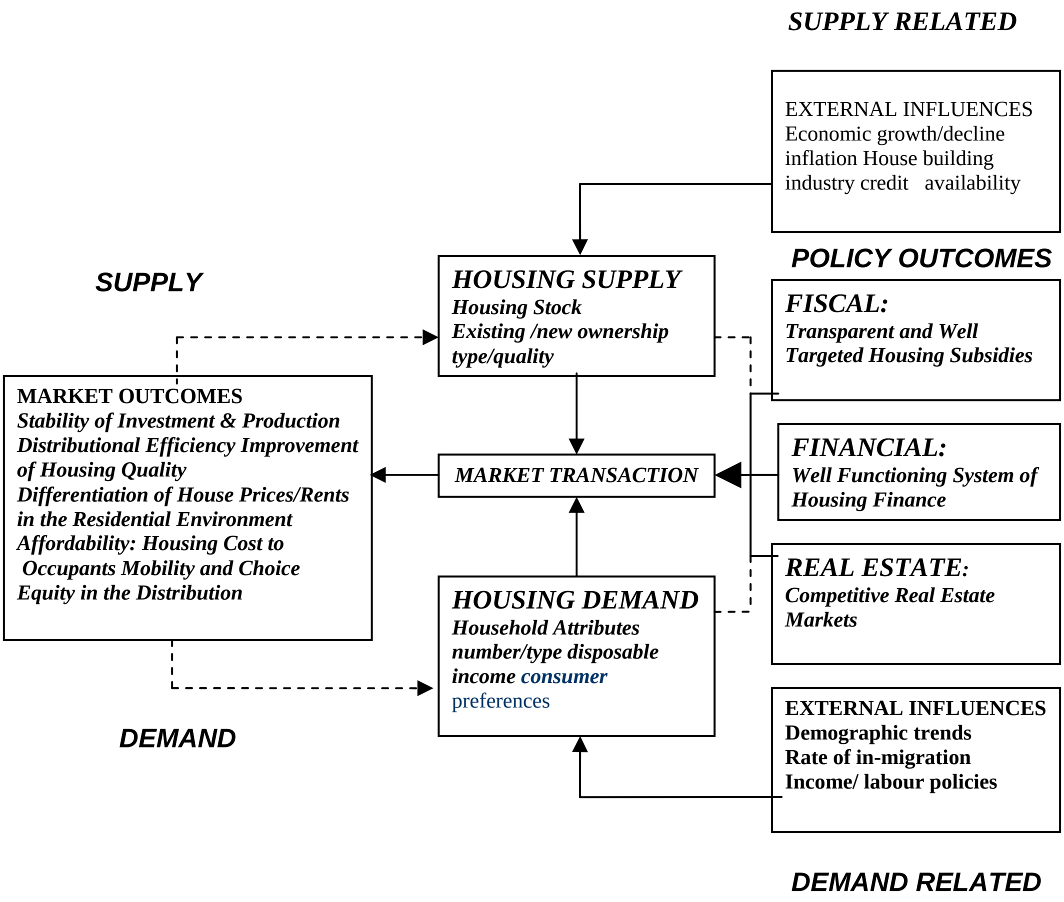
This paper focuses on addressing obstacles affecting delivery of quality Affordable Housing through offsite construction by: 1) Conducting archival analysis through survey of both academic and industrial literature in the study area. 2) Identification of the obstacles from industrial and academic literature. 3) Recommendation of strategy to facilitate increased delivery of quality Affordable Housing through off-site.

Study has shown that delivery of Affordable Housing by off-site construction is currently being inhibited by many obstacles. Among these are: 1) Small scale delivery of Affordable homes which are not economically viable, hence requiring substantial capital investment or subsidy from the government; 2) Many developers that are still emotionally attached to the old traditional system of Affordable housing delivery with great limitations thus presenting great challenges to off-site construction; 3) Many Architects argue that the system of off-site construction restricts creativity and compromises quality and uniqueness of residential buildings; hence they are reluctant in adopting the new methods Brown, (2006). Though obstacles for delivery of Affordable Housing through off-site construction are enormous, this research intends highlighting them. Using continuous impact monitoring system provided in benchmark framework, the paper also suggests useful recommendations aimed at eradicating them.

2. AFFORDABLE HOUSING (Dynamics of Demand and Supply)

In a free market economy, the price of housing is determined by 'demand and supply' and as such these variables are highly significant in delivering Affordable housing. High price for houses located at certain areas reflects greater pressure of demand in certain areas, while low price reflects increased supply in other areas. Conversely, land availability and accessibility is also ideally used in restricting supply. This was clearly underpinned by principle of Affordability paradox which states that, 'in equilibrium environments, both land and properties are priced based on market values.' Hence, it is not affordable to people below median income. The usual urban economic view of housing markets suggests that the restriction on housing supply is availability of land Glaeser and Gyourko (2003). Accessibility and availability of land has significant influence on demand and supply of housing and also on affordability of housing. Tsenkova (2004) has investigated other variables which are responsible for housing performance. In his findings, certain variables were classified under three broad spectra which are indicative of [fig2]: (Supply-related external; Demand – related external and Policy Outcome groups).

Fig 1: Determinants of Housing Performance *(Source: Tsenkova, 2004)*



Some variables have been identified under each spectrum and were classified under supply related external influences. These variables are:-economic growth; decline inflation; house-build Industry and Credit Availability. Demographic trend; rate of in-migration; income and labour policies were grouped under demand related external influences while fiscal; financial and real estate policies were grouped under policy outcome.

This research aims at offering collaborative benchmark system with a customized toolkit for incorporating all relevant components of delivery while also monitoring parameters for delivery of quality Affordable Housing. Katz et al, (2003) had examined three broad categories under which the parameters are classified in affordable housing. The categories were identified as rental assistance, homeownership assistance, and regulatory policies. The effectiveness of the parameters was assessed in their capacity to address six goals of Affordable Housing which are: 1) Preservation and expansion of supply of good-quality housing units; 2) Making existing housing more affordable and more readily available; 3) Helping household build wealth; 4) Strengthening families 5) Linking housing with essential supportive services; and 6) Promoting balanced metropolitan growth.
Research in the area of benchmark technique has recently been on the increase though with minimal application to Affordable Housing. Though investigation of off-site delivery using participatory observation method is limited in the field this method is being adopted here. The instrument of benchmark is also being used in this research to maximize the benefits derived from off-site through continuous monitoring of Affordable Housing quality. Using DBERR (formally DTI-Constructing Excellence) template which greatly adopts Questionnaire survey in designing Key Performance Indicators (KPIs), primary data will be derived. Subsequently, this data will be analysed and used in developing toolkit and benchmark model for Affordable Housing.

3. OFFSITE CONSTRUCTIONS

This research has identified increasing number of factories engaging in off-site production system. Some of these factories are located in Japan, USA, Canada, Australia and some parts of Europe. One of such factories is(Westbury Homes Space 4 system) and located in the West Midlands region of England. It had the initial capacity of manufacturing 6000 houses per annum at the rate of 6-8 weeks per building installation for panelling system and 3 weeks for volumetric system, Housing Forum (2006). Refer to Fig. 1a.and 1b which shows production lines for 3DM’s (now Environmental Recycle Technologies’) PIM Process Production Lines. Delta and Alpha Lines can be used respectively for small and large scale production of low-cost modular housing. By this process, highly reinforced building components are produced using cheap light-weight, re-cycled materials. Despite huge development recorded in this area, the facilities could hardly have meaningful impact in abating housing crisis or attaining optimal utility except if tied to a system-wide organisational approach driven by partnering, offsite construction and benchmarking process.

In the framework for delivery of Affordable Housing through off-site construction, this paper suggests ways to increase efficiency using partnering, and policy framework to increase production of decent Affordable homes. Off-site techniques have increasingly been used in the last few years as a means for improving quality and efficiency in the built environment. Site activities are by this means transferred to factory environment by manufacturing building components which are subsequently installed at site. The success of Affordable Housing delivery through offsite construction greatly depends on change from original traditional (non-collaborative system of procurement) to a new strategic and collaborative delivery system.

Fig2a. Delta Production Line for Off-site Building Components adopted from3DM PIM Process website (http://www.3dmworldwide.com/pim.html).

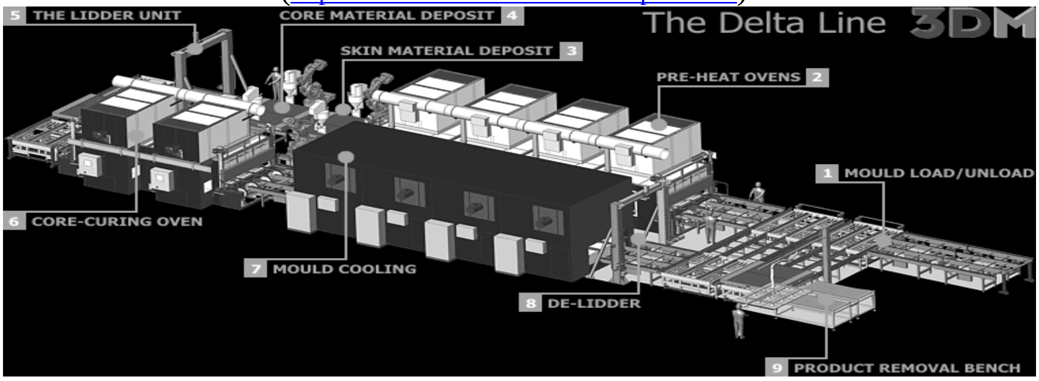
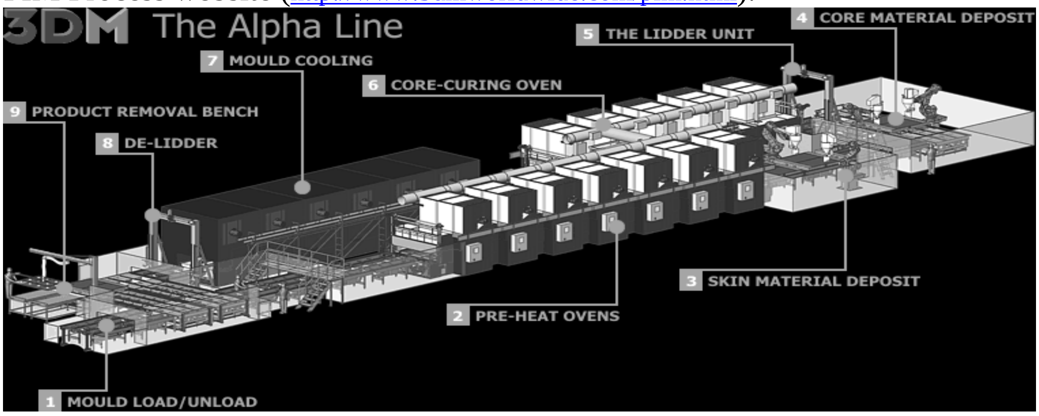


Fig2b. Alpha Production Line for Off-site Building Components adopted from3DM PIM Process website (http://www.3dmworldwide.com/pim.html).



This system will ensure that all stakeholders are made to be significant partners with Architects and Designers as drivers. Hence the need for a ‘step-change’ in procurement system will be addressed through restructuring of delivery system. When restructured, it will then retain sufficient potentials to sustained supply to increasing demand of quality Affordable Housing while simultaneously identifying decline in productivity in the sector.

Lack of system-wide organisational approach with benchmarking research and application has been identified by Yasin, (2002). This was largely consistent with the views of Jackson et al (1994). It was mainly because benchmarking has not been fully exploited along the supply-chain as a catalyst in the delivery process and where it has been adopted, greater attention has been paid on application of benchmark for individual components of delivery to the detriment of system-wide organisational approach. The success recorded by application of Total Quality Management (TQM) and ‘‘reinvention’’ at multiple levels of government in USA was considered as a major recent organisation–wide change mechanism in this regard, (Bowman, 1994; Rago, 1996). The problem of housing crisis could hardly be addressed without acknowledging the gap created by paradigm shift in technology and housing delivery through off-site construction. A strategy with collaborative approach that will significantly transform the sector by enhancing quality and productivity with consequent reduction in unit cost must be adopted CIRIA, (2005). This strategy involves partnering between developers, designers, contractors, manufacturers, suppliers, government, advisors and researchers and it is focused at meeting affordability needs through design–led solutions. In advocating for a paradigm shift for construction procurement in the built environment Constructing Excellence (2006) identified off-site construction as a significant component of the shift. Realization of a collaborative monitoring system for Affordable Housing delivery will eliminate barriers associated with delivery. The benefits to be achieved are performance improvement of quality; cost effectiveness through economy of scale; and increased delivery which are all responsive to needs.

Partnering has been identified as a strategy that increases delivery and promotes the quality of the end products. The challenge in improving governance in Public and Private Partnership is to support governments and the private sector to implement real change United Nations Economic Commission for Europe, (2005). However, the beauty of partnering in construction is that it allows the clients' requirements to be understood by the entire supply chain while integrating individual resources for greater advantage of both the client and the end-users. In this context, information flow along the supply chain is highly essential to foster required bond among members. This helps in consolidation of a long term relationship that attracts innovation and reduction in cost and time. In strategic partnering, continuous improvement is a driving force for implementing partnering, goal evaluation and problem resolution Cheng and Li, (2002).

In a wider spectrum partnering has been viewed as an effective tool for achieving cost reduction, work efficiency, opportunity for innovation, equitable risk allocation, and less confrontation in construction projects CII (1989); Black et al. (2000); CIRC (2001) and Bayliss (2002).The benefits of this include creating dedicated manufacturing supply chains, incorporating product suppliers, manufacturers and development bodies. It offers a real opportunity for designers to involve themselves, through partnerships, to influence design quality and flexibility at an early stage in the residential-development process Brown, (2006).The overall under-supply of Affordable Housing vis-à-vis the increasing needs is usually a pointer to an indication of a faulty delivery process. An efficient system is structured in such a way as to be proactive to anticipated crisis.

Evidence shows that Affordable Housing delivery like construction industry has inherent problems with its structure and fragmentation which has largely impeded its performance, Banwell (1964), Latham (1994), and Egan (1998). Delivery mainly depends on collaborative working among the stakeholders of the supply chain, Anumba *et al.* (2000). A good supply chain management is fundamental for the success of the product, because products and services provided by the supply chain account for 80% of the total costs of the project. Consequently, the ways in which these products and services are procured also have a profound effect on the final product. Therefore, this research focuses at introducing benchmarking as a strategic platform for objective and collaborative process among stakeholders in the supply chain. Some of the benefits to be derived through benchmarking are as outlined below: 1) Potentials to identify opportunities to improve; 2) Increased competitiveness; 3) Improved productivity; 4) Employ of best practice procedures; 4) Development of strategic action plans. 5) Addresses growth issues 6) Overcomes competitive threats; 7) Gains a complete picture of the business; 8) Open minds to new opportunities; and 9) Attracts funding/investment.

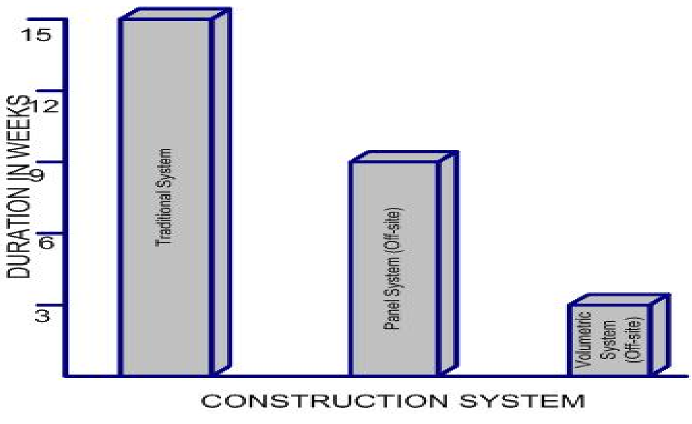
4. THE NEED OF OFFSITE CONSTRUCTION FOR AFFORDABLE HOUSING

Great benefits can be derived from application of offsite technique in Affordable Housing delivery, though the level of uptake by house builders has remained very marginal. In their study of performance of offsite construction Goodier and Gibb (2005), reported of low output in the current number of buildings that were built through offsite construction in England. Analysis from the study indicated that offsite construction accounted for 2.1% of total construction and 3.6% of all new build. Also, the house builders expressed satisfaction for their individual firm's performances, contrary to poor overall performance resulting from use of traditional method. However, most firms have adopted strategies to increase delivery and quality. Such strategies are mainly related to process, procurement learning, benchmarking and training. Application of offsite construction benefits to Affordable Housing will ensure increased stock output; quality of products and significant cost benefits.

Off-site construction induce job shift from the site to the factories, and exposes the builder as a strong retail interface, fabricator and supplier of product. This will greatly enhance specialisation of the profession in the field. It also provides opportunity for house builders to easily interact with the customers. A 'retail interface' will be created for house builders during off-site delivery. This enhances their capacity to create opportunities for facility management (post-occupancy) services; allow development of client-focused designs and provision of lifetime services.

Fig 3 shows comparative timescale for construction time for an average house of (3 bedrooms) built through traditional method which takes about 12-15 weeks but could take 2-3 weeks for volumetric and about 6-10 weeks for panellised system of off-site. This shows significant reduction in time frame for delivery, with cost saving and risk reduction in site operation due to minimized site exposure. However, the overall work force is also considerably reduced.

Fig3. Comparative Timescale for Construction of Standard 3-bedroom Apartment



The huge number of suppliers usually engaged in any single project is reduced while purchasing large sub-assemblies. Sourcing supply with manufacturing industry standards of performance could easily be managed by the prefabricators. Other benefits also include: 1) Reduction of unpredictability of construction; 2) Improved product quality and reliability; 3) Increased efficiency; 4) Reduction of cost; 5) Increased social benefits through waste reduction and enabling a bigger scope for recycling materials; and 6) The benefits to be derived from off-site construction are as enormous as the barriers to be encountered.

5. OBSTACLES

Despite huge advancements in off-site construction sector, it is still challenged by numerous obstacles. Reluctance of the key players in the industry to engage in off-site development is mainly due to unfavourable fragmentation of activities in supply chain. Ramsey (2006) identified ten top significant obstacles among others outlined as follows:

- Lack of confidence in the process of change.
- Cost perception.
- Inadequate track-record or information flow to date.
- Lack of agreement on product and process standard.
- Traditional process management or inadequate benchmarking for off-site.
- Design bias or inability to ratify early enough
- Supply-chain Immaturity.
- Lack of skills.
- Turning MMC from a requirement into a want.
- Non-liberal planning system
- Complex interface and non-collaborative links between systems/supply-chain
- Difficulties encountered in achieving economies of scale.
- Fears from likely repeat of previous failures in off-site construction that lead to collapse and defect of some structures. This was mainly responsible for discouraging private investors, insurers and the end-users. The general perception by the public is borne out of fear of the unknown which is potentially inimical to uptake in off-site. Lenders are also nervous about the long-term value of the home and whether it represents adequate security for the loan.
- The fragmentation of the construction industry’s supply chain is substantial inhibition to progress in the built environment. Beatham (2003). Affordable Housing could hardly attract huge sum of capital investment from the private sector except supported by high level of partnership required by off-site construction to record success and reasonable return.

Despite these obstacles, there is persistent need for a favourable atmosphere for integration of the supply chain as provided in benchmark technique.

6. CONCLUSION

Although serious gaps have been identified in Affordable Housing delivery through offsite construction, evidence on the experience of the past has a lot to offer today's policymakers and practitioners. Gaps were identified mainly in the area of inadequate organizational benchmark and performance measurement. Goodier and Gibb (2005), in their report suggested areas for future research exploring the concern and strategies of stakeholders in the industry other than house builders and project case studies. This research suggests the application of holistic organizational benchmark embracing all components of delivery. The strategies will greatly eliminate barriers and enhance production of more quality Affordable Housing using offsite construction to satisfy housing demand.

Meanwhile, it has become very significant to incorporate a collaborative framework that will coherently integrate the supply-chain variables in Affordable Housing stock delivery. These variables include the construction toolkits, policy framework, stakeholders, partnering, offsite construction and other relevant components of delivery. While identifying areas for further improvement, study so far conducted in this research has identified huge number of development in the area of fundamental project toolkits and expertise required for delivery. Though, there are few operational (sect oral) toolkit for Affordable Housing delivery, there inefficiency has been traced to failure of incorporating all components of delivery including offsite construction and partnering with necessary support from the private sector. The support from the private sector is absolutely essential for sustainable transformation of delivery to meet with increasing.

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EMPIRICAL ANALYSIS OF CONSTRUCTION MANAGERS' PROFICIENCY IN FINANCIAL DECISION-MAKING

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Abstract: The paper identified the basic financial variables that affect corporate financing decision-making and examined the level of manager's financial proficiency in context of applications and the significance in the overall corporate financing decision-making process. Criteria such as ability to interpret financial information and ability to analyse financial data were found to be the most important factors necessary. Data collection was by census survey using forty nine large construction firms of annual turnover between £50,000-500,000 pounds sterling. Descriptive statistics, chi square test and explanation building analytic technique were employed to analyse and present the data. The contribution of the paper is the presentation of operations directions about the ways construction managers can create action plans to improve their financial decisions through a deeper understanding and application of the financial variables.

Key words: construction corporations, decision-making, financial variables, proficiency.

1. INTRODUCTION

Managers of business corporations of all kinds with no exception to construction corporations are under constant pressure to perform better and boost their financial results (Alan, 2005). This is true even if the financial results are good already as managers of companies are reminded everyday of the need to improve company profits; to manage cash flow efficiently, to keep stock levels down, to optimize available financial resources (Robbie, et al. 1993). Similarly, there is apparent need for managers to make sound financial decisions, to attain superb financial records, to avoid creating financial problems and obtain appreciable returns (Robbie, et al. 1993; Rouse, 2002).

Moreover, in recent times, business and capital market environment is changing rapidly, financial markets are becoming global, competition is becoming more intense and the financial communication is becoming increasingly complex (Andreas, 2001).

As a result, there is a perceived need for construction managers to be alert, abreast with the requisite financial variables and make the right financial decisions. To be able to achieve this, construction corporations will need managers of substantial proficiency in managerial finance in order to make informed financial choices (Wilson & McHugh, 1990). According to Alan, (2005), business corporations, likewise, construction firms do not necessarily need more accountants and financial consultants in order to make prudent decisions; the problem is about managerial financial proficiency. The historical problem of managers financial proficiency is that they are not keen to know much about finance and its sophistications (i.e. profit and loss accounts, balance sheet, financial innovations, etc) (O'Regan, 2001; Alan, 2005). Instead, most construction corporations heavily rely on financial consultants and pay so much for the so-called "expert" financial advice while they can simply make sound decisions with little proficiency (Rouse, 2002).

Apparently, for a construction company to make significant growth, its managers should be in a better position to interpret and analyse historic financial information in order to be at competitive advantage (Adreas, 2001; O'Regan, 2002; Alan, 2005). Much is desired of construction managers; thus to be able to spearhead their corporations by maintaining standards, making informed financial choices, develop financing strategy and achieving corporate financial balance. Achieving this largely depends on the level of managements' financial proficiency (Robbie, et al. 1993), which are explored and presented in this paper. While there is a good indication of how firms make specific lease/buy decisions (Mukherjee, 1991), the factors that influence their overall financing decision-making are still not certain.

To fill this void, the paper offers an empirical analysis of the factors that influence firms' acquisition financial decisions. It then uses the results to examine the level of proficiency of construction managers and provides better perspectives for managers to be keen with these financial variables that directly drive acquisition decision-making. Primarily, among other objectives were; (i) to identify the financial variables that influence corporate financial decision-making process, (ii) determine the level of proficiency of management executives of construction corporations in those variables, (iii) to establish stylised facts on the significance of the variables in financial decision-making and (iv) examine the practical application of the variables by construction managers in order to provide the grounds for further research.

2. THEORETICAL UNDERPINNINGS OF ACQUISITION DECISION-MAKING

The decision to start a business or expand an already existing firm by increasing the productive assets, involved an implicit decision to raise money capital in order to finance the growth (Wilson, 1990). According to McLaney (2005), acquisition financing decisions involve the determination of the optimal mix of the various

sources of funds required for financing the assets of the firm. Given the different sources of funds, acquisition financing decisions imply two separate types of decisions. First, management must decide the optimal capital structure of the firm, that is, the optimal proportion of debt in its total capital (Modigliani and Miller, 1958). The capital structure is reflected in the firm's debt-equity ratio, (that is the proportion of debt to equity in the total assets of the firm) (Koutsoyiannis, 1982). Second, management must decide an optimal dividend payout ratio (the ratio of dividends to total earnings available to shareholders after payment of interest and corporate taxes).
That implies the determination of the retention ratio, the proportion of earnings to be retained for financing investment projects that will yield increased earnings in future periods (Koutsoyiannis, 1982). The acquisition decisions therefore involve the determination of a best possible debt equity ratio (capital structure decision) and optimal dividend-payout decision (retention-dividend policy) (Koutsoyiannis, 1982; Mwenda, 1993). Initially, there was an assumption that the project (i.e. acquiring capital equipment) had been appraised using some appraisal techniques and had passed those tests. That is, the acquisition was consistent with the firms' corporate objectives, economically sound and anticipated to yield an appreciable level of profit judged by profitability measures. There was also a derived assumption that management had passed the investment decision and that the investment decision did not impinge on the acquisition financing decision. According to Fawthrop, (1969), a decision to the method of financing one project will usually interrupt the decisions as to the financing of other projects, which the firm may wish to implement sometime in the future.

3. METHODOLOGY

This paper takes a different approach in considering the acquisition decision thus, to lease, to borrow or use equity capital. We first consider the factors that determine whether a firm uses equity or fixed financing to undertake acquisition investments. This approach is basically an extension of earlier works such as Bradley et al. (1984), Long and Malitz (1985) and Titman and Wessels (1988), which consider the empirical determinants of regular debt leverage. The focus is changed to consider the factors that determine financing alternatives. These factors are taken as those previously used in determining the firm's regular debt usage, (Adreas, 2001), Kanga and Long (2001) (Bradley et al., 1984) Lewellen et al. (1976), Smith and Wakeman (1985).

Specifically, they are those used by Bradley et al. (1984) and also the work of Long and Malitz (1985). Both of those studies scaled the variables by the firms estimated market value. The market value according Kanga and Long (2001) is estimated as equity's market value plus the firm's reported long-term debt, which includes capital leases and the value of operating leases. At this point the paper reviews the factors that should favour a specific form of acquisition.

The methodology adopted was divided into three distinct phases, thus, (i) design of survey and sample characteristics; (ii) distribution and collection of questionnaires; and (iii) preparation prior to the analysis.

Data collection was mainly survey conducted on forty nine large construction firms in Ghana. In designing the questionnaire, efforts were made to ask questions, considering the background of contractors so to generate understanding and interest. Where appropriate, therefore, questions of similar studies (Wahab, 1996) were adopted. In order to achieve strong theoretical underpinnings, a number of factors had to be considered. First, financial variables applicable in making corporate financing decisions were advanced through literature. The variables were further grouped into two main categories with each category identified into sub-themes. Second, questionnaires were formulated in line with the study objectives to solicit empirical data. A draft of the questionnaire was discussed with three researchers in Ghana. The updated questionnaires were pre-tested with three contractors who had previously been involved in research programmes. The final version of the questionnaires was packaged into a booklet format as recommended by Dillman (1978). The sample frame for the questionnaires was drawn from a census of 49 large construction companies registered with the Association of Building and Civil Contractors of Ghana (ABCCG). These contractors were selected because they were those that had well-defined management set-ups where acquisition decisions were made at the corporate level. Notwithstanding, there were exceptions, thus most CEOs in the firms that were examined had veto authority to make acquisition decisions.

The way in which the survey questions were presented and administered would invariably be affected in terms of quality of the responses. Therefore, it was imperative to ensure that the right questions were asked, well understood and asked in the right way and the right respondents handled it (Wahab, 1996). As earlier discussed, most CEOs in the respondent firms were very instrumental when it came to making corporate financing decision. On this account, the researcher accordingly disseminated the questionnaires to targeted respondents personally and was given some time to be collected. A follow-up visits to the respondents to remind them of the agenda concerning the completion of the questionnaires was made via telephone calls, emails and personal visits. There was a certain amount of groundwork that had to be accomplished before the analysis was performed on the data. Before the analyses took place, the data was placed into proper format. The data was gathered and processed into a suitable form for the analysis (thus, sorting, editing, coding, etc).

Descriptive statistics, chi square test and explanation building analytic techniques were employed to present and analyse the data. Frequencies distribution based on actual responses are presented. Weights were assigned to level of agreement attached to variables on a five-point scale. The mean rating of the variable was obtained using the sum total of point obtained and the number of responses for that particular variable.

4. DATA PRESENTATION AND ANALYSIS OF RESULTS

4.1 The dataset

The dataset was derived from a survey conducted on forty nine large construction firms operating in Ghana. The firms were selected based on their size. The firm size was measured in terms of annual total turnover of the firm (thus, a turnover between £50,000-500,000 pounds sterling) and real total assets of more than two million

(£1,000,000) pounds sterling. All firms with characteristics below this category were not included in the survey. More than 99 percent of the firms included in the dataset are not traded on the Ghana stock market. The dataset provides information on companies over a five-year period from 2001-2006. The firms in the dataset operate mainly in the construction sector and do not operate in other business sectors. Firms that did not have any financial systems in place were not considered in the survey. Similarly, firms that did not have complete records on assets, profitability, and demonstrates substantial familiarity in the application of financial variables, which we included in the survey, were also dropped during the data sorting and subsequent analysis.

4.2 Presentation of data

Certain indicators were established to measure the variables investigated, which included; level of proficiency, level of application in practice and level of practical significance. Out of forty nine questionnaires despatched to the targeted construction firms, thirty three were returned and the twenty nine that were fully completed were used in the analysis. In effect, the response rate that was used in performing the analysis was 71%. The apparent high response rate, comparable to that registered in the study by Eyiah and Cook (2003), which had a response rate of 61%, can be attributed to the technique employed in distributing the questionnaires. The analytical procedures employed were aimed at establishing the level of proficiency, application and practical significance of the financial variables under investigations. Frequencies distribution based on actual responses are presented. Weights were assigned to level of agreement attached to variables on a five-point scale. The mean rating of the variables were obtained using the sum total of point obtained and the number of responses for that particular variable (Everritt and Dunn, 1991: Lynn, et al. 2001).

4.3Representative Results

Table 1 presents means and standard deviations of the main variables that influence acquisition-finance decision-making process, for all firms in our sample. We can see that, without holding other factors constant, the mean values of financial statements variables are generally larger. Surprisingly, the mean values of other variables such as that of profitability, activity, liquidity and gearing seem to be almost the same and also larger than the mean values of trend and common size and investor ratios. Those variables with higher mean values are more likely to be significant than their counterparts. This preliminary descriptive analysis of our data shown in preceding discussions suggests that construction managers of large construction firms in Ghana have basic financial proficiency and that the financial variables are prevailing in acquisition decision-making. In the sections that follow, we will formally test whether this is the case using chi-square test and factor analysis.

Table 1: Descriptive statistics of the financial variables

	N	**Mean**	**Std. Deviation**
Financial Statements			
The Balance sheet Statement	29	4.1379	1.09297

The Income Statement	29	4.1724	1.07135
The Statement of Cash flow	29	4.2069	1.08164
The Statement of Retained Earnings	29	3.7586	1.32706
Profit/Loss Statement	29	4.1379	1.02554
Statement of Auditors Report	29	3.8621	1.27403
Trend & Common Size Analysis			
Financial Trend Analysis	29	2.9655	1.72135
Common Size Analysis	29	2.8621	1.66313
Profitability Ratios			
Return on Equity Profitability	29	3.4828	1.52645
Return on Asset Profitability	29	3.4828	1.45457
Gross Profit Profitability	29	3.7241	1.36006
Net Profit Profitability Ratios	29	3.8276	1.36458
Operating Profit Profitability	29	3.5862	1.47642
Activity Ratio			
Net Asset Activity Ratios	29	3.6897	1.46637
Stockholding Activity Ratios	29	3.2414	1.61809
Average Payment Activity	29	3.2759	1.62341
Liquidity Ratios			
Current Ratio Liquidity Ratios	29	3.6552	1.47057
Quick Asset Liquidity Ratios	29	3.5172	1.54967
No Credit Period Liquidity	29	2.9310	1.64601
Acid Test Liquidity Ratios	29	3.2069	1.71920
Financial Leverage/Capital Gearing Ratios			
Total Debt Gearing Ratio Analysis	29	3.2759	1.66683
Debt to Equity Gearing Ratio Analysis	29	3.3448	1.56470
Long Term Debt Gearing Ratio Analysis	29	3.2414	1.59587
Time Interest Gearing Ratio Analysis	29	3.0000	1.75255
Investor/Market Value Ratios			
Earnings Per Share Investors Ratio Analysis	29	2.8966	1.79970
Price Earnings Investors Ratio Analysis	29	2.8621	1.76724
Market to Book Investors Ratio Analysis	29	2.8276	1.79422

Similarly, Table 2 presents frequency analysis of the perceived need of proficiency in the financial variables examined. Respondents were asked in the survey to indicate whether financial proficiency is necessary for management executives. Interestingly, the study observed that, a high number of the respondents (86.2%) considered financial proficiency for management executives of construction corporations as very necessary, and would want their respect companies to develop training schemes to boost their proficiency in managerial finance. Fortunately, high percentage (89%) of the respondents indicated that financial proficiency can be acquired on the job through the firm's regular training schemes via conferences, seminars, workshops, forums, short courses. Contrary, to other business sectors such as banks, airline and manufacturing, it was observed that construction companies in Ghana had no policy framework for personnel development in many areas such as finance and information technology. Perhaps these coupled with our other findings about managerial finance will help academics and practitioners alike understand the pervasive relation between financial proficiency and corporate practices in order to be well positioned in financial decision-making process. Aside, the earlier assertion on the techniques of acquiring managerial financial proficiency, our research suggests that construction corporations should establish mini-libraries in their offices, stocked with financial materials and archives viz books, journals, magazines, news letters, financial reports, etc where managements could easily have access to them for references. Routine financial training programmes should also be encouraged to build the capacities of stakeholders involved with financial decision-making

Table 2: Frequency Analysis of Financial proficiency of Management Executives

		Frequency	Percent	Cumulative Percent
Valid	Yes, very necessary	25	86.2	86.2
	No, not necessary	1	3.4	89.7
	Quite necessary	3	10.3	100.0
	Total	29	100.0	

A further manifestation of the desperate need for managerial finance proficiency was high among CEOs, Project Managers, Quantity Surveyors, Accountants and Human Resource Managers. The paper observed that, these executives were very influential in corporate financial decision-making process in the firms examined. Though, the results of the respondents' financial proficiency were impressive, it is unfortunate however, most of them did not take keen interest in their application (see Table 8). Tables 3 – 7 present frequency analysis of the financial education acquired by top management executives mostly involved with financial decision-making. Apparently, it can be inferred from the results in Table 3 that 62.1% of the respondents CEOs have acquired some sort of financial education or training.

Table 3: CEOs Financial Education

		Frequency	Percent	Cumulative Percent
Valid	No	11	37.9	37.9
	Yes	18	**62.1**	100.0
	Total	29	100.0	

Unfortunately less than 50% of the respondents Project Managers and HR Managers have acquired some financial training.

5. FURTHER EMPIRICAL RESULTS

With the data identified, chi square test was undertaken to validate the statistical significance of the variables in the domain of management proficiency, application of the variables in practical context and the significance of the variables in the decision-making process. Initially, three assumptions were made that formed the null hypotheses for the investigation, thus, first construction executives are not proficient in the basic financial variables examined; secondly, construction executives frequently use the financial variables in practical context; and finally, the financial variables play significant role in the acquisition decision-making process. Table 4 presents the results of the analysis using chi-square with predicted significant values of 0.05. At 0.05 confidence level, coefficient values that were not in this range were rejected. Column 1 of Table 4 demonstrates the results of the chi-square test performed in determining the significance of management's proficiency in the control variables. The control variables were found to be significant, with the expected signs. Apparently, variables that have values below 0.05 suggest that management executives are proficient and therefore, reasonable to reject the null hypothesis. Surprisingly, with few exceptions, the results in column 2 of Table 4 also suggest contrary opinion to the null hypothesis as most of the values showed signs above the significant range for acceptance.

This is quite controversial, in the sense that it raises several questions regarding the context within which financial decisions are taken by construction executives. Further, the fact that the practice of managerial finance is not given any serious consideration could be an underlying cause of many financial-related anomalies in many construction firms in Ghana. It is therefore safe to say that most of the fatal occurrences of financial recess, acute growth and eventual liquidation of some construction companies in Ghana are largely attributed to the lack of adherence to the application of these variables in the context of financial decision-making, as most often, managers make ill-informed financial.

Similarly, the results are reassuring in the sense it creates practical impressions of the realities and provides a new thinking into how construction executives view these variables. Furthermore, in column 3 of Table 4, all the variables showed strong coefficient values of less than 0.5. The interpretation of this observation is that, any singled-out variable from the continuum of financial variables is crucial in the acquisition financial decision-making process. For that matter, it is imperative that management's take keen interest in their application.

Table 4: Chi-Square Significance Test

Financial Variables	**Chi-Square Coefficient Values X^2**		
	Proficiency	**Application**	**Significance**
Financial Statements			
The Balance sheet Statement	0.000	0.081*	0.014
The Income Statement	0.000	0.050	0.003
The Statement of Cash flow	0.000	0.064*	0.002
The Statement of Retained Earnings	0.012	0.370*	0.000
Profit/Loss Statement	0.000	0.511*	0.000
Statement of Auditors Report	0.006	0.824*	0.000
Trend & Common Size Analysis			
Financial Trend Analysis	0.089*	0.021	0.000

Common Size Analysis	0.153*	0.370*	0.018
Profitability Ratios			
Return on Equity Profitability Ratio	0.175*	0.016	0.003
Return on Asset Profitability Ratio	0.067*	0.089*	0.008
Gross Profit Profitability Ratios	0.029	0.021	0.000
Net Profit Profitability Ratios	0.012	0.029	0.000
Operating Profit Profitability Ratios	0.059	0.575*	0.000
Activity Ratios			
Net Asset Activity Ratios Analysis	0.038	0.012	0.000
Stockholding Activity Ratios	0.226*	0.051	0.012
Average Payment Activity Ratios	0.257*	0.572*	0.050
Liquidity Ratios			
Current Ratio Liquidity Ratios	0.211*	0.038	0.012
Quick Asset Liquidity Ratios	0.067*	0.518*	0.012
No Credit Period Liquidity Ratios	0.370*	0.175*	0.044
Acid Test Liquidity Ratios Analysis	0.057	0.257*	0.001
Financial Leverage/Capital Gearing Ratios			
Total Debt Gearing Ratio Analysis	0.170*	0.038	0.000
Debt to Equity Gearing Ratio	0.328*	0.059	0.000
Long Term Debt Gearing Ratio	0.370*	0.328*	0.000
Time Interest Gearing Ratio Analysis	0.018	0.089*	0.002
Investor/Market Value Ratios			
Earnings Per Share Investors Ratio	0.009	0.067*	0.016
Price Earnings Investors Ratio	0.021	0.017	0.016
Market to Book Investors Ratio	0.006	0.055	0.012

‘*Significant at the 0.05 level for one-tailed test, and the null hypothesis was rejected’

6. CONCLUSIONS

The empirical survey presented here is both reassuring and puzzling. For instance, it is reassuring that the financial variables examined are dramatically more important now as a means of equipping construction executives with the requisite skills to articulate strategy and financial performance with shareholders, accountants and financial managers in their firms and understand the impact of financial decisions on firm's profitability, efficiency and riskiness information. However, it is surprising that though construction executives have basic financial proficiency they do not apply those principles in the decision-making process. Interestingly, they relied extensively on “Rule of Thumb” without evaluating the fatal risks consequences involved. On other hand, they increase the company liabilities by hiring the services of rather expensive external financial consultants. The study observed that, perhaps the underlined financial principles are valid descriptions of what firms should do but companies ignore the theoretical advice. In conclusion, this paper empirically tested the significance of the main financial variables that influence acquisition decision-making. The study has indeed provided the basis for further research by establishing a set of stylised facts on corporate financial proficiency and suggests additional research to investigate and design the framework for financial training programmes for construction executives.

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DRIVING INDUSTRY CHANGE FROM A SECTOR SKILLS COUNCIL PERSPECTIVE

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Abstract: In 2003, following the 2001 DfEE initiated consultation into the effectiveness of the National Training Organisation (NTO) network, a new Skills for Business Network (SfBN) was launched which is comprised of a network of Sector Skills Councils (SSCs). All SSCs are tasked with delivering against their respective Sector Skills Agreement (SSA) priorities. The SSC for the construction industry, ConstructionSkills, comprises CITB, CITB Northern Ireland and the Construction Industry Council. The aim of this paper is to examine the key issues that impact upon the achievement of the Construction Skills SSA targets. This was examined by a series of staff focus groups through which the challenges and enablers to meeting the industry's skills challenges were identified. The results revealed the existence of many inter-related contributory factors for example terminology, employer and stakeholder perceptions, recent organisational changes and historic staff working areas. This paper focuses upon the work of one SSC and their SSA, although the implications of the findings will be significant for all SSCs seeking effective SSA target realisation.

Keywords: Sector Skills Council, Sector Skills Agreement, ConstructionSkills.

1. INTRODUCTION

The initial driver for the Sector Skills Council network was provided by the DfEE's consultation into the effectiveness of the National Training Organisation network in 2001. All industrial sectors over the past 3-4 years have acquired their own new representative bodies, Sector Skills Councils (SSC), to drive significant and measurable workforce and productivity improvements within those sectors which they cover. Collectively the Sector Skills Council role is one of change management through a Sector Skills Agreement (SSA). The SSA is a tri-partite agreement between the SSC, government departments and employers within the specific sector, and whilst the actions and targets contained within the SSAs vary to accommodate individual sector needs in essence they are all focused on improving the process of workforce development and driving up productivity and performance amongst employers and their staff.

The overarching purpose of a Sector Skills Agreement is that it should primarily alter the way skills are demanded, delivered and developed throughout the UK. SSAs are envisaged as providing the mechanism to enable government, employers, employee representatives and organisations who plan, fund and support education and training to work together to tackle the provision of skills around a common set of objectives. By mapping out exactly what skills employers need their workforce to have, and how these skills will be supplied, the achievement of SSA targets will ensure the UK has the skilled workforce it needs to increase productivity and profitability, now and in the future (Sector Skills Development Agency 2005).

ConstructionSkills has a long history of representing the construction industry stretching back to 1964. It still retains its Industry Training Board (ITB) status and whilst it now maintains a Sector Skills Council role, has in the past acquired first the Industry Training Organisation (ITO) licence and latterly prior to its current SSC role was part of a network of 73 National Training Organisations (NTOs). The challenge for all SSCs is to amplify the collective voice of their sectors employers and significantly improve the responsiveness of training and skills provision via agreements with stakeholders with the ultimate aim of increasing the productivity of those sectors.

The SSA as defined in 2005 via employer and stakeholder consultation contains 13 separate priorities, some of which have been the focus of concerted action for a number of years by CITB (formerly), whilst others are relatively new. ConstructionSkills still continues to implement the SSA that was agreed in 2005. The Skills for Business Network (SfBN) is now four years old, as are some of the early SSC licence receivers. As they have matured and government policy has evolved over this period, the environment that Construction Skills operates has also begun to change. Understanding the new socio-political climate within which construction labour market policy is enacted is essential, therefore, if SSA targets are to be achieved and the future supply of appropriately skilled workers safeguarded.

This paper examines the factors that contribute to the realisation of Sector Skills Agreement priorities. The literature review and the primary research activity undertaken thus far have already identified further areas for examination that will potentially also have an integral role to play in achieving SSA priorities. This paper reflects one aspect of a far wider and interwoven group of determining factors, and concludes with recommendations for future research activity on the specific factors for future examination.

1.1 Literature Review

Given that the research reported here represents the early stages of doctoral research, the research approach should not be too narrow or prescriptive. The review positively assisted in placing the SSA into the historical context of construction industry challenges, whilst also aligning the concurrent organisational changes within the Sector Skills Council itself with theoretical perspectives on change management practice. During the initial scoping phase of this research activity the literature review incorporated essentially three different themes:-

- the exploration of literature covering the history and evolution of the construction industry whilst investigating the major drivers for change in the industry permitting the placing of the SSA targets into a historical context
- the study of literature reflecting on the role that industry representative bodies have played historically and CITB (ConstructionSkills) more specifically
- the examination of theoretical perspectives on organisational change management

History and evolution of the construction industry

In terms of providing confirmation on the congruence of SSA priorities with challenges experienced by the construction industry, the literature review identified a well defined list of historical industry training and skills challenges to which the SSA priorities can be anchored. This provided a degree of reassurance on the current relevance of the research question under study. Murray and Langford (2005) underpin the relevance the SSA in the context of the recurring industry challenges described in the main Government reports on the construction industry produced since World War II and Gruneberg (1997), albeit from the perspective of the individual construction firm, provided additional complimentary confirmation that the SSA priorities squared with the construction firms' challenges.

Historical role of industry representative bodies

In terms of reviewing literature on the historical role played by industry representative bodies and ConstructionSkills (formerly CITB) in particular proved to be difficult task. Heathcote (1970) provided a review of the Construction Industry Training Board's evolution from its early days in 1964 following the launch of the White Paper on Industrial Training in 1962 to the end of 1965. Whilst the paper did not provide a critical review, it did usefully provide a historical narrative on the original role played by the CITB. Senker (1991) noted the CITB's primary role as being to raise the quantity and quality of training in Britain to a level comparable to that prevailing in other advanced industrial countries. Overall however, there appears to be a dearth of analysis on industry representative bodies and ConstructionSkills, specifically with its relatively recently acquired SSC status, in any type of publication.

Organisational change management

Undertaking a review of literature pertaining to change management theories provided an essential grounding for the research theme, primarily because it enabled the change process that has been on-going within the Sector Skills Council to be included as one of the factors that has the potential to affect the overall achievement of the SSA priorities. Buchanan and Huczynski (2004), Hendry and Pettigrew (1990) and Kotter (1995) approach change management from a behavioural and interpretative approach, which underscored the centrality of human resource management within any change management programme, noting the importance of understanding the "resistance" to change prior to the implementation of a programme of organisational change.

The review also, as noted above, enriched the theme at the centre of the wider research activity. The varied thematic nature of the review offered up many more avenues for further research activity which will, in time, provide a richer perspective on the factors that are integrally influential in affecting the realisation of SSA priorities. The review undertaken was inclusive by design, intentionally eclectic of different theoretical perspectives on the reasons why the industry is currently shaped and operates as it does. Whilst the intention of the review was not to weigh up the validity of one theory over another theory, what transpired was an insight into a whole raft of the other "effective" drivers upon the industry. Essentially the review undertaken opened out the research theme into a new unforeseen territory, and that consideration of the Sector Skills Councils and their tools for driving change in the skills and training arena cannot effectively be undertaken from a narrow perspective that is limited by the number of variants at play or the timescale under focus. The realisation that the SSA targets will be dependant upon a wide range of interdependent factors assisted in the framing of this paper.

Undertaking the literature review has provided a deeper level of understanding of the wider context into which the research question under study is placed. What became apparent is the requirement to undertake this research activity with a more enriched appreciation of a wide range of socio-economic and political factors that drive and shape the construction industry, factors which will affect the effectiveness of the SSA as a driver for change.

Whilst the literature review confirmed the appropriateness of the thirteen SSA priorities for the construction sector it did however serve to identify that there are research gaps requiring further examination, in order that a more comprehensive review of factors affecting SSA target realisation can be proposed. Essentially the SSA is a dynamic "tool" that individual Sector Skills Councils have to drive advantageous change in the skills and training arena on behalf of the industries that they represent, ensuring that skills and training *supply* offered by funders and providers is responsive to the skills and training *demands* made by employers within respective industry sectors. What emerges therefore is a scenario whereby the SSA, its effectiveness or otherwise, cannot be considered in isolation from both exogenous and internal (to the SSC as an organisation) factors, furthermore, whilst the SSA is fixed in the sense that it contains a firmly defined set of targets, the exogenous and internal (organisational) context in which the SSA operates is far from fixed. The SSA is a fixed set of priorities, crucially though it does not operate in a vacuum but rather a dynamic environment and hence the requirement to examine as fully as possible, in the course of time, these other variables. This paper focuses upon first of the variables/research gaps that have emanated from the literature review, namely the need to understand Sector Skills Council staff perceptions of the effectiveness of the Sector Skills Agreement as a driver for change

2. METHODOLOGY

The way in which the investigation of ConstructionSkills staff perceptions of the effectiveness of the SSA as a driver for change in the construction industry was explored was through a series of cross-departmental focus group sessions. The focus groups provided an opportunity for staff to describe their views and opinions on why a SSA exists, what its objectives are, to examine staff understanding of their responsibilities in SSA delivery and to discuss any factors that, in their opinion, help or hinder the achievement of the SSA targets. ConstructionSkills has had two years experience of working with and driving SSA achievements. However, examining the general level of SSA understanding amongst staff would provide useful contributory primary data as one element of the bigger exercise seeking to establish clarity on the factors that might impact upon the achievement of SSA objectives. SSA targets achievement, it is proposed, can be heightened if an examination and identification is made of any existing hindering factors. The objective of the research was to test the theory that a lack of inter-departmental communication between the departments within an area office would hinder the realisation of SSA objectives and targets.

A predominantly phenomenological/interpretative methodology was employed for the study. Initially during the end of year 2006 Midlands Staff Meeting, all staff were informed of the existence and purpose of this research activity as a precursor to their individual involvement in the internal focus groups during 2007. Following this it was necessary to devote some time to the establishment of effective groupings for the internal focus groups. It was vital to ensure that the appropriate geographic/county boundary groupings were established, whilst at the same time ensuring that each group contained the front facing staff from each of the four departmental teams contained within the Midlands Area office. The Midlands Area office boundary was chosen as the initial geographic focus because it provided a manageable but large enough sample size of staff members from which to gain a representative range of views and opinions. Initially the office based administrators were to have been included within the county based groups however, due to the problems with the transportation logistics of organising this it was decided to create a distinct and separate "administrators" group. Five groupings were created, including the administrators group, two covering the East Midlands and two covering the West Midlands, fifty four staff were involved in total covering all departments within the area office. Groups ranged in size from seven members to seventeen members.

Prior to the first round of focus group meetings a "Generic brief for Midlands Area Working Groups" was produced and distributed to all staff. Primarily this was done to refresh memories as to the purpose of the groups and to clarify and remove any residual concerns. The first round of focus group meetings took place in spring and essentially provided an opportunity for all staff to collectively and informally discuss the purpose and background to this study. Discussions were recorded in note form. The second round of meetings took place during the early summer months, they took a more formal, semi-structured approach and all discussions were taped and transcribed.

The discussion themes included within second round of meetings were designed based upon both change management theory literature and that relating to the pure conceptual purpose of a Sector Skills Agreement, as conveyed by the Sector Skills Development Agency. There were three distinct, though inter-related themes that each second round focus group meeting was requested to consider and discuss. The first part was about establishing their level of understanding of why a SSA exists and what its objectives are, the second part was about establishing understanding on individual and team responsibilities for SSA delivery and the third part was about identifying factors which helped and hindered SSA achievement. At the beginning of each of the second round focus group meetings, members were given the three discussion areas in the form of an agenda type note, the note and personal introduction to the sessions confirmed the purpose of the exercise, the confidential nature of the discussions and the request that everyone's views were being sought. It was also brought to their attention that the facilitator would not seek to interject or direct the discussions unless it was absolutely necessary to do so.

3. RESULTS & DISCUSSION

3.1 Key points from the first round of internal focus group meetings:

Meeting places

The first round of meetings took place in environments that staff had chosen themselves, typically informal settings over a lunchtime break at a location convenient to them. This was important for a number of reasons, but particularly from the point of view of encouraging a willingness to participate in the meetings was more likely to be present if group attendees had not had to travel great distances to a meeting venue that they were unfamiliar with. The decision not to impose a formal venue for the first meeting was also done because the intention was to create a professional, but relaxed, environment and atmosphere to enable the group members to interact socially as part of the first stages of beginning to "feel" like they belonged to a group. To further encourage staff to feel as if they belonged to a group, a chair was appointed who would also agree to organise the date and venue of the next meeting, furthermore a note-taker was also agreed.

Familiarisation

One theme running through the majority of first round meetings was the desire of ConstructionSkills staff to re-familiarise themselves with the roles and responsibilities of their colleagues in other departmental teams in the Area Office and to discuss and reach an understanding on developments within the whole of the organisation. ConstructionSkills as an organisation has been going through a sustained period of re-structuring, the change process has affected all of the organisations' Directorates, both at a national Head Office level, through to all Area and Regional offices. The Area office from which staff participated in the focus groups were drawn from four different departments, Advisory, Education, Apprenticeship and Strategy and all four departments had witnessed, to varying degrees, changes to job roles and responsibilities. The first round of focus group meetings took place three months after the announcement that changes would be made to the Area office where all participants in the focus groups are either physically based in or consider to be their "hub" office due to their mobile/home-based role.

Clarification

The Midlands Area staff team had, intermittently over the previous five – ten years, been requested to participate in various forms of geographic working groups. All, except for one group across the East and West Midlands had ceased to meet, consequently during all first round meetings, participants were keen to understand the drivers for re-instigating the meetings and gain clarification on the beneficial outcomes that would be experienced by themselves as teams and individuals.

Pre-existing communication arrangements

One of the five groups has a pre-existing history of semi-formal meeting arrangements, and an interesting number of observations could be made with this group in comparison with the other four groups for which either there had been either intermittent communication arrangements or none at all. It is important to note that this group maintain their regular inter-departmental communications without instruction, ie it is undertaken on a completely self-instigated, voluntary basis. The majority of the pre-existing group were keen to understand what the added value would be to them of incorporating discussions surrounding the Sector Skills Agreement into their regular meetings. Whilst there was an openness to consider this new aspect and several members stated that they could see the potential "wins" for individual target achievement, cautionary opinions were also expressed along the lines of "if it isn't broke don't fix it" additionally the concern was expressed that to *formalise* what has hitherto been considered as informal would kill the group enthusiasm that had been generated over a period of time.

There is a secondary aspect to pre-existing communication channels that requires discussion. Whilst only one of the five groups actually had a history of meeting up regularly to collectively up-date themselves on issues concerning their geographic patch, within the other four groups there was evidence of some very well established bi-lateral communication links usually between two (rarely three) of the four departments within the area office. These links were usually either between an Advisory Team member and an Apprenticeship Team member, an Advisory Team member and an Education Team member, or an Apprenticeship Team member and an Education Team member. Rarely were the links tri-partite, or extended to include a Strategy Team member.

3.2 Key points from the second round of internal focus group meetings:

In general terms one of the key observations that can be made of the second round of focus group meetings was their similarity in terms of issues discussed, albeit that these issues were not originally anticipated to comprise such a significant proportion of the discussions. As noted above the Agenda, distributed on the day of the focus group meetings, was structured around three themes emanating from the original literature review. Whilst it was possible to reflect upon the results of the focus group discussions using the original focus group themes, what actually transpired was the emergence of a wider range of issues that staff, across all five groups, felt were relevant to their discussions of the Sector Skills Agreement.

In discussing the question of why a Sector Skills Agreement exists and what its objectives are, most groups collectively demonstrated an understanding of what its core purpose is. Whilst reference was not made in any group directly to the implied increase in productivity as a consequence of increased investment in skills, the consensus opinion was that the SSA was driven by the need to increase investment in skills and training. One group specifically noted that if ConstructionSkills were unable to deliver as an SSC through the SSA then the industry and the organisation would suffer as a result. Interestingly whilst some staff appeared initially to feel disconnected from the SSC remit and the priorities contained within the SSA, as discussions progressed it became apparent that staff in the main did connect with, in their opinion, the SSA priorities directly attributed to their specific team targets. The absence of a wider comprehension of the full set of 13 SSA priorities appeared not to be problematical to some staff, in the sense that their day to day work did not appear to be adversely affected. This latter fact appeared primarily as a direct consequence of the fact that in their day to day work, little reference was made to SSC status or the existence of the SSA by external stakeholder partners or smaller employers. If however, they were required to answer SSC/SSA type queries then they felt confident that they had sufficient knowledge to provide a suitable answer.

All groups noted the aspiration that being a Sector Skills Council should give ConstructionSkills additional leverage to drive changes on behalf of the construction industry. A further more specific recurring theme was the fact that as an SSC the organisation is expected to deliver on the promises made in our SSA. The point was made during each of the focus group sessions that the terminology and jargon surrounding the SSA was not always readily understandable, either to themselves individually or, more importantly at the point at which they were required to describe the role of the SSC or the SSA to an employer. It was noted that larger employers are more likely to be familiar with the organisation's SSC remit and SSA priorities, on the other hand though, smaller employers in their opinion would be unconcerned by this new status and solely concerned with the provision of the traditional CITB products and services. The *average* builder, it was suggested, wouldn't understand, care or be bothered about it. Whilst some staff actively promoted our SSC status to external audiences, this was not prevalent across all individuals who noted that whilst they initially promoted the SSC/SSA in the early days however, as a reaction to the indifferent responses they had received, had become more selective to the groups that were more likely to undertake pro-active promotion with.

In two of the focus groups as part of the discussion on the first theme, it was noted that the apparent disconnect between a staff member's individual job role and the wider, more inclusive SSA agenda, could in part be explained by their lack of information on progress to date against all 13 SSA targets. Acknowledgement was made of the annual updates received during all staff meetings, and the vast range on information regular input onto the ConstructionSkills' intranet, but significantly it was suggested that a shortage of SSA progress data would inhibit and restrict staff from further promoting the SSC/SSA due to the lack of existing promotional "ammunition".

The second theme of the focus group meeting agenda, the discussion surrounding the existent level of individual and team responsibilities for SSA delivery in the Midlands, in general terms generated much discussion amongst staff on the implications on the bigger organisational changes that have been on-going within the whole organisation over the past two years. The vision driving the change process was, primarily through the restructure, to re-align the ConstructionSkills business processes alongside and in tandem with successful SSA target realisation. The fact that ConstructionSkills is now at the latter end of a significant change management programme that originally started midway through 2005 provides the context in which the majority of staff addressed this area of discussion. Whilst achieving effective SSA delivery framed the context for the change management programme, some aspects of its ultimate destination are still in the final stages of completion, therefore providing the qualifying context within which their comments need to be considered. An all encompassing restructure has touched almost all Directorates and Field offices within the organisation, and staff included in the focus group sessions have all been affected to varying degrees. In terms of the amount of time that was dedicated to this topic of discussion by the staff, and mindful of the fact that it would not have been appropriate for the facilitator to interject too much on the natural flow of conversation, the overarching change processes within the organisation should, it is proposed, be considered currently as a contributory factor in SSA achievement.

Focus group members were generally clear that their individual targets were collectively linked together to support SSA target achievement, but less clear on the potential advantages to be gained from working cross departmentally. Some strong bi-lateral communication linkages exist between staff and examples of this working in practice were offered. These linkages have enabled staff to refer their information on to a different department, the outcome contributing to SSA target achievement. Similar types of cross referral processes were offered in each focus group however, vary rarely did the linkages extend to incorporate individuals from all four teams.

The final focus group theme discussion on the identification of factors that prevent and encourage interdepartmental achievement of SSA targets highlighted two key themes. Firstly, in terms of factors that will encourage interdepartmental working more frequent, appropriate and tailored information communicated to all departments was identified as the single most important element that would be required to enhance inter-team working. Significantly however, the point was made in all focus group meetings that the *quantity* of the information should not be too long otherwise digesting it would become a burden and an onerous task. Additionally, linking to the point made earlier, this information should use a minimum of *jargon* and be readily comprehensible by any staff member irrespective of the department they are based in. In terms of preventative factors, it was stressed on a number of occasions that because most area office staff are *mobile* staff and based from home, this in itself detracts from the realisation of regular interdepartmental communication flows, and due to the size of geographic area that they cover to maintain communication channels with their counterparts in other departments could be hard at times. Whilst the merits of continuing to meet as county based groups of staff (inclusive of representatives of all four departments) to support SSA target realisation was supported by some, the ancillary comment made by four staff was that for these to become sustainable would depend upon the level of formality imposed upon them.

3. CONCLUSIONS

In conclusion, the results of the focus group sessions have identified two main areas for reflection and future work. They have identified a number of areas that can be positively addressed that would, if undertaken across all four departments, have the potential to encourage a greater communication and cross referral flow between all staff as individuals and within the teams that they are based, providing the opportunity for enhanced SSA understanding and consequently SSA target realisation. Continuation of the county based group meetings is anticipated, the focus groups provided the opportunity to kick-start the communication process and to disband them at this point would be counterproductive to the overall communication progression exercise. Some of the hindering factors are less easy to confront, for example the SSA terminology and “jargon” is a given, it is not within the area office’s gift to re-write the SSA using alternative language, however, it is to be hoped that the continuation of the county groups will, over time, encourage a familiarity with the SSA that has hitherto been elusive.

The key themes identified during the focus group sessions provide several avenues for future research activity. Much reference was paid to the employer perspective on the SSC/SSA relevance during focus group discussions. Further exploration and examination of this theme has the potential to engender an inclusive dialogue incorporating a range of factors that have the ability to affect the achievement of SSA targets.

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THE NATURE OF PROGRAMME MANAGEMENT AND HOW THEY DIFFER FROM PROJECT MANAGEMENT

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Abstract: In business, changes bring about intense pressure to the managers to think and rethink, search and research, view and review the variables for a new approach that will place them at the top of competition. Maturity in project management gave birth to the phenomenon of programme management as a de facto means of aligning, coordinating and managing portfolio of projects to deliver benefits which would not be possible were the projects are managed independently. Programme management is now a widely used approach to bring about planned strategic changes. Similar to any other management approach, to fully understand the intricacies and realise the benefits embedded, programme management relies on certain parameters. These parameters include the structure, nature, management skills and competencies, tools and techniques, critical success factors etc. Based on an on-going doctorate study which aims to develop an appropriate body of skills, knowledge and competencies for programme managers, this paper will conduct comparative examination on the relationships between project management and programme management and attempt to provide a clear demarcation between the two.

Keywords: Project, programme, manager and management.

1. INTRODUCTION:

Project management has grown in scope, significance and recognition, I has also benefited from acceptance in wide variety of industries ranging from its origin in major engineering projects to a broad spectrum of human endeavours such as IT to lunching of new products. The continuous use of project management approach in the planning, managing, coordinating, executing and implementation of different kinds of change enterprises, most of which have a technological or corporate attributes and lifespan, coupled with the change in demand posed by modernisation in business needs render it insufficient. Organisations are now coming to realise that much of their success is in the ability to manage projects effectively. The maturity of project management, complex changes of human endeavours and its limitations gave birth to the phenomenon of programme management. Programme management is a de facto means of aligning, coordinating and managing portfolio of projects to deliver benefits which would not be possible where the projects are managed independently. Embracing the concept is more than a heuristic approach but rather a deliberate attempt to maintain effective control of portfolio of projects or business strategies through sharing common resources, planning and other management control in an efficient manner.

Williams and Parr (2006) suggest that the economic drivers pressing organisations into major changes have never been greater, fierce competition, changing business models; new technology, deregulation, cost pressures and globalisation are creating the need for organisations to undertake more and more initiatives of unprecedented complexity and speed. Office of the Government of Commerce (OGC) (2004) discuss change for organisations as a way of life now, new services introduced, processes evolve and organisations merge and divide in response to political and market forces.

2. DEFINITION OF PROGRAMME:

The concept and definitions of programme management are still in a rather fluid state. There are different perceptions to what researches agree to a universal definition. Milosevic *et al.* (2007) highlight that there is no universally accepted definition of programme management, also Pellegrinelli *et al.* (2007) suggest that perhaps it is not surprising for individuals involved in programmes meet one another and spend time trying to understand what the other means by programme management. These ambiguities surrounding the nature and practice of programme management remain despite well over a decade of academic and practitioner interest. OGC (2004) highlights that programmes and programme management may be used to deliver change in parts of an organisation or entire organisation. This research aims to fill the void left in attempt to properly define the concept of programme and programme management.

According to Project Management Institute (PMI) (2006), programme is a group of related projects managed in a coordinated manner to obtain benefits and control not available from managing them (the projects) individually. In a similar attempt, Bartlett (2002) describes programme as collection of vehicles for change, designed to achieve strategic objective(s). Programme is a structured framework to coordinate, communicate, align, manage and control activities involved (in related projects) (OGC, 2004). This paper defines programme as an approach where portfolio of projects are aligned, coordinated and managed to together with the aim of achieving overall benefits that may not be possible when the projects are managed separately.

3. DEFINITIONAL ISSUES AND CONCEPT OF PROGRAMME MANAGEMENT:

There many different definitions for programme management, each of the attempts offer different spectrums on similar theme. E-programme (2007) explained that programme management has a number of definitions but it is often clearly connected with the management of a portfolio of projects but not always leading to organisational change. Williams and Parr (2006) highlight that within the practitioner and academic literature, the term programme management is both loosely and poorly defined and often used interchangeably with project management to describe the specific delivery of large projects. Bartlett (2002) observes that definitions of programme management was at that point at somewhat fluid state but express no surprise as even more matured disciplines like project management have many definitions. Williams and Parr (2006) also explain that many sources define programme management as management of portfolio of projects but without much insight into how programme management processes, techniques and structures are distinct from other management disciplines.

PMI (2006) define programme as the centralised coordinated management of a programme to achieve the programme's strategic benefits and objectives. Although PMI's definition did not offer any detailed insight as to how the strategic benefit can be managed and achieved, Pellegrinelli *et al.* (2007) explain that programme management is now a widely used approach to bring about planned changes. It is also adopted to implement strategy to develop and maintain new capabilities in management of information systems implementation and many other business changes. The approach is used to implement strategy (Partington, 2000 and Pellegrinelli and Bowman, 1994) to develop and maintain new capabilities (Pellegrinelli, 1997); to manage complex information systems (IS) implementations (Ribbers and Schoo, 2002) and many other business changes. Pellegrinelli *et al.* (2007) highlights that it will perhaps not be surprising, when individuals involved in programmes meet one another to spend time trying to apprehend what the other means by programme management. The ambiguity surrounding the nature and practice of programme management remains despite well over a decade of academic and practitioner interest.

CCTA (1995) define programme management as the selection and planning of a portfolio of projects to achieve a set of business objectives; and the efficient execution of these projects within a controlled environment such that they realise maximum benefit for the resulting business operation. Burke (2003) defines programme management as managing a large capital project, it may divide into smaller projects to achieve single common goal in the same way whereas Turner and Speiser (1992) define programme management as a portfolio of projects which are managed in a coordinated way to deliver benefits which would not be possible where the projects are managed independently. In other words they define it further as the process of coordinating the management, support and setting of priorities on individual projects, to deliver additional benefits and to meet changing business needs.

Lycett *et al.* (2004) defined programme management as the integration and management of a group of related projects with the intent of achieving benefits that would not be realised if the projects were managed independently. Whilst connected, this is distinct from portfolio management while Reiss (2003) defines programme management as management of portfolio of projects which call upon the same resources and is about the next stage of development – it involves planning each individual project planned and resourced. In other words, is directing of portfolio of projects, one huge project (mega project), managing series of projects for same client which benefit from a consolidated approach. Another definition of programme management is the coordinated support, planning, prioritisation and monitoring of projects towards meeting business needs.

According to Project Management Body of Knowledge (PMBOK) (2006), programme management is the coordinated management of related projects, which may include related business-as-usual activities that together achieve a beneficial change of strategic nature for an organisation. In an earlier research by Pellegrinelli (1997), he sees programme management as a framework for grouping existing projects or defining new projects, and focusing all activities required to achieve a set of major benefits, the projects are managed in a coordinated way either to achieve a common goal, or otherwise to extract benefits that can not be achieve independently. Williams and Parr (2006) suggest that programme management is the management and consistent application of specific processes, tools and methods in order to enable the coordinated delivery of projects within the programme, in a consistent and efficient way.

Bartlett (2002) thinks programme management is the approach taken to manage a programme, which may comprise the employment of a management method or selection of appropriate management techniques, while CCTA (1995) describe programme management as the management, and selection and portfolio of projects to achieve a set of business objectives preceded by efficient of the projects within a controlled environment to realise maximum benefit. In addition, Bartlett (2002) observes that sub-projects in a programme may be physically different but they all relate to the programme as a synergy to its overall objectives. For that reason, programme management becomes continuous that it is seen as a fundamental part of a continuing business operation.

In another twist, Williams and Parr (2006) in their book *Enterprise Programme Management*, define programme management as the capability to lead and manage resources, knowledge and skills in the effective deployment of multiple projects designed collectively to deliver enhanced value. Although the above study seeks a level higher than basic programme management, it is directed towards the approach deployed when the traditional programme and project management become less effective – enterprise programme management. They argue that enterprise programme management is an integrated approach to deliver business changes, creating a means for continuous delivery, not just technique of controlling individual initiatives.

Having seen what many writers define the term “programme management”, this paper seeks to fill in the voids left by other definitions. Programme management can be defined as an integrated, structured-framework to coordinate, align, allocate resources, plan, execute and manage a portfolio of projects simultaneously in view of achieving optimum benefits that can not be realised if the projects are managed independently. The figure below depicts the interrelationship between group of projects and programme.

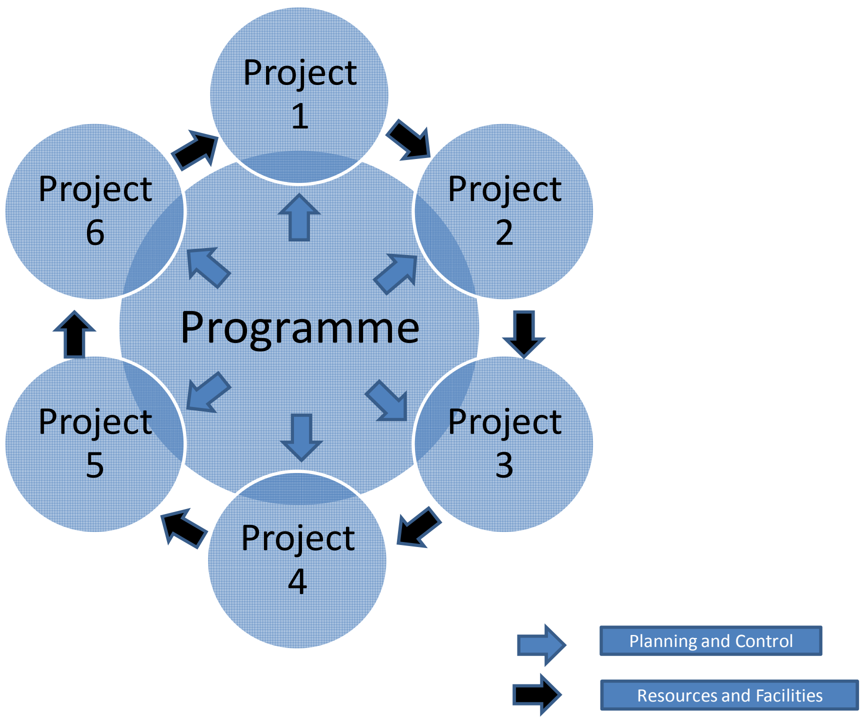

Figure 1: Programme and Projects Relationship

Projects come and go with certain start and end dates but Bartlett (2002) indicates that is not strange to see a two-year programme or even longer period thus suggests the critical difference between programme and project management is in handling of changes which are likely to occur during the duration of the programme. In the same light, Pellegrinelli (1997) warns that, programme management is not the same with multi-project management; indicating that the nature and practice of programme management are far wider reaching than common resources management; thereby clearly subjugating resources management and information systems to programme management. William and Parr (2006) consider programme management as the mechanism for translating strategic priorities into coordinated practical initiatives, and managing the resultant programmes and projects to achieve those strategic priorities, and adapting to changing imperatives.

4.0 DEFINITION AND CONCEPT OF PROJECT MANAGEMENT:

Having seen the various definitions of programme management, to make stronger comparison, the concept of project management will also be defined and discussed in this section. Pellegrinelli (1997) sees project management as a well-established approach for affecting a wide range of changes in different human endeavours. PMBOK (2006) defines project as a temporary endeavour undertaken to create a unique product or service. However, Turner (1993) defines project as an endeavour in which human, (or machine) material and financial resources are organised in a novel way to undertake a unique scope of work, of given specification, within the constraints of cost, (quality) and time, so as to deliver beneficial change defined by quantitative or qualitative objectives. OGC (2007) define a project as a unique set of coordinated activities, with definite starting and finishing points, undertaken by an individual or team to meet specific objectives within defined time, cost and performance parameters as specified in the business case. It should have the following characteristics:

- a finite and defined lifespan
- defined and measurable business products (that is, deliverables and/or outcomes to meet specific business objectives)
- a corresponding set of activities to achieve the business products
- a defined amount of resources
- An organisational structure, with defined responsibilities, to manage the project.

Projects should contribute to business objectives; typically their funding is identified as part of business planning. They may be part of an overall programme of business change.

OGC (2003) see project as a management environment that is created for the purpose of delivering one or more business products according to a specified *Business Case* or a temporary organisation needed to produce a unique and predefined outcome or result at a pre-specified time using predetermined resources.

Project management can be defined as the management of project(s) from start to completion. In addition, OGC (2007) describe Project management as much more than the tasks carried out by a project manager, it is a combination of the roles and responsibilities of individuals assigned to the project, the organisational structure that sets out clear reporting arrangements and the set of processes to deliver the required outcome. It ensures that everyone involved knows what is expected of them and helps to keep cost, time and risk under control. Due to the significance and dominance of project management, Maylor *et al.* (2006) conclude that it is hard to imagine an organisation that is not engaged in some kind of project activity. Over the past decade, organisations have been turning from operations to project management to achieve competitive advantage.

5.0 SIMILARITIES AND DIFFERENCES BETWEEN PROGRAMME AND PROJECT MANAGEMENT:

Archibald (1976) suggests that programmes and projects are similar, that is understandable given that programme roles appear to have direct parallels with projects roles. Thiry (2003) explains that the programme environment as complex and multiple stakeholders with differing and often conflicting needs, emergent inputs always exist to affect the process with ambiguity. Due to these facts, programmes are typically of a longer duration than projects, needs and expectations will evolve, intermediate results will affect the final output and interdependencies will further complicate matters. Pellegrinelli *et al.* (2007) suggest as organisations now face the need to coordinate and plan than the complex changes initiatives and project-based working have turned to programme management as potential way forward. Table 1 below, highlight common differences between programme and project management:

Table 1: Difference between Programme Management and Project Management. Adapted from (Reiss, 2003; Pellegrinelli, 1997 and PMI, 2006)

Programme Management	Project Management
Many simultaneous (related) projects	One project at a time
Personal relationship with the skilled resources	Impersonal relationship with unskilled resources
Concentration on resources	Resources less important
Need to maximise utilisation of resources	Need to minimise demand for resources
Projects tend to be similar to each other	Projects tend to be dissimilar to each other
The team must ensure that the project's aim helps the organisation forward	The team do not care what happen to the project after they have finish their part
Concentration on the corporate objectives	Concentration on the project alone
There are a lot of tools available	There are few available tools
Programmes have a wide scope that may have to change to meet the benefit expectations of the organisation.	Projects have a narrow scope with specific deliverable
Programme managers have to expect change and even embrace it	The project manager tries to keep change to a minimum.
Success is measured in terms of Return On Investment (ROI), new capabilities, and benefit delivery.	Success is measured by budget, on time, and products delivered to specification.
Leadership style focuses on managing relationships, and conflict resolution. Programme managers required to facilitate and manage the political aspects of the stakeholder management.	Leadership style focuses on task delivery and directive in order to meet the success criteria.
Programme managers manage project managers	Project managers manage specialists, technicians etc
Programme managers are leaders, providing vision and leadership	Project managers are team players who motivate the team members using their knowledge and skills
Programme managers create high-level plans providing guidance to projects where detailed plans are created.	Project managers conduct detailed planning to manage the delivery of products of the project.
Programme managers monitor projects and	Project managers monitor and control tasks and

ongoing work through governance structures.	the work of producing the projects products.
An organised framework	A process for delivering a specific outcome
May have an indefinite time horizon	Will have a fixed duration
Evolve in line with business needs	Has set objectives
May involve the management of multiple, related deliveries	Involves the management of a single delivery
Focused on meeting strategic or extra-project objectives	Focused on delivery of an asset or change
Programme manager facilitates the interaction of numerous managers	Project manager has single point of responsibility for project success

In further argument, Thiry (2003) suggests that the processes may be applicable to project management cannot be readily applied to programme management, as programmes have an uncertain finality, which requires processes that are both cyclic and aimed at reducing ambiguity. These may include the identification of needs and expectations, value management, ongoing negotiation and group decision-making. Programme management can be considered as a strategic analysis process. Lycett *et al.* (2004) observe that programmes exist to create value by improving the management of projects in isolation to create benefits through coordination but they do not deliver individual project objectives.

6. WHY PROGRAMME MANAGEMENT?

It is obvious that one will argue that if project management was able to realise tremendous success in all human endeavours why should organisations eschew it for another approach they don't know or have never used? Is it that organisations or somebody was just tired of the title of project management and decided to rebrand it to a new acronym - programme management, or is it just another buzz-work into project management?

In the highly demanding and volatile business atmosphere, programme management evolved and develop to provide a centralised view of all projects in an organisation, enabling a coordinated financial, planning, risk analysis, modelling interdependencies, sharing resources, prioritisation and selection of projects and ensuring accountability and governance of projects (De Reyck et al., 2005 as cited Shehu and Egbu, 2007).

In many cases, project management deals with single projects in isolation whereas in reality, organisations find themselves managing more than one related projects simultaneously. The evolution of programme management is in reality based on the maturity of project management and encompassing the following considerations:

- Limited supply of human and material resources
- Planning related projects using common tools and techniques
- Executing projects harmonically
- Integrating line of communication throughout the portfolio of the projects

When projects are aligned, coordinated and managed as a programme, the benefits that may be driven are unlimited. The benefits may include:

- Effective control of projects as all projects are directly visible to management
- Reduced cost as the resources are revolved round the programme
- Improve quality when common resources are used in a cyclic manner
- Reduce duration as one project leads to another and were planned with one another in mind

Williams and Parr (2006) also suggest that the following are the benefits of programme management:

- Effective control and execution of major business investment in projects
- Improved delivery of benefits in agreed timescales by undertaking key dependencies, effective sequencing of projects and managing critical interfaces.
- Effective deployment of the organisation's resources on projects with the right skills and clear accountabilities.
- Reduced potential for overrun in time and cost, and negative impact on current operations, by identifying and managing major risks
- Effective decision-making concerning the conflict between scope/output quality, time and resources, made from a business perspective, by the right people.
- Increased value from supplier inputs by effective management of suppliers and contractors.
- Enhanced overall delivery capability through shared approaches and best practice.
- Increased realisation of benefits through integration of process, system, people and organisational changes.

7. CONCLUSION:

Programme management is similar but not the same thing with project management. The nature and practices of programme management are far wider reaching and more complex than project management as programme management consist more than on projects are aligned, coordinated, executed and manage together while project management is only concerned with the effective delivery of a single project or human endeavour. Despite their differences, it is clear that a successful programme is usually dependant on the success of the portfolio of the related projects. The projects in a programme are usually related but may not always be the case.

Programme management environment usually requires subtle blend of political and market awareness than in the case of project management. Programme management is entirely different in the skills and competencies requirement of the managers, critical success factors, stakeholders' management and patterns of their lifecycles. Therefore, there are still areas of similarities and differences that require defining and refining. The similarities and differences between programme and project management all depend on the nature of projects and programme under consideration.

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ASSESSMENT OF RISKS IN HOUSING PROJECTS IN NIGERIA

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Abstract: Construction projects are faced with varying risks, especially housing projects. The risks associated with housing projects have effect on the quantity and quality of available housing units and the environment. The study identifies and ranks the significant risk factors in housing projects in Nigeria. A questionnaire survey was carried out on construction professionals from the public and the organised private housing providers in Nigeria. Interviews were also conducted on professionals at the on-going and abandoned housing project sites. The result reveals that risks related to economic, social and political are the most significant in housing projects. There is need for government to open up the remote areas by providing the basic infrastructural facilities to ease the high cost of land in the metropolis. Government should put in place policies that will ensure price stability, speedy approval and issuance of permits, equal access to land and security to property.

Keywords: housing projects, National Housing Policy (NHP), Nigeria, risks.

1. INTRODUCTION

Nigeria is a developing country, with fast growing economy and estimated population of about 150million. Nigeria is considered one of the most urbanised on the African continent. The Nigerian construction industry plays a leading role in the economic development of the country by provision of shelter for various uses, supporting facilities and infrastructure. Housing is among the three basic needs of human being. Thus, housing is a basic human need in every society and regarded as a fundamental right of every individual (UN, 1976). Housing is regarded as a system made up of shelter and the supporting basic infrastructure required by man (Ezenagu, 2000).

Housing project is a capital intensive investment. For this singular reason, the inherent risks in housing project are: high vulnerability to political and economic forces, difficulty of changing or influencing the market mix or product characteristics during the development cycle; and the problem to reach the cash break-even point (Omoniyi, 1995). In construction industry, investment projects such as housing is prone to risk and uncertainty. The design phase and the construction phase of housing projects are characterized by risk. This is a major challenge confronting the stakeholders (public and private) when embarking on housing project.

It is important to identify risks, measure them and think about how to manage them. Kumaraswamy (1997) proposed that the likelihood of risk occurrence and the degree of risk impact are appropriate to judge the level of risk. The frequency of risk occurring and its impact will influence the degree of risk. Thus, the objective of the study is to identify and rank the significant risk factors in housing projects in Nigeria.

2. LITERATURE REVIEW

2.1 HOUSING IN NIGERIA

Housing problems in Nigeria are enormous. A study of past policies and programmes aimed at solving the housing problems in Nigeria by the private and public sectors yield no meaningful result (National Housing Policy, 1991). This was examined under three distinct phases namely; the colonial era, the post independence period (1960-1979) and the second civilian regime (1979-1983). Investment in the housing sector by the government in the past years was around 1.0-9.0% of the total annual budgets (Federal Office of Statistics, 1988). This figure is below the 15% that is in operation in developing nation like Singapore (Ughamadu, 1991). There is a sharp drop in the provision of supporting amenities such as potable water and electricity in past years (Federal Office of Statistics, 1979).

Housing problems in Nigeria is relative to quantity and quality. State of Lagos Megacity and Other Nigerian Cities Report (2004) reveals that there is a shortage in supply of housing in Nigeria. Housing problems result from complex interdependency of elements such as material, social, political and economic with interaction with activities in other sector of the economy (Okusanya, 1994)

Shittu (1995), Windapo (2005), Agbola and Olatubara (2003) and Iyagba (2003) identified the factors militating housing in Nigeria and they include: difficulty in land acquisition, lack of housing finance, high cost of building materials, problems in existing land policy, poor infrastructure among others.

In Oladapo (2001) proposed a framework for the cost management of low cost housing developement. This was based on appropriate technology, labour intensive methods, local materials and standardization amongst other factors. The framework is useful in managing costs within the informal sector which results in achieving value for money and provision of a greater number of houses

Babagida (1994) suggests the possible ways for Nigeria to attain 75 percent self-sufficient in housing delivery. Iyagba and Onukwugha (1994) proposed the systems – based approach as the best alternative to the traditional approach. The approach is aimed at minimizing cost, minimizing construction time and maximizing the quality of housing stock.

2.2 CONSTRUCTION RISK

Risk is inevitable in construction project most especially housing project. Construction risk is regarded as a variable in the construction process whose occurrence results in uncertainty in the final cost, project duration and the quality (Bufaied, 1987). Risk is the possibilities of an event occurring that will have a potential negative impact on the achievement of objectives and it is measured in terms of likelihood and impact (Wikipedia, the free encyclopedia, 2007). Construction risk can be regarded as an economic loss or gain arising from construction process (Healey, 1982 and Perry and Hayes, 1985). It is a common belief that risk in construction constitutes a threat, but this definition suggests that risk does not always have negative consequences but may well have positive effects-outcomes may be better or worse than originally expected. The effect of risks can result to time and cost overruns amongst others.

Odeyinka and Yusif (1997) studied the time and cost performance of housing projects. The study reveals time overrun of between 21% and 63% of the initial duration as well as cost overruns. The constraints of the private housing developers includes: land acquisition problems, high cost of capital required, currency depreciation and inaccessibility to housing finance, lack of infrastructures, inflation, unfavourable government policies, rules and regulations etc (Okulaja, 1990; Okupe, 2000).

Edwards and Bowen (1998) classified risk as natural and human risks. The sub-categories of human risks relating to construction and project risks include: social, political, economic, financial, legal, health, managerial, technical and cultural risks. While the sub-categories of natural risk include weather system and geotechnical systems. Significant factors causing cost overruns in construction are: cost of materials, fraudulent practices and kickbacks, fluctuation in prices of materials amongst others (Elinwa and Buba, 1993; Okpala and Aniekwu, 1988)

3. RESEARCH METHOD

The risk factors are generated from literature (mainly from Mustafa and Al-Bahar, 1991; Edwards and Bowen, 1998; Elinwa et al, 1993; Okpala et al, 1988; Santoso, Ogunlana and Minato, 2003) and interviews conducted at the on-going and abandoned housing project sites. Since the factors identified influence the cost, time and quality of construction/housing projects, they are regarded as risks in this study. A total of 29 risk factors were identified and grouped into six categories.

A survey questionnaire was used to collect data. The questionnaire is divided into two parts. The first part sought for general information about the respondent and the second part sought for the judgment/view of the respondent on the frequency of occurrence of risk factors and the impact of risk factors on housing projects in Nigeria.

Respondents were requested to rank the frequency of occurrence of risk factors using 1 for very low, 2 for low, 3 for medium, 4 for high and 5 for very high. Equally, ranking the degree of impact was achieved using 1 for little impact, 2 for fairly critical impact, 3 for critical impact, 4 for very critical impact and 5 for extremely critical impact. A total of 82 questionnaires were distributed to the professionals in the public and private organizations involved in housing projects. 64 questionnaires were returned and three were treated as invalid.

Table 1: Respondents' organisation

Organisation of respondent	Number of respondents
Public	25
Private	36

The respondents' characteristics are summarised in Tables 1, 2 and 3. About (82%) of the respondents have Bachelor degree and above while 84% of the respondents have more than ten years experience in housing project.

Table 2: Respondents' academic qualification

Academic Qualification	Number of respondents
Ordinary National Diploma	4
Higher National Diploma	7
Bachelor	35
Post Graduate Diploma (PGD)	5
Masters	8
PhD	2
Others	-

Table 3: Respondents' experience in housing project

Experience in housing project (years)	Number of respondents
Less than 10	10
11-20	37
21-30	14
Above 30	-

The characteristics (especially the academic qualification and experience) of the respondents are sufficient enough as the bases from which value judgment can be made.

4. RESULTS AND DISCUSSION

4.1 Mean value of risk factors

The mean value of the risk factors was calculated for the frequency of occurrence and the degree of impact. This is shown in Table 4. Since the number of identified risk factors is many, the significant risk factors that affect housing projects were selected. The selection was done by using the mean value of the risk factors for both the frequency of occurrence and the degree of impact.

Table 4: Mean value for risk factors

Table 5: Selected risk events

No	Classification	Risk factors	Code	Mean Value	
				Frequency of occurrence	**Degree of impact**
A	SOCIAL	Criminal act like sabotage, arson, vandalisation etc	RA1	1.85	2.20
		Theft of materials	RA2	2.28	1.85
		Area boys syndrome (hooliganism)	RA3	3.38	4.00
		Community fracas	RA4	2.90	2.40
B	POLITICAL AND REGULATION	Unstable politics	RB1	4.07	4.27
		Instability of policies	RB2	4.25	4.20
		Customs and import restrictions	RB3	3.15	3.90
		Statutory amendments	RB4	2.52	2.30
		Problems with land acquisition	RB5	4.52	4.45
		Long procedure for approval and permit	RB6	4.30	4.35
		Cost of corrupt government officials	RB7	2.42	2.03
C	ECONOMIC/ FINANCE	High interest rates	RC1	4.50	4.45
		Lack of capital	RC2	4.37	4.47
		Inflation	RC3	4.45	4.55
		Exchange rate fluctuation	RC4	4.27	4.18
		High local and national tax effects	RC5	3.38	2.97
D	ENVIRONMENT AND INFRASTRUCTURE	Site location and access	RD1	3.33	2.65
		Unfavorable site conditions (e.g. poor bearing capacity etc)	RD2	2.70	2.88
		Poor infrastructures (e.g. roads, electricity etc)	RD3	4.43	4.27
E	MANAGEMENT	Developer's inexperience in housing project	RE1	1.98	2.25
		Coordination problems	RE2	2.50	2.58
		Corruption and fraud	RE3	3.13	2.93
		Poor communication between users and developers	RE4	4.00	2.85
F	TECHNICAL / LABOUR	Lack of technology improvement	RF1	4.20	4.15
		Design failures/ errors	RF2	2.75	2.58
		Construction failure	RF3	3.20	2.93
		Poor workmanship	RF5	2.58	3.20
		High cost of labour	RF6	3.75	3.85
		Low productivity	RF7	3.28	4.17

Risk Code	Risk factors	Frequency of Occurrence	Degree of Impact
RC3	Inflation	4.45	4.55
RB5	Problems with land acquisition	4.52	4.45
RC1	High interest rates	4.50	4.45
RC2	Lack of capital	4.37	4.47
RD3	Poor infrastructure e.g. road etc	4.43	4.27
RB6	Long procedure for approval and permit	4.30	4.35
RB2	Instability of policies	4.25	4.20
RC4	Exchange rate fluctuations	4.27	4.18
RB1	Unstable politics	4.07	4.27
RF1	Lack of technology improvement	4.20	4.15
RF7	Low productivity	3.28	4.17
RA3	Area boys syndrome (hooliganism)	3.38	4.00
RF6	High cost of labour	3.75	3.85
RB3	Customs and import restrictions	3.15	3.90

Therefore, the risk factors selected should at least fall in the medium level for both the frequency of occurrence and the degree of impact. Table 5 shows the result of the selected risk factors.

4.2 Selected significant risk factors

Economic/financial factors affecting housing development in Nigeria are interwoven. The economic risk factors are inflation, high interest rate, lack of capital and fluctuation in exchange rate. Nigerian market is characterised with instability in prices of major construction materials. Upward movement of price is prevalent and when price of material goes up in Nigerian market, it never comes down. This is as a result of unfavourable economic policies. Provision of housing is vested in the hands of the public and the private participants. Due to the nature of housing, it is a capital intensive project and it is a long term investment. Fund is not readily available for developers and where it is available; the procedure of securing the fund is cumbersome. The bottleneck ranges from the request of collateral and high interest rate charged by financial institutions. Nigeria is a developing country which is also import dependent economy. All these are threats to investing in housing development projects in Nigeria. The effect of economic/financial risk leads to cost and time overruns. It equally affects the quality of the housing stock.

Regulation/political risks affecting the development of housing project in Nigeria are enormous. Land is a major factor in any developmental project, most especially housing. The process of acquiring land is time consuming and capital intensive. Government policies on land pose major constraints in land acquisition. Land Use Decree of 1978 which vested all the land in the country in the hand of government failed to achieve its objectives. With the private sector, there is difficulty in obtaining approval and all the necessary construction permits. Inconsistency in government policies in the area of housing finance, land use act, customs and import restriction and mobilization of the private sector to play active role in provision of housing suffered as a result of instability in government.

Government's inability to open up remote areas/vacant lands through the provision of infrastructural facilities has great impact in housing development. The value of housing stock is a function of the housing and the supporting infrastructures. A major set back in the Nigerian construction industry is the lack of technology improvement thereby making construction labour intensive task. This has led to high cost of labour. Equally, the industry suffers from low labour productivity.

Social risk such as hooliganism (by the area boys) is a major threat to housing development projects. This is accompanied with the problem of land owners popularly called the "Omo-onile' syndrome" in south-western Nigeria.

5. SUMMARY AND CONCLUSION

The risks associated with housing projects have been identified through a questionnaire survey on the public and the private sectors in charge of provision of housing in Nigeria. The study focused on the frequency of occurrence and the degree of impact. The significant risks were selected using the mean value of the frequency of occurrence and the degree of impact of the identified risk factors.

Fourteen risk factors were considered significant in relation to both the frequency of occurrence and the degree of impact. The significant risk identified are economic/financial, political/regulation, technical/labour and infrastructure. In order to encourage the private sector in investing in housing projects, there is need to address these problems. Government should develop and continuously review policies that will enhance private sector participation in housing. The policies should be directed to solving the problem(s) associated with land acquisition, housing finance, planning laws and regulations, cost of building materials, manpower development in construction, infrastructural facilities and social problems. If the above risks are properly handled, the participation of private investors (both local and foreign) in housing will be enhanced.

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THE NATURE OF TRAINING PROVISION FOR KNOWLEDGE CAPTURE IN SMES IN THE UK CONSTRUCTION INDUSTRY – AN EMPIRICAL STUDY

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Abstract: The growing popularity of knowledge management in the construction industry has, unfortunately, not been matched by parallel empirical research in training and benefits of knowledge capture for small and medium enterprises (SMEs). This is more so, given the fact that 99% of firms in the UK construction industry can be classified as SMEs (< 250 employees). This paper discusses the nature of training provisions for knowledge capture that currently exists in SMEs in the construction industry. Emphasis is also given to future training needs for knowledge capture. It is based on an exploratory research conducted among 53 professionals in 26 SMEs in the UK construction industry. The Grounded theory method was used to guide the data collection and analysis. The data was analysed using Strauss and Corbin's method. This paper concludes that training provisions for knowledge capture in SMEs in the construction industry are mainly in-house, on-the-job training, which includes apprenticeship and mentoring. The paper indicates that training interventions are a complex and context-embedded activity. Knowledge capture should not only focus on the specific knowledge to be captured and transferred between individuals but should also address strategic concerns at group and organisational levels. Small and medium enterprises must also hone in on these basic modern day truths and implement knowledge capture training which focuses both on tacit and explicit knowledge.

Keywords: knowledge capture, knowledge management, small and medium enterprises, training

1. INTRODUCTION

Knowledge management (KM) is an emerging field that has attracted attention and support from academics and practitioners. Many large construction organisations are now engaging in KM in order to leverage knowledge both within their organisation and externally to their shareholders and customers. There seems to be less evidence of Small and Medium Enterprises (SMEs) adopting it. This is despite the fact that over 99% of organisations in the UK construction industry are SMEs and they deliver 52% of the construction industry's workload in monetary terms (DETR, 2000). In this study, The European Union definition of SMEs is adopted which suggest that "micro" organisations are organisations with one to nine employees, "small" organisations are organisations up to 49 employees and "medium-sized" organisations are up to 249 employees (European Commission, 2005).

The Rethinking Construction report – "Respect for people: A framework for action" (Rethinking Construction, 2002) recommended that every firm and project should review it’s induction training, so that the whole workforce receives details of organisational structure, immediate and long term aims, an explanation of standards and practices, rewards and penalties, and is provided with support through an effective mentoring approach. The report also suggests that the construction industry should begin to identify ‘People’ as a key asset.

Hughey and Mussnug (1997) noted that the underlying aim of all employee training is to increase efficiency. Mathieu et al. (1992) stated that individuals rely on training to improve their current skills and to learn new skills. Muscatello (2003) emphasised that little has been written about the use of “knowledge” to directly serve the training needs of the firm. It is necessary to understand the difference between training and education prior to the need for training in knowledge capture initiatives in SMEs in the construction industry. In distinguishing training from education, Morris (1971: p33) considers training as the “use of specific learning, often with the use of techniques that can be identified and continually improved”. For education, he noted that it is “a broader process of personal change in abilities and attitudes which may take place independently of its application of work”.

The Oxford English Dictionary (2007) defines training as teaching (a person or animal) a particular skill or type of behaviour through regular practice and instruction. The operational definition for training in this study adopts Armstrong’s (1996) definition, which purports that training usually refers to learning a specific task or job, the skills and behaviours of which are specifically defined, whereas development is an ongoing process involving changing people. This implies that training is more of a mechanistic process, which is job-centred, while development involves educating the workforce, which is person-centred (Fryer, 2004). It is important to note this distinction in order not to use the terms interchangeably resulting in confusion.

Anecdotal evidence and empirical results (Curran and Stanworth, 1981) suggest that the lack of training in small firms hinders growth. By reading a document or manual about their jobs and the organisation, and by reflecting upon it, trainees can internalise the explicit knowledge written in such documents to enrich their tacit base (Nonaka and Toyama, 2003). Thiry (2004) suggests that training programmes are embedded into a complex context where cultural and competitiveness issues are often at odds with each other.

Ulrick (1997) suggested that organisations need to be able to capture the tacit knowledge of its employees and to do this effectively, it is argued that management needs to involve and engage employees fully in the activities of the organisation. The operational definition for knowledge capture adopted in this study is a “process of obtaining and collecting key knowledge (both tacit and explicit) from an individual, group or organisation in order to improve organisational competitiveness”. Knowledge capture initiatives provide opportunities for organisations to innovate, improve project methodologies, cut costs, and save design time.

Based on the literature review on training, there seems to suggest that there is lack of training geared towards knowledge capture initiatives in SMEs in the construction industry. Therefore, empirical results on the nature of training for knowledge capture in SMEs in the construction industry is analysed and reported in this paper. Prior to it, research methodology is discussed.

2. RESEARCH METHODOLOGY

In the study reported in this paper, qualitative research approach which includes Grounded theory was adopted to uncover many of the complex and intricate issues associated with the nature of training for knowledge capture in SMEs in the UK construction industry.

Sample size is deemed to be satisfactory only when the key concepts that have been identified from the collected data have reached saturation point; in other words, when no new data emerges. However, Morse (2000) suggests that to reach saturation point, the sample size depends on several factors: the scope of the study, the nature of the topic, quality of the data, study design and research technique. Semi structured interview was used as the research technique for this study. Data was collected through semi structured interviews which spanned between 45 minutes to 60 minutes.

The database for the study was collected from the Small Business Gateway (2003) for the construction industry. Attempts were made to have a sample across architecture; engineering and construction organisations (See Table 1).

Table 1: Representativeness of the sample organisations

	Architects	**Engineers**	**Contractors**	**Total (organisations)**
Small	4	4	2	10
Medium	3	6	7	11
Total	7	10	9	26

For this study, the researcher chose the Strauss and Corbin methodology for analysis of data. The main principles behind the Strauss and Corbin (1990) method for analysing data are as follows:

- The development of analytic techniques with the provision of guidance to novice researchers.
- A micro analysis (word-to-word) adopted for the data obtained through interviews.
- A constant comparison method of data analysis (deductive and inductive) involves:
    - Open coding: The researcher forms initial categories of information about the phenomenon being studied from the initial data gathered.
    - Axial coding: This involves assembling the data in new ways after coding. A coding paradigm is developed which incorporates:
        - identifying a central phenomenon
        - exploring causal conditions
        - specifying strategies
    - Selective coding: This involves the integration of the categories in the axial coding model. The essential idea is to develop a single storyline around which categories are formed.

Morse (2000) produced a 'rule of thumb' for grounded theory studies recommending approximately thirty to fifty interviews. Data saturation was reached in 48th interviews in 21st organisation. This research study concluded with 53 interviews in 26 organisations.

3. THE NATURE OF TRAINING PROVISION THAT CURRENTLY EXIST FOR KNOWLEDGE CAPTURE IN SMES – AN EMPIRICAL STUDY

During the semi-structured interviews in this current study, the subject of training was raised, i.e. "in your organisation, is there any specific knowledge capture training programme in place"? This stimulated responses about training as part of the corporate strategy, delivery methods of training and more specific information about the training methods used. The interviews with 53 professionals from 26 organisations revealed three types of corporate strategy for training (see Table 2).

Table 2: Training as part of corporate strategy

Training as part of corporate strategy	**Number of interviewees (N = 53)**	**Number of organisation (N = 26)**	**Percentage (%) (Number of organisation/ total number of organisation)**
Training programmes specifically designed for knowledge capture	35	16	62 %
General training but not specific to knowledge capture	15	8	30%
No general training and no training specific to knowledge capture	3	2	8%

Only two of the 26 organisations stated that they did not have any training (general or specific to knowledge capture). An owner of one of the two organisations stated that

> "Employees training programmes demand a significant investment in terms of both financial and human resources. Training can also take up a great deal of time which could adversely effects schedules and deadlines".

This was further emphasised by another organisation's manager who noted that training was a waste of time and did not feel the need to attend training because he felt he was too busy dealing with urgent tasks for the day-to-day survival of his organisation. One of the three interviewees from the two organisations noted that professionals in SMEs are usually recruited because they are experienced and familiar with the construction industry; therefore there was no need for training.

Eight of the 26 organisations that provided general training, training were provided by professional bodies such as The Institute of Civil Engineers (ICE), The Institute of Structural Engineers (ISE), The Royal Institute of Chartered Surveyors (RICS) and The Royal Institute of British Architects (RIBA). However, there was no training specifically geared towards knowledge capture in those eight organisations from an organisation's perspective. The reasons stated were:

- Knowledge capture in construction industry is a specialised area and to the best of their knowledge; no external training providers offered courses in this area.

- Professionals had to make a case why particular training was important and how it would help the organisation. Hence, 12 interviewees said that they lacked the awareness of knowledge capture benefits and did not present a case to their management to attend knowledge capture training course.

From the data in Table 2 it is evident that 16 of the 26 organisations had training programmes for knowledge capture, therefore, the nature of current training for knowledge capture in 16 SMEs was investigated.

Four interviewees from four organisations of the 16 organisations suggested that they had attended external training for knowledge management hosted by the Centre for the Built Environment (CBE) and The Construction Productivity Network's (CPN). The interviewees also revealed instances where members of staff had to submit reports after attending external training. In one of the organisations, external training was encouraged, for which employee's paid 20% of the training fee and the remaining 80% was paid by the organisation.

A literature review indicated that training for knowledge management in specific business settings, had not been fully developed (Muscatello, 2003). However, training has been offered in KM for construction professionals by The Construction Productivity Network's (CPN, 2005), The Centre for the Built Environment (CBE, 2005), Glasgow Caledonian University (GCU, 2006), and Hemdean Consulting which has joined forces with Henley Management College, Taylor Woodrow, Arup, EC Harris, CBPP and Rethinking Construction in a project to create a knowledge management community (Hemdean, 2002). The Construction Productivity Network's (CPN, 2005) delivers leading-edge thinking and improvement opportunities to the construction industry. The CPN offers a unique opportunity for construction organisations, clients, designers, suppliers, and research bodies to learn from each other's experiences through training courses. A list of the training provided by CPN (2005), over the past four years was collected by the author and the number of training courses that focused on knowledge management was counted. An average of one training event a year was held on knowledge management in the last 4 years. One of the interviewees in the current study had attended the training course titled, "improving business performance through knowledge management initiatives". The interviewee further noted that he now fully realises the importance of knowledge and the amount of key knowledge available within his organisation. He also thought that training within organisation, for knowledge capture, is very important and would be adopting mentoring as part of knowledge capture initiative.

The Centre for the Built Environment (CBE, 2005), facilitates and acts as a conduit for training to be delivered to SMEs in the construction industry. The training courses on KM are held at irregular intervals containing some aspects of knowledge capture. In summary, the results from this study "leave no doubt" that there is very little, provisions of knowledge capture training, directed at SMEs.

Thirty one interviewees from twelve of the twenty six organisations suggested that they had in-house training for knowledge capture. This study supports the CITB (1988) study which shows that most construction organisations prefer in-house training courses to external courses. Findings from this current study suggest that nearly 20 years after the CITB study, the attitude towards in-house training has not changed. Three reasons given for in-house training on knowledge capture are:

- In-house courses are cheaper than external courses
- In-house courses are directly geared towards meeting the objectives/needs of the organisation
- There seemed to be very little or no external courses focused on knowledge capture

The researcher of the current study investigated 12 organisations that have in-house training methods for knowledge capture in SMEs in the construction industry. In-house training can either be on or off the job (See Table 3).

On-the-job training, for the purpose of this study, is the term used to describe training given in the normal work situation. This includes mentoring and apprenticeship.

Off-the-job training refers to training which takes place within the organisation, but not during the normal work situation. This includes seminars, group discussions, case studies and programmed instructions and lectures.

Of the fifty three professionals who participated in this study, twenty eight interviewees had on-the-job training for knowledge capture, while three interviewees revealed that they had off-the-job training for knowledge capture. Both the methods (on and off the-job training) were followed in one organisation.

Table 3: In-house training methods in SMEs in the construction industry

In-house training methods for knowledge capture	**Number of interviewees (N =31)**	**Number of organisation (N = 12)**	**Percentage (%)**
On-the-job	28	10	83%
Off-the-job but in-house	3	2	17%

The data in Table 3 shows that off-the-job but in-house training was followed in two of the twelve organisations and ten of the twelve organisations adopted on-the-job training for knowledge capture. The relatively high response for on-the-job training when compared to off-the-job training reflects the necessity for hands-on experience backed up with coaching and/or mentoring.

Ten of the twenty six organisations had on-the-job training for knowledge capture, a further examination of the nature of on-the-job revealed two types i.e. mentoring and apprenticeship (See Table 4).

Table 4: On- the-job training as a means for knowledge capture

On-the-job training for knowledge capture	**Number of interviewees (N =28)**	**Number of organisations (N = 10)**	**Percentage (%)**
Mentoring	18	7	70%
Apprenticeship	10	3	30%

Both mentoring and apprenticeship provides a tacit form of knowledge capture. Egbu et al. (2003) noted that mentoring is a process whereby a trainee or a junior staff is attached or assigned to a senior member of an organisation for advice related to career and knowledge development. The mentor provides a coaching role to facilitate the development of the trainee by identifying training needs and other development aspirations.

Emmerik (2004) empirical study focused on the beneficial effects of mentoring and his results replicate and underscore mentoring to be a critical resource to boost the career and psychosocial development of employees (Allen et al., 2004). Mentors are individuals with advanced experience and knowledge, who are committed to providing upward support and mobility to their employee's careers (Emmerik et al. 2005).

One of the interviewees noted that

> "a mentor's role is important in helping employees to develop their own reflection process. A mentor is a source of insight and offers employee advice on how to check their questions or ideas".

Swieringa and Wierdsma (1992, pg. 137) stated that a mentor may play "a role of both the content expert and the process consultant". This was evident in seven of the ten organisations who used mentoring as a mechanism to capture knowledge and called their mentors "experts" within the organisation. In this study, it was observed that mentors were often senior management staff who helped individuals to learn, unlock their talents and develop their knowledge in the organisation.

Apprenticeship as a mode of knowledge capture training was used by ten interviewees from three organisations as a mode of on-the-job training. Egbu et al. (2003) suggested that apprenticeship is a form of training in a particular trade carried out mainly by practical experience or learning by doing (not necessary through formal instruction). Egbu et al. (2003) also noted that the long tradition of apprenticeship schemes in the construction industry is responsible for producing various craftsmen who rely on their tacit knowledge to solve construction problems. Three organisations noted that apprenticeships improved the knowledge and skills of the individuals so that they can later perform tasks on their own. This process of skill building required continuous practice by the apprentices until they reach a required level of "competence". Apprentice engineers and draftsmen often work with their masters to learn craftsmanship, not through formal instruction but by socialisation which involves observation, imitation and practice (the case in three organisations in this study). Through mentoring and apprenticeship training, employees develop the skills necessary to continue experimentation at work to develop or improve processes (this was the case in ten organisations in this study).

4. FUTURE TRAINING FOR KNOWLEDGE CAPTURE IN SMES

The interviewees were asked to volunteer information on the nature of training to capture knowledge in the next 5 years considering how their jobs are likely to change in the future (See Table 5).

Table 5: Future knowledge capture training

Future Delivery	**Number of interviewees (N =53)**	**Number of organisation (N = 26)**	**Percentage (%)**

methods			
In-house	43	20	77%
External	10	6	23%

The results of this study indicate that training delivery method for the future is similar to the present delivery method. Ten interviewees from six organisations stated that, for external training, they would prefer a one hour training programme which deals with the benefits, challenges and case studies of other SMEs who have successfully implemented knowledge capture initiatives. The interviewees also said that most of the training programmes were hosted in London and hence they would prefer training to be conducted regionally e.g. held in Edinburgh or Glasgow. This would enable more employees in SMEs to attend. Forty three interviewees from 20 organisations noted that in-house training for knowledge capture is the way forward for knowledge capture training (See Table 6).

Table 6: The nature of future In-house training for knowledge capture

The nature of future In-house training for knowledge capture	No. of interviewees (N = 53)	No. of organisations (N = 26)	Percentage %
Training needs to capture internal knowledge	43	20	77%
Efficient use of technology for knowledge capture	35	15	58%
Need for a formalised training programme for knowledge capture	25	10	38%

The data in Table 6 indicate that there is a need for training to capture internal knowledge. This is followed by an efficient use of technology for knowledge capture, and the need for a formalised training programme for knowledge capture. During the interviews, all the participants realised that there was immense knowledge embedded in their organisations. They also suggested that mentoring/coaching, apprenticeship and job rotations were means of capturing organisational tacit knowledge. For capturing explicit knowledge, the efficient use of technology was thought to be useful by 35 interviewees from 15 organisations. For example, through indexing and archiving best and worst practices in various projects. The interviewees also noted that knowledge capture and codification are particularly critical when an issue of knowledge continuity arises.

It is interesting to note that 25 interviewees from 10 organisations thought that there is a need for formalised training programmes to “collect and obtain” past and present knowledge from an individual, group or organisation in order to improve organisational competitiveness. One of the interviewees suggested a formalised training programme using knowledge capture training metrics of input or output indicators which could be used to monitor the performance of knowledge assets. On the input side, the indicators should reflect enablers or actions required to implement or achieve business objectives. Examples of input indicators are number of training days per employee, proportion of staff with professional qualifications (i.e. chartered) or with over two years’ experience, and senior managers with experience on major projects. The output indicators should measure the performance or the result of those actions, such as the number of defects after project completion, complaints from clients, and cost and time overruns".

Forty interviewees from 19 of the 26 organisations suggested that motivation for increasing their skills seems to be lacking because they do not believe the organisation values training. This may be because the organisation has not provided an incentive or a vehicle that meets their particular needs. Training in non-working hours is considered to be difficult because the employees have other demands on their time.

Facteau et al.'s., (1995) study indicates that motivation has an important influence on the extent to which trainees actually learn the material presented to them during a training program. Baldwin et al.'s., (1991) study found that motivation may influence important training outcomes such as performance appraisals. None of the 26 interviewed organisations noted any influence of training on performance appraisals.

The discussion on the nature of future training for knowledge capture indicates the need for training to capture knowledge internal to the organisation for which technology could be used as an enabler. Furthermore, formalised training programme for knowledge capture would be useful.

5. CONCLUSIONS

The paper indicates that training interventions are a complex and context-embedded activity. It requires the consideration of different issues discussed in a holistic way. The conclusions that follow from this paper are:

- There are very few, knowledge management courses, in-house or external, directly geared towards knowledge capture; yet evidence suggests that for both the organisations and its employees, there is an urgent need for appropriate training for knowledge capture.
- Seventy seven (77%) percent of those interviewed in the current study prefer in-house knowledge capture training to external courses. The reasons are primarily to do with cost, relevance in meeting organisational needs in capturing both tacit and explicit knowledge.
- In-house and on-the-job is the most preferred type of training for knowledge capture. This reflects the importance of hands-on experience given by apprenticeships and mentoring.

Knowledge capture should not only focus on the specific knowledge to be captured and transferred between individuals but should also address strategic concerns at group and organisational levels. Small and medium enterprises must also hone in on these basic modern day truths and implement knowledge capture training which focuses both on tacit and explicit knowledge.

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PERCEPTION OF STATUS OF DEMOLITION ENGINEERS

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Abstract: Demolition engineers in the UK construction industry are not held in 'high regard'. The image of the profession suffers more profoundly than most other sectors in the economy. As sustainability and safety become increasingly important themes, there is a need for demolition to be managed by Chartered professionals. The study provides an assessment of current demolition guidance, and of demolition engineers' required knowledge base. A questionnaire survey is undertaken of two groups of construction professionals, (i) Members of the Institute of Demolition Engineers, and (ii) Members of Chartered professional bodies. Forty responses were received. The study hypothesis is that affiliation of respondents influences their perception of the demolition industry's professionalism. Mean scores for perception of professionalism were 61.36% (IDE) and 57.20% (Professionals). Unrelated t-tests gave probability values exceeding 0.05; the null hypothesis cannot be rejected. Checks on reliability and validity are supported by internal reliability and confidence interval calculations. Supplementary, qualitative analysis was utilised to help interpret results. Two contracting organisations were interviewed. Client education, training and experience are important for facilitating increased understanding. Licensing and structured affiliation schemes may reduce the advent of uncontrolled contractors.

Keywords: Demolition, education, engineers, licensing, professionalism.

1. INTRODUCTION

Creation is often lauded, with seminal structures defined by their "landmark" status (Kitching, 2006, p.18). Yet, as demolition is perceived as the antithesis to professional "technical" or "scholarly" vocations such as civil engineering and architecture, it is generally recognised as an antiquated subservient. However, it is often this profession that bears responsibility for reverse engineering systems, methods and techniques that initially defined the building. Rumsfeld (2002), whilst not specifically referencing the demolition process, eloquently extols the complexities and vagaries associated with deconstruction works in his comment, *"as we know, there are known knowns . . . We also know there are known unknowns; but there are also unknown unknowns, the ones we don't know we don't know."*

Recently, there appears to be an industry reversal of this trend, with demolition organisations now receiving both praise and award (Construction News, 2006), indicating that the notoriety once afforded the industry, is being repealed. Yet, public perception is still antagonistic, particularly in light of the sociological effects of community clearance projects (Lambrick, 2007; Zeidler, 2004). With the U.K. Government currently specifying targets for brownfield development and sustainability defining the agenda for regeneration projects (Sustainable Development, 2006); specific improvements to enhance and develop socio-economic communities may provide substantial opportunities for the demolition industry.

Through the presentation of a valid, professional approach to property management (Laing, 2005, p.4), stable re-establishment of requirements, re-appraisal of the industry's fundamental nature (Weber et al, 2006, pp.19-21) and desirability afforded by association, the industry should attempt to utilise fundamental resources effectively to establish a foundation for professional necessity. In the case of Attorney General v Ferey [1968] (Jersey Legal Information Board, 2006) the Deputy Bailiff set precedent by claiming that the act of demolition is, when carried out as an integral function of construction works, development. Yet, in isolation, deconstruction did not constitute the same; interestingly, the antithesis of the construction industry's current approach to the integration of functions in order to facilitate "whole-life" appreciation (OGC, 2003, p.12). Analysis and application of Von Bertanaffly's General Systems Theory, may allow the construction industry to attend to this methodology (Walker, 2002, p.29). Yet, it must be considered whether the industry is presently suited to providing the open environment, free from negativity, required to facilitate an understanding of the importance associated with preliminary works and integrate the field as a professional function. As the mental juxtaposition of definition and discipline provides neophytes with a continued interest in the industry (Byles, 2006), the emphasis is primarily on vivification, and not demolition per se. In this respect, the engineer's role is often misrepresented, or negative, subsidising poor public perception and creating an intransigent archetype (Kennedy, 2006). However, traditional methodologies are constantly being enhanced with new developments offering social improvement by reducing noise, contamination and inconvenience, leaving unorthodox, experimental demolition techniques efficacious in enhancing perception and reversing the impression of the demolition engineer as a remnant of World Wars' clearance projects (Morton, 1947, pp.204-206).

2. LITERATURE

2.1 History

Until the advent of the Second World War, demolition works were widely regarded as an integral aspect of the construction process. Structures were demolished by unqualified, willing and cheap labour; supervised by operational metier. Without any substantial legislation (Denison, 1995) and limited technology, British industry suffered from a high number of fatalities (Dickens; Whittaker, 2006, Column 1292).
A significant change occurred in 1941, with the National Federation of Demolition Contractors created (NFDC, 2006); subsequently leading to the development of the national Demolition Industry Wages Board during 1943, ensuring industry operatives became recognised tradespersons. As the NFDC were primarily associated with the contracting arm of the industry, the professional demolition engineer received limited recognition. In rectification, the Institute of Demolition Engineers was established in 1976 to "promote and foster the science of demolition engineering", noting efficiency, safety and the creation of a "qualifying" body the Institute's primary functions. The assistance of these governing bodies has allowed the profession to establish development frameworks, drive progression and adopt non-legislative best practice.

2.2 Education and Legislation

In 1978, the UK based National Demolition Training Group, an affiliate of the NFDC, was established, specifically to educate demolition operatives and supervisors. National Vocational Qualification (NVQ)/ experience based qualifications were tailored to provide a suitable source of knowledge for interested parties (National Demolition Training Group, 2007). However, as the qualifications primary source of knowledge is site-based experience, the suitability of the scheme must be questioned in terms of technical, or theoretical, validity.

A distinct lack of demolition training and similar demographic employment model led to the American-based Purdue University and National Demolition Association joining forces to present a specialised qualification to students. This specialisation outlines the demolition function of whole life development and aims to provide students with the skills required of a demolition engineer (Steakley, 2005). As yet, UK institutions have failed to realise the lack of career guidance for young people entering the industry, leading to human resource problems for future generations (Kingston, 2005) and issues regarding "competency" based regulation. The Egan report "Rethinking Construction" recommended both a "commitment from Government" and "best practice" (Construction Task Force, 1998, p.40) as drivers for change. Yet, it is interesting to note the lack of any specific legislative frameworks that would enable a structured progression of the demolition industry. Under current United Kingdom statute, demolition licencing is restricted to isolated legislation which exists in the Building Act 1984 and whilst this appears adequate, the term "demolition" is rarely mentioned. BS 6187: 2000, the Code of Practice for Demolition was intended to combat insufficiencies in protocol and integrate current statute such as the Construction, Design and Management Regulations. However, as the EU are presently criticising the amount of construction regulation, the necessity to introduce supplementary statute must be questioned (Verheugen, 2005, p.68).

2.3 Sustainability

Sustainable, Government-driven redevelopment is assured for the foreseeable future. However, speculators are suggesting the adoption of non-specific, generic development organisations to manage projects, negating industry specificity and diluting knowledge (Campbell, 2006, p.13). As new construction becomes an increasing feature of the built environment; particularly with the Government dictating that 60% of projects be undertaken on brownfield sites (BRE, 2007, p.1); demolition organisations will become prominent and should realise the effect of value as a product of presentation and presence, being representative of the industry as a whole (Melvin, 2002, p.2).

Continual modification and constricted timescales are often forced on project managers, with inadequate attention paid to environmental impact or profitability through resource recovery, material reuse and recycling (London Remade, 2007, p.2-13). In the majority of deconstruction projects up to 85% of material used in the body of the structure can be reconstituted in some form, whether by re-application or recycling (RICS, 2007). As the Department of Trade and Industry (DTI) are actively pursuing a reduction in construction waste; issuing such publications as the "Site

Waste Management Plans, Guidance for Construction Contractors and Clients" document (Department of Trade and Industry, 2004); it is imperative that construction organisations realise their statutory duty and improve sustainability through secondary recycling (Van Eijk and Brouwers, 2002). Yet, social and environmental impacts cannot be valued in monetary terms and this must be recognised (Hampton, 2005, p.6). Impassioned management can influence public consultation processes; a substantial measure of the projects' favourability; and ensure continued support, enhancing community pride. Ideally, environmental concerns should be concluded during initial feasibility studies and the local community continually informed by open promotion to increase the perception of unity (Forstner and Bales, 1993, p.35; Cowley, 2003; Caddy, 2001).

2.4 Technology

Contemporary demolition techniques and methodologies are frequently applied to provide clients with satisfactory outcomes. In order to provide an understanding of scope, a limited synopsis of technique follows.

With an explosive demolition industry reputedly valued at over $2.5 billion in the United States alone (Gershman et al. 1999, p.2) and annual growth rates of approximately 10% (Taylor, 2006, p.26), the use of explosives has become a viable option. As projects have a significant impact on neighbourhoods, the environment, members of the public and provide "media friendly" opportunities, demolition engineers' should be considered the construction industry's advocates and respected accordingly. Contrastingly, in order to provide a safe, controlled, technological solution to the problematic deconstruction of Madrid's fire damaged towers during 2005, Brokk robotic demolition units were utilised. Remote, exclusive access was required (Redfern, 2005, p.16-17) to ensure that demolition did not adversely affect the four subterranean rail tunnels, major highway or department store in proximity to the site.

Recent research into microwave/RF Technology and its effect on internally bonded water particles has provided evidence that this methodology produces pressurised steam fractures which destruct internal, cementitious aggregate bonds, destroying specified material. In association with typical demolition techniques, this method may be utilised to provide semi-independent failure or provide an isolated, fully processed, deconstruction technique (Humphreys-Jones, 2004, pp.56-57). Soundless Chemical Demolition Agents (SCDA) are granular materials that catalyse when added to water. The agent is generally comprised of inert, natural materials which expand significantly, providing up to 500kg/cm² of internal pressure to pre-prepared fissures (Gambatese, 2002). Both systems provide low environmental impact, with noise, dust and impact contamination held at significantly reduced levels. Water Jet Abrasive Cutting employs a semi-robotic system, utilising hi-pressure jet nozzles, typically between 10-30,000 PSI, to integrate fluid with a secondary abrasive, forming an effective cutting medium. Due to the semi-inert nature, this technique is particularly useful in areas that contain combustible materials such as chemical or fuel plants (Frey, 2002; NLB Corporation, 2007).

2.5 Perception

As subjects are, in many cases, old, deteriorated, aesthetically unpleasing structures, there is little scope for the creation of any public intimacy in association with the demolition facet of the construction industry (BFM Ltd, BRE Ltd, 2004, p.77). Rapid deconstruction and invasive means create disamenity, ensuring that attention is drawn to the area's associated decline (Giddings and Shaw, 2006, p.2). With the necessity to increase reliance on new technology, demolition organisations should be undertaking active promotion (Morledge, 2002) and attending to customer service; subsequently improving perception and aiding in the retention of clients for the long term (American Institute of Architects, 2003, p.3-4).

Cultural change provides the primary driver for industry transformation (McCabe, RICS, 2004) and recognition, the solution to improving public perception (Steele, 2006). Improvements in the way the industry undertakes consultation, develops social inclusion, considers environmental impact, cleanliness and safety are all key aspects that require addressing (Kass, 2001, p.7). Recent issues surrounding the Government's Pathfinder programme have been detrimental by association, enhancing the abject nature of the profession (Deputy Prime Minister, 2005, p.11). In addition, many construction clients incorrectly regard demolition as an isolated aspect of the works; generally tendered and administered rapidly; as a separate operation of the redevelopment cycle (Hurley and Hobbs, pp. 4, 46). Deconstruction of existing premises is an integral part of any construction proposal and should be considered as the start of the scheme, bearing the status associated with that aspect of the project (Gershman, Brickner and Bratton Inc.1999, p.3).

3. METHODOLOGY

3.1 Quantitative Analysis

An explanatory study (Naoum, 2004; p. 46) investigating the property-disposition relationship (Worrall, 2005) between professional institution members was adopted as the nature of this research, as face validity suggested quantitative analysis, enhanced with qualitative support, would effect a suitable result (Alderson *et al*, 1995, pp.172-173). A sample based on national representation was utilised in order to affect satisfactory analysis of the topic, with 2 segments of the population identified:

- Members of the Institute of Demolition Engineers (IDE).
- Selected professional members of the Chartered Institute of Building (CIOB) and Institution of Civil Engineers (ICE).

A non-random, purposive sample (Naoum, 2004, p. 59) of all IDE members and select CIOB/ ICE representatives was utilised, with no population exclusion parameters established. Specific survey questions were constructed in strict adherence to the Likert method of data collection (Fellows & Lui, 2003, p. 147; de Vaus, 1996, pp. 252-257). However, other questions were developed using supplementary, semantic differential values and attitude choices as representative sampling media, providing a simplified, closed format. A total of 24 professionals and 16 IDE members replied, equating to response rates of 40.67% (professionals) and 5.36% (IDE).

A methodical approach to question construction was employed in order that the subject matter evoked psychomotor reactions (Anon, 2007), ensuring a dependable judgement and ascertaining the respondent's direction, extremity and intensity of attitude (Peterson & Dutton, 1975, pp. 393-414). Questions were designed to ensure that candidates would remain attentive by randomising their structure, ensuring respondents analysed each statement prior to selecting a singular response. One specific question was manipulated to evoke a considered response by omitting the medial "Fully trained and experienced" category; thus negating any outlying behaviour patterns (Herzog & Bachman, 1981; p. 549).

Ten questions were designed to provide suitable data which would enable the authors' to measure the null hypothesis; that the professional affiliation of respondents does not influence their perception of the demolition industry's professionalism; and assess whether any additional subject variables offered supplementary hypotheses for future investigation. Prime statistical data was comprised of nominal variables, with allocated ratings devised from singularly categorised answers. As variables held a minimum of four categories, production coding was utilised in order to facilitate a standardised media for analytical purposes (Naoum, 2004, p.104). A minimum score of "0" for low status and 4, or 5, for optimum status, allowed candidates to determine their view without compromise, as corresponding ratings were not available. A two-way questionnaire recording scheme (Borgatti, 2007) was developed for analysis, recording and summary purposes. Both sample groups were categorised, with individual questions providing headings to elicit rankings and sub-divisions which would allow simpler referencing, processing and comparative assessment (Anon, 2007).

3.2 Qualitative Data Analysis

Qualitative analysis of contracting organisation interviews was undertaken to provide external, supplementary evidence which would allow the authors' to consider whether a type 2 error had occurred. Interviews were undertaken with two senior members of separate demolition organisations. Both parties had direct, personal experience of professional affiliates and their attitudes, specifically in relation to contracted deconstruction works. Candidates sat semi-structured interviews (Naoum, 2004, p. 57) and were requested to provide answers to set criteria sequentially. Questions were created to reduce the Hawthorne Effect (Vandersluis, 2005) and allow each candidate to express their views openly, avoiding influence. The authors' utilised a positivist approach to maintain internal validity (Bloomer & James, 2001, p. 9) and reduce the possibility of affecting replies (Garson, 2006). Coding was used to section the interview transcriptions (Taylor and Bogdan, 1998, pp. 134-163), with raw data tabulated and assessed for antithetical comment.

4. ANALYSIS, RESULTS AND FINDINGS

The independent variable represented the affiliation of chartered professionals; namely members of the CIOB/ ICE; whilst IDE membership supported the views of the demolition industry; allowing an initial, visual means analysis of "status" based dependent variable responses to provide an analogous illustration of parity. Non-parametric testing was considered suitable as questionnaires were presented to unrelated subjects and produced nominal level data, ensuring summary manipulation of results was ideal for rank analysis utilising a non-directional, unrelated Mann-Whitney test. Cramer's Phi was used to test correlation, with Fleiss' Kappa utilised as an intra correlation test. Cronbach's Alpha was calculated using Seigle's (2007) online Reliability Calculator and was intended to provide further evidence of internal reliability by providing an indication of summarised data and the relative basis as a measure of defined variables.

Mean scores equated to 61.36% (IDE) and 57.20% (Professionals) of the maximum, substantially below predicted differences, suggesting that sample candidate responses to category relationships were ambiguous. As n=40, therefore >32, it was considered that the total number of candidates in the sample was suitable for analysis using large number statistics (Fellows & Lui, 2003, p. 227). A Mann-Whitney, non-parametric test was used to discern "U" based on two-tailed value tables with a significance level of p=0.05 (Billiet, 2003). The results presented figures that suggest U = 176.5 > Critical Value of U = 120 < U Prime = 207.5: P >0.05; ensuring that the null hypothesis (Ho) cannot be rejected (Texasoft, 2004).

Cramer's Phi, at 0.20, presented a low, positive co-efficient of correlation (Connor-Linton, 2003), providing evidence that the IV was marginally influenced by the DV. In this respect, it was considered that supplementary external variables held additional causal effects on the data. Phi² (r²), the variability expressed between variables, provided evidence that non-specific causality accounted for 96% of the respondents' perception of the demolition industry's status (Field, 2002, p. 90). By calculating Fleiss' Kappa, a nominal level, non-parametric, inter-rater correlation co-efficient, the level of internal correlation between candidate's responses was determined. With 'K' calculated at 0.09, the ratings provided evidence of a low agreement (Docktor, slide 27, 2006) and were not considered significant at any prescribed level, subsequently defining poor equivalency reliability (Colorado State University, 2007). In support, confidence intervals were calculated (Howell, 1995), with results depicting a noted difference in the two groups' returns; Professionals 34% and IDE members 17%. In order to test the validity of confidence interval results, Cronbach's Alpha was determined and provided a rating of 0.29. Internal reliability results suggested that the analysis of those individual, grouped questions utilised in sourcing candidate responses was insufficient; ensuring that improved interrogation should be considered in future research (University of the West of England, 2006; Whitley & Ball, 2002, pp. 424-428). Homogeneity was assessed by investigating supplementary subject variables using an unpaired T-test, which presented no significant findings. Issues surrounding internal question reliability and sample validity; possibly as the result of causality (Frankfort-Nachmias and Nachmias, 1996, p.103); violation of the Markov Assumption (Neapolitan, 2007) or the Hawthorne effect; may have been influential in determining the outcome.

Whilst quantitative analysis provided evidence that Ho cannot be rejected, qualitative data was antithetical, claiming institutional support failed to lend credence to the industry and was ineffective. Interviewees concurred that the perception of the demolition industry was based on a lack of client knowledge, with the environment and social exclusion creating negative disposition, increasing impact. It was suggested that aesthetic-based assumptions on organisational capability appeared to be assessed

through visual interrogation affecting credibility through association. Interviewees explained that private contracting organisations were profit focussed and did not consider best practice, restricting timescales and allowing economy to drive safety. Additionally, vague tender documentation, unqualified liquidated damages and extensive payment timescales led to anxiety. Candidates also agreed that supplementary works were frequently expected to be undertaken without any claim.
When questioned regarding training, experience was considered the primary method of ensuring satisfactory site administration; however, training was considered as an effective supplement. In conclusion, it was recommended that client training, particularly in contract protocol was essential, to establish clarity and reduce extensive criticism.

5. DISCUSSION AND CONCLUSIONS

Qualitative interviews confirmed that there was a distinct negativity regarding clients' perception. Causes appeared to be a lack of knowledge, experience and a failure to understand the demolition process; from legislation to operational constraints; leading to antagonism, diametric ideologies and consequently causing homogenous or heterogeneous conflict. Yet, whilst the demolition professionals' career is technically intricate and adaptive, it is often overlooked; contemporary techniques and processes frequently being utilised to provide solutions to complex and diverse problems. Stereotypical techniques are associated with the demolition profession, yet stringent intellectual solutions are also a pre-requisite and can generate awareness. Diversity regarding isolation of industry professionals has contributed to a decline in representative status, communication and a general lack of appreciation. As quality reduced, a product of client time restrictions, personal issues became prevalent, blame cultures becoming adopted as a source of ensuring credulity. Time restrictions impact on material recovery, as demolition projects are often driven to completion without consideration of resource use as a balance against reclamation. Placed in a key position to affect change, demolition organisations can reduce primary material appropriation levels of 77% by enhancing reconstitution, subsequently recovering up to 85% of material. Depletion of some non-renewable resources has been projected as early as 2040 (SAUNER, 2000), further emphasising the importance of reclamation. Increased landfill tax and the reduction of licensed sites (HM Revenue & Customs, 2007; Environment Agency, 2007) has led to restrictions on the classification of waste, subsequently increasing expense. With the construction industry currently recycling 51.33%, this figure represents 33.67% less than could be expected (RICS, 2007). The demolition industry is able to manipulate and arrest economic and environmental cost, reducing the amount of material being used as landfill by increasing reclamation.

As anticipated CDM health and safety prosecutions lead to proposed prison sentences (New Civil Engineer, 2007); it becomes notable that an industry so fraught with inherent dangers is not specifically regulated. Demolition is varied, yet there is no statutory instrument designed to cater for this facet of the construction life-cycle. In order to develop the perception of a pro-active demolition industry, the creation of unified legislation must be considered as a method of integrating whole-life development and sustainability through national interest groups; i.e. NFDC, IDE.

Academic qualification was considered essential criterion in effecting a change in status. At present, no academic UK institutions offer formalised demolition management courses; though accreditation enhances credibility through structured career pathways by assuring technical competency. Project team education, or training, is a necessity prior to the start of demolition works, with training, as a function of development; establishing neurophysiological pathways (Pirenne, 1954, p.153), important in creating relationships and enhancing reasoned action.
Research limitations can be considered a response to literature scarcity, insubstantial Health and Safety records and the study's scope. Population variability was restricted with content and construct validity an issue. It is recommended that further study be undertaken; allowing specificity to be derived from quantitative questionnaires and supplementary professional interviews. A secondary, tertiary study may supplement this research and provide understanding of the demolition industry's professional status, acting as an internal, institutional driver for change.

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INFRASTRUCTURE:
PROCUREMENT AND MARKET BEHAVIOUR

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Abstract: In the Netherlands the Directorate for Public Works and Water Management has changed her procurement policy. The maintenance and exploitation of infrastructure networks will be integrated in future contracts for construction projects. The so-called DBM contracts, Design, Build and Maintain, will be based on the total service life of the construction. But will the market be suitable for those kinds of contracts? The question to be answered is: will the market require a suitable approach for that special situation or will the market behaviour be a response to that market approach? First the research is based on economic and organisation theory. In this paper the approach is focused on the application of the Living Building Concept (LBC) in DBM contracts in the Dutch construction market. Then a model is specified that will be verified in real life cases with respect to the construction of infrastructure projects. The research will confront procurement with market behaviour. The conclusion could be that the LBC is suitable for either the total market or just for a niche of the market for construction, maintenance and exploitation.

Keywords: construction, procurement, economic model, DBM contracts, markets

1. INTRODUCTION

In the Netherlands affordable, available and reliable road infrastructure is vital for today's society. The Dutch government is responsible for spatial planning and the execution of plans, programmes and projects with regard to the infrastructure network. The national government has to implement policies with regard to societal needs. Agencies, like Rijkswaterstaat, the Dutch infra provider, have a program of activities that have to do with maintenance and repair. Rijkswaterstaat is responsible for the efficient execution of these plans according to governmental policies in a way that is beneficial for society, with road networks that are in outstanding shape. To reach that goal, decisions have to be taken at several levels. Management has to coordinate activities at a strategic, a tactical and an operational level as illustrated in figure 1.

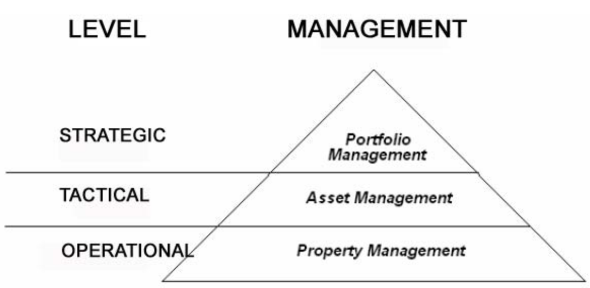

Figure 1: Management levels (Driel 1998)

In order to meet these goals good investment decisions have to be taken at the strategic level and efficient procedures have to be followed. In this research the interaction between the tactical and operational levels is of special interest. On that interface the programming unit (tactical level) has to specify the functions (and values) in such a way that a contractor (operational level) can offer a solution. The Living Building Concept (Ridder 2006), as explained later, shows a possible way to obtain the goals set by government policies with respect to societal needs.

Procurement as an interaction between the tactical and the operational level is highlighted in this paper. Several cases will illustrate the progress made by Rijkswaterstaat in recent years.

Initiatives have been taken in the areas of 'innovative contract arrangements' and PFI's (Private Finance Initiatives). These initiatives have led to new contract forms (Design Build Maintain Finance Operate), new construction processes and new project cooperation concepts. In the Netherlands we have about 10 large (on a national scale) PFI projects in infrastructure. For some of them a DBFM contract is used. The output (contracts) is in accordance with the Government's Strategy, but will the outcome (processes) do the same? Product innovations should lead to reduction of the overall costs of projects (outcome) and to even more innovations in products as well in processes.

But will that be the case? Will the market follow government's strategy?
In this paper the influence of procurement on market behaviour is subject of study.

2. PROCUREMENT

2.1 Strategies of procurement

According to the economic principle at least the variables price and value should be involved in the procurement procedure. In the Living Building Concept this is illustrated in figure 2.

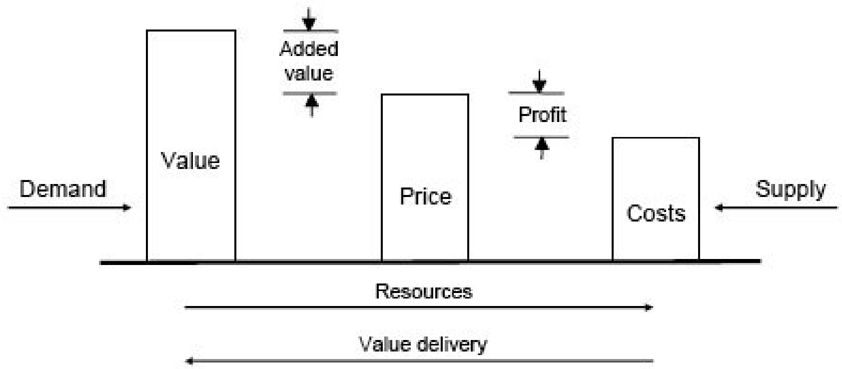

Figure 2: Living Building Concept – definitions (Ridder and Vrijhoef 2006)

The mechanism of the economic principle holds that at a fixed price more value is better. Or the other way around, at a certain value the lowest price is the best. In both cases the return on investment (ROI) is the key indicator of what is the best option, economically.

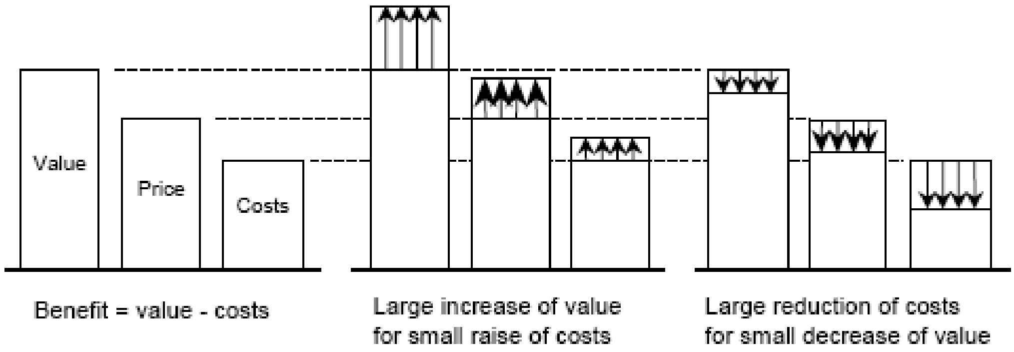

Figure 3: Two basic strategies for maximizing benefit (Ridder and Vrijhoef 2003)

Price competition is the dominant mechanism in building industry markets. At present, lowest price selection seems to be the most used procurement strategy in the public sector. Seems? Because, the economic principle leads to realisation of the highest value for a fixed budget– that means realising the best value/price ratio. This is rational for the 'homo economicus' because he gets the project done for the lowest price. In this paper we are asking ourselves "Is price really the only thing that matters?". Kashiwagi states that this is not the case (Kashiwagi 2002). In his so called 'low bid arena' (selection at lowest price and minimum standards) several drawbacks and the resulting excessive price leads to detrimental effects (exceeding time schedule, budget overruns, poor quality and lots of change orders).

More recent contracts aim at describing the desired result (performance) or functionality based on the principles of system engineering, leaving the contractor the flexibility to decide how to reach that desired result. Innovative contracts, so called in the Netherlands, are DC (Design & Construct), DCM (Design, Construct & Maintain) and DCFM (Design, Construct, Finance & Maintain). Not the lowest bid, but the lowest life cycle cost will be used (as one of the criteria) to determine the Economically Most Advantageous Tender (EMAT).

2.2 Dealing with restrictions – procurement space

In the research the model of the procurement space is used for mapping selection mechanisms, see figure 4. The grey area is the area where suitable options are mapped, but one option could be better than another. How is the prioritising of the suitable options organised and what are the restrictions involved?

In a procurement procedure not all proposals are relevant or attractive to the owner or client organisation. First: a proposal is attractive when the value of a proposal exceeds the price. Second: the Program of Requirements formulate a minimum value. Third: The budget forms a price constraint.

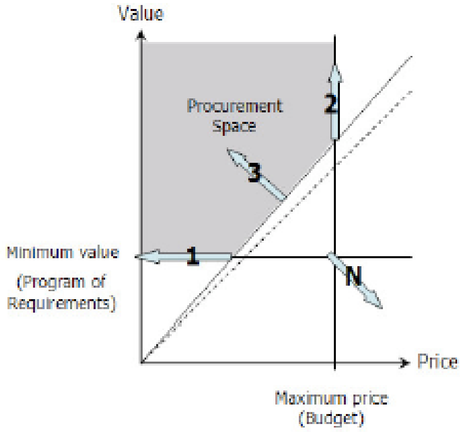

Figure 4: Selection strategies (Dreschler, Vrijhoef et al. 2006)

A number of strategies can be followed as indicated in figure 4 as follows:

1. Minimize price at a given quality (value) level,
   According to the costs leadership strategy (Porter 1980);
2. Maximize value at a given budget,
   Corresponds with a design competition;
3. Maximize value/price within (mentioned) boundaries,
   Corresponds with the selection based on the Economically Most Advantageous Tender.
4. The strategy N represents the tendency to deliver less value for more money, due to optimistic or opportunistic planning and unforeseen events.

Selection strategy #1 is dominant in the Public sector of the Dutch construction industry. Until recent years traditional contracts contain detailed descriptions of the contractors work. That is a minimum standard as mentioned by Kashiwagi. The combination of minimum standard and procurement on the lowest bid gives a miserable result, called the low bid arena, as illustrated in figure 5.

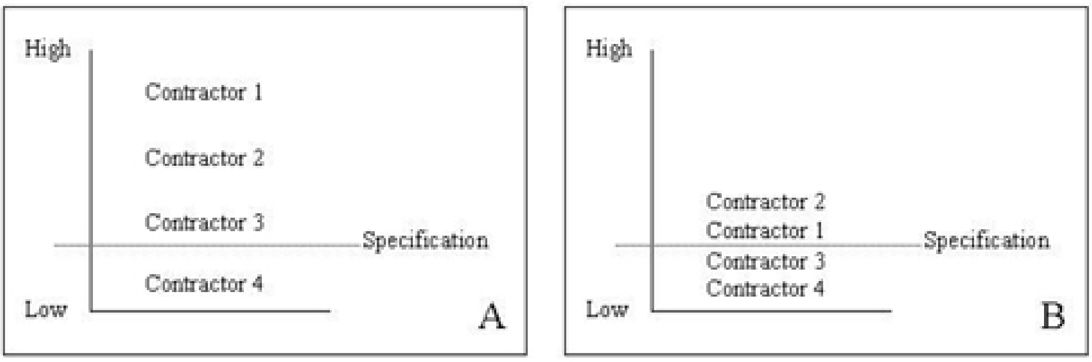

Figure 5: Low bid arena (Kashiwagi, 2002)

In the figure on the left side the contractor 1 is never successful in the procurement process, because he offers to much quality (value) and that's why he does not offer the lowest bid. Contractor 4 does not meet the asked requirements. And contractor 3 will do the job (meets the requirements and is the lowest bidder). As a reaction contractors 1 and 2 will offer at a lower price level in future projects. To do so, they have to bid a lower level of quality by using poor materials and less qualified personnel. That is an unintended outcome, caused by the detrimental combination of the lowest bid and the minimum standard. Unfortunately this situation is often seen in the Netherlands. This traditional way of procurement has some unwanted side effects, like low quality, many change orders, less innovations.

Because of those reasons the Public Sector wants a transition to use selection strategy #3. The expectations are that strategy #3 offers new possibilities and more value for taxpayers' money.

In accordance with that transition Kashiwagi states that the industry has to move to a situation of best value procurement, where Best Value is defined as: delivering on time and on budget while meeting the owner's expectations. Rijkswaterstaat has made some steps towards that situation by changing their procurement procedures.

2.3 Variables of procurement → Price and Value

In tenders price and value (based on quality and performance) are the critical variables. The best combination of these two will form the most economical proposal. But what is the best combination and are there any restrictions? First, the combination that offers the best return on investment is the most preferable. Figure 6 illustrates the relation between value and price assuming that these variables can be determined.

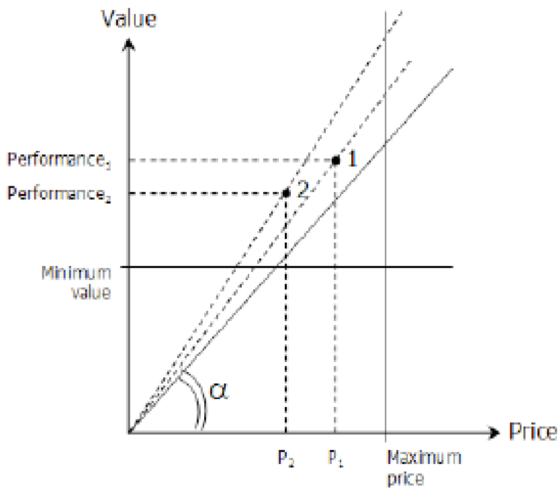

Figure 6: Selection between two proposals (Dreschler, Vrijhoef et al. 2006)

In a tender each contractor is able to submit his specific proposal. Each proposal should be based on life cycle analysis and consists of a system (built object) with associated specifications. The set of specifications represent the value of the system. If the proposal meets the restrictions (quality, requirements, budget) the value to price ratio determines the best value proposal. In figure 6 the angle alpha represents the value to price ratio, The supplier with the highest alpha bid wins the contract. Contractor 2 wins because the ratio $Performance_2/P_2$ is better than $Performance_1/P_1$.

2.4 Selection of relevant aspects

The value of civil engineering objects varies over time: value is a dynamic aspect of constructions. In this matter the technical and economic disciplines will meet each other. In order to assess the feasibility of a project, Cost Benefit Analysis (CBA) can match all costs and all benefits. However it is not clear which stakeholder gets the benefits and who will pay for them. Thus the CBA can determine the ‘overall value’ of a project in relation to the ‘overall costs’.

The research aims to develop “the Sponsor Theory” for assigning costs to budgets. Since only sponsors will provide budgets it seems fair that only sponsors decide what value aspects will come to realisation. If a stakeholder wants to realise a value aspect, that stakeholder has to provide a budget for it and at that very moment that stakeholder is a sponsor. It will be clear that sponsors add budget to the project. But if somebody doesn’t want the realisation of the project because of noise annoyance, he cannot take budget out of the project. However, he has the opportunity to become ‘indirect sponsor’ by asking the Environmental Department for counter measures. If that department can provide a budget for mitigating measures, the stakeholder is an indirect sponsor then.

This is the “Sponsor Theory” (Verlaan and Ridder 2007). Which is in a validation phase. If this theory is validated by current Rijkswaterstaat projects a generalisation can extend the theory to all cases.

On the other hand the LCC analysis (Life Cycle Costing) has the objective to realise the project at lowest long-term cost (rather than short-term savings) for the sponsors. Asset management will play an important role as an integrating process and can be seen in a narrow and broad sense (see figure 7).

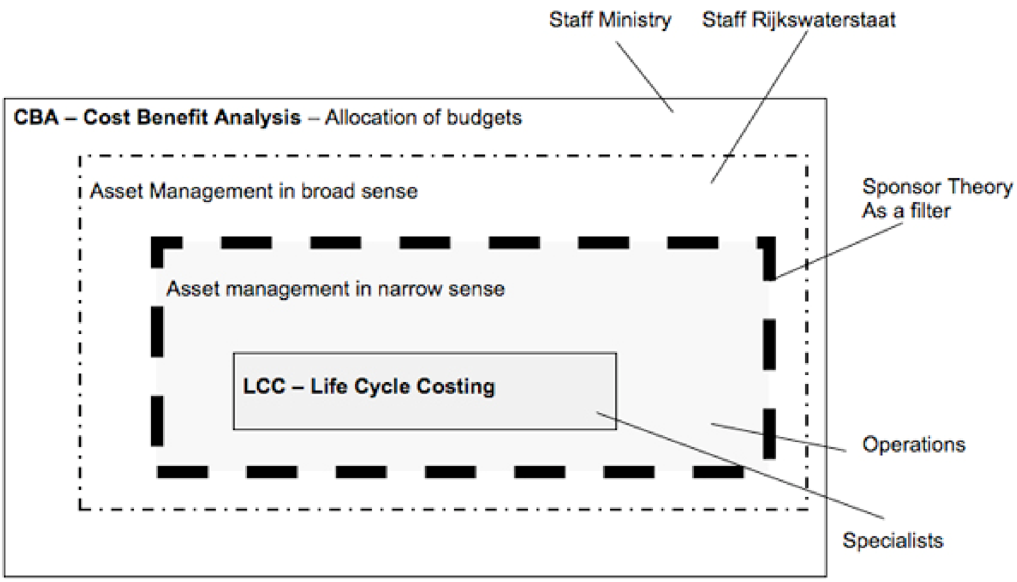

Figure 7: Sponsor theory as a filter (Verlaan and Ridder 2007)

Asset management in a narrow sense aims to keep the assets in optimal condition.

In a broad sense the task is extended by “Does the organisation have the right assets?” (Ingenium / NAMS Group 2002). The policy makers at the ministry use Cost Benefit

Analyses (CBA) for investment decisions. The specialists use the Life Cycle Costing (LCC) instrument to calculate the costs of a project. E.g. these calculations can be used for procurement purposes.

2.5 EMAT – Economically Most Advantageous Tender

Most open tendering procedures in the real world are highly complex, uncertain, and costly. With an increasing emphasis on the quality and value of procurement, economically most advantageous tender (EMAT) has been widely adopted as an alternative, contract-awarding criteria, which has changed competitive strategies in the construction industry.

3. CASES – ZUIDAS AMSTERDAM, ECODUCT LEUSDERHEIDE

Rijkswaterstaat has implemented innovative contracts in some recent projects (Rijkswaterstaat 2004). But will the market react on this procurement strategy in a way as intended. Some projects showed the opposite. To highlight these findings two projects will be mentioned. First the **Zuidas Project**, a €2 billion (plus) PPP/PFI infrastructure and office development in the prestigious Amsterdam area. National and local government as well as contracting, engineering and banking companies, participate in a PPP (Public Private partnership). The goal is to obtain a win-win situation in which all actors will benefit. All costs, benefits and risks, will be shared amongst the participants. Involved parties wanted to act in accordance with the Value/price ratio (strategy #3 in figure 4). A strategic game for attracting / delivering the necessary budgets was started. The minister makes a budget available. Especially the banks will accept this budget and in return they will deliver the asked required functionality. But requirements will not meet the owner’s expectations because they are in the low bid arena by setting the (minimum) standard. Rijkswaterstaat has been forced into a non-strategic position. This is not the position Rijkswaterstaat had in mind at the start of the project. The response of the market is not only the response to the procurement strategy alone. The lessons learned of this project are that setting the standard and making the budget available is not enough. More arrangements are needed to obtain the desired strategic position.

Ecoduct Leusderheide (an ecoduct is an environmental viaduct for wildlife) is another project in which Rijkswaterstaat used new procurement strategy and new integrated contracts (DB, DBM, DBFM). In this project strategy #2 – maximising value at a given budget – was the expected strategy. In this project the price is fixed and value (the standard) is the variable. Contrary to the Zuidas project the owner of Ecoduct Leusderheide is not trapped in the Low Bid Arena and wants to maximise value at a given budget.

The aspects of value as defined by the sponsors are:

1. The ecological function;
2. The architecture of the construction;
3. The hindrance during the construction phase.

In short, the procedure is as follows. An expert committee gives a score to each of the three mentioned aspects in points. The points are transformed to a monetary value (in euros). The proposal with the highest value scored is awarded the project and will be allowed to build the ecoduct for the fixed price. This procedure to optimise value is far better than the situation with pure price competition in combination with a minimal standard (requirements).

4. CONCLUSIONS

In this paper a few procurement procedures are shown. The research question: "does the procurement and market behaviour interact" is answered positively. But whether this interaction is reciprocal is a question that is not easily answered. A few conclusions can be drawn.

- The living Building Concept is an appropriate model to illustrate the value/price maximising strategy;
- The Rijkswaterstaat projects indicate that the value to price ratio strategy will be the best to obtain optimal economic results;
- Experiments with procurement strategies in the Netherlands indicate that optimising these strategies promises more effective and efficient solutions for infrastructure problems;
- The selection of value aspects in procurement procedures could benefit from the Sponsor Theory.

Although the research and its results are promising, additional research is necessary to obtain sufficient proof.

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METHODOLOGICAL REFLECTIONS ON CASE-RESEARCH FOR PARTNER SELECTION IN ARCHITECTURE

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AbstractIn architecture it is very common to select an architect based on the perception of his or her previous work. For more complex projects often a sketch design is asked to get a preview of the architects' work in combination with the specific context of the project. In Europe, public organisations are obliged to tender design work for large building projects according to EU procedures. Judging design value within the context of legislation is crucial in these kinds of procedures. This paper reflects on several case studies in which a judgement is made about the quality of a design. The focus in the paper lies on the methodological challenges and experiences with different kind of research approaches in the context of design tenders. The findings of the cases are discussed and future steps to meet the research objectives are described.

Keywords: case study, decision making, european tender procedure, research methods, partner selection

1. INTRODUCTION

1.1 Problem description

Since 1994 every European public client body is obliged to a European design tender procedure for the design of building projects above a certain amount of money (147.000 Euros for services for central government bodies, 211.000 Euros for services for other government bodies). In the Netherlands this obligation led to a situation in the construction industry where the issues around the selection of design partners come to the surface more regularly. Both architects as well as clients face a lack of knowledge about the right way to implement the EU legislation regarding design services. The fact that most public clients are not professional builders contributes to the growing dissatisfaction on the side of the architects who feel that EU tenders threaten their business in financial as well as creative manner (Maandag, 2007). The procurement system currently being used for architectural and design services has its roots in three distinct systems of selection: tendering for the work, the selective search to identify a suitable designers and the architectural competition (Strong, 1996). While the traditional tender and selective search enables clients to ask design parties for cost estimations and design visions only, the design competition allows clients to consider several designs. At the moment a whole range of mixed procedures is being used interweaving two or three elements of the traditional procedures. Problems occur when these mixed approaches involve taking different parts of integrated system without considering the original role or intent or assessing the effects of the change. In practice, the objectives of securing the right architect and of identifying the best design approach can become intertwined (Strong, 1996).

In the world of architecture design competitions are common and they make news (Strong, 1996). The complications of these phenomena however, might be as common as the competition itself. Spreiregen (1979) talks about three myths in case of design competitions: competitions cost money, competitions take more time and competition designs never get built. However, as with any myth, these biases are not supported by facts. Strangely enough only few publications consider the design competition more thoroughly then showing pictures of the winning design and reflecting the opinion of the jury and some other assessors. The publications that do discuss the premises and weaknesses of design competitions show great similarities internationally in the definition of the problem (Stichting Bouwresearch, 1980; Spreiregen, 1979; Strong, 1996), even though they are all not very recent. Problems mainly concern the honesty of (criteria for) selection of the participants, the communication about the requirements by the client, the objectivity of the judgement by the jury and the financial compensation compared to the amount of work. Because design competitions rarely occurred in the Netherlands, not much action was undertaken to resolve the existing tension between the field of architecture and the client on these matters. Other countries like Finland, Germany or Switzerland established official bodies to support and regulate the organisation of design competitions. It seems like now is the time for simular organisational bodies to find solutions for the consisting problems between clients and architects considering communication, objectivity, and financial compensation during selection, and apply these solutions to the practice of European tendering.

This paper deals with the considerations researchers have to make find solutions for the current problems in selecting an architect. Especially the EU tendering procedures that withhold elements of a design competition are studied. Judging the quality of the designs and the final decision to award the contract to an architectural design firm are considered as two different managerial decisions. Managerial decisions are based on rational and intuitive ways of thinking about the qualities of a design (Beach and Connolly, 2005; Simon, 1987). First we come up with the general possibilities and EU regulations regarding tendering. Based on experiences with different kind of case studies, the methodological difficulties of conducting research on design partners selection are discussed. The paper ends with a short discussion and conclusion about these kind of selection procedures as a research topic and the next steps to take in trying to solve the growing dissatisfaction about this topic in practice.

1.2 Regulations and tendering procedures

Strong (1996, p43) states a definition of what distinguishes a competition from other forms of commissioning. Four criteria are listed:
- There are several entrants
- There is an identical problem for all entrants
- Rules and procedures are prescribed and followed
- Systematic and independent assessment by a panel of assessors is used to select a winner.

There are two principles which can be regarded as providing the foundation for the whole system of architectural competitions world wide:

- The panel assesses the quality of the design against criteria established in the brief
- The whole process is conducted in a fair and equitable manner.

These principles are usually incorporated in standardized formats and model competition conditions. Increasingly, these are being replaced by guidelines setting out good practice procedures. Just a few months ago the Association of Dutch Architects (BNA) published guidelines about European tendering procedures including a model of the procedure conditions (Chao-Duivis et al., 2007a).

Architectural competitions can be open, limited or invited; tendering procedures distinguish open, restricted or negotiated procedures. Restricted or limited procedures are procedures with a pre-selection of the participants. They can be run in one or two stages. They can look for a design approach or a more fully worked proposal. All architectural competitions, whatever their country or origin, share these common attributes (Strong, 1996). The most common European tendering procedures for public clients are (Chao-Duivis et al., 2007b):

- Open tender (in Dutch: public tender)
- Restricted tender (in Dutch: non-public tender)
- Competition based dialogue
- Negotiation procedure
- Contracting by negotiation without announcement
- Contracting by means of a design contest

During these kind of procedures, several methods are used to exchange information between the assessors of the clients and the competitors:

- Interviews
- Written questionnaires and reports
- Discussion
- Presentation of a design approach or sketch design

The restricted tender and the design competition are seen by the architectural profession as most suitable to select a design service. Both these procedures include submitting a design or design approach by the competitors. The design competition allows every interested architectural firm to participate in the tender. The restricted tendering procedure permits the client to take a range of criteria into consideration. It allows the client to first select a minimum of 5 design firms based on prescribed requirements out of all firms that showed interest in this project. Although the EU rules for design contests preclude interviews, presentations and briefing seminars during competition process, the restricted procedures allows some interaction with the competitors. However, the contact moments have to meet the EU ground principles of public information, transparency and non-discrimination.

Restricted design tendering procedures follow the same basic pattern as design competitions as described by Strong (1996). In all these procedures the contracting authority is required to place a notice in the Official Journal of the European Communities setting out the basis on which the contract if offered and the criteria which have to be met. Most of the time this announcement includes a brief setting out the promoter’s requirements. Competitors are invited to respond to the brief in accordance with the set of instructions specifying the type, scale, size and number of drawings and accompanying material to be submitted. An independent panel of assessors is appointed. The panel usually consists of architects and/or other suitably qualified members of the design professions and/or representatives of the client. The panel works on the principle that the entries are judged on the basis of the material submitted and are assessed against the criteria established in the brief. The technical requirements may be checked by specialist-consultants. The panel makes its decision and reports to the promoter who proceeds to commission the architects responsible for the winning the design on the terms set out in the competitions conditions. Prices are awarded and payments made in accordance with the published rules. Most of the time a public exhibition is held of the competition entries and the designs are published on the internet.

One of the key problems with the EU procedures is the cost and work involved in administering the invitation. Response rates can be high. A client organisation may be required to send out a few hundred selection manuals even when it intends to select only a few service providers to tender. There is also a time factor to be taken into account to allow suppliers to react. The limited amounts for projects to be tendered are relatively low so almost all of the projects need official tendering. Organisations are beginning to define their selection criteria more carefully. The key rules seems to be that the selection must be made against acceptable and stated criteria and the contracting agency must be able to defend the basis on which it is made. Architects suspect that in situations other than an open design contest, some firms are invited especially to join the tender or that the selection has already been made (Strong, 1996; Volker, forthcoming). This view is reinforced by the limited penetration of the national markets by international firms. The principle of an open market doesn't really seem to be encouraged by the current practice of EU legislation because of the relatively easy ways to get around it. For example in the Netherlands, clients include restrictions about communication in the Dutch language in their tender. The requirements about a relative high yearly turnover also appear to be a successful strategy to limit the amount of response. This leaves a lot of international and small firms out of competition. In the Dutch professional field of design criticism about the tendering practice is therefore increasing.

2. OBJECTIVES

The procedure that is studied in this research project is called the non-public tendering procedure in the Netherlands. Internationally one refers to a restricted procedure with a pre-selection. This procedure consists of two rounds of selection, based on preset non-discriminatory selection criteria and bidding criteria. Focus in this project lies on the second round of selection in which a minimum of 5 selected architectural design firms develop a sketch design based on an identical global brief. Most of the time the contract is awarded on the basis of 'the economically most advantageous bid'. This means that the client panel of assessors decides on the winner by comparing all design products against the criteria of architectural quality established by the brief. The procedure is described in Figure 1.

The main objectives of our research project are:

- to understand the judging and decision making processes of the assessors on the architectural quality of the selected designs;
- to register the differences in the perception of the assessors of the architectural quality of the selected designs.

These two aspects of judging quality (decision making and differences in perception) are considered to be the key factors of the EU selection procedure for design services and design competitions in general. Both aspects of judging quality are accepted by practitioners, but not really understood because of the high level of complexity and intangible aspects. In this project the judging process is seen as making a decision based on a frame of reference of architectural quality. The frame of reference influences the perception of architectural quality. Therefore assessors show different associations with the quality of the designs. Differences in perception need to be overcome to make a joint decision on the winning design. The assumptions made in this research are based on theories about decision making, environmental psychology and cognitive psychology.

In the first stage of selection, the architectural firms are judged on the competences of their firms based on organizational and performance criteria. In the second stage a judgement is made about the quality of the design approaches as developed by the selected designers and a winner is chosen. We acknowledge the relevance of the first selection stage for the final decision. However, we decided to focus on the second stage because of the direct inclusion of design quality during this stage.

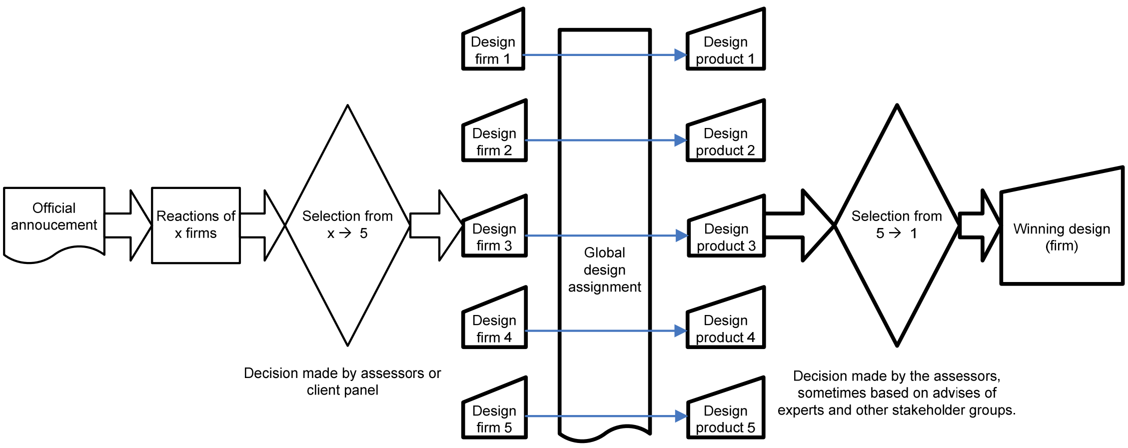

Figure 1: Restricted tendering procedure with pre-selection. Based on Volker (forthcoming).

3. METHODOLOGICAL CHALLENGES

European tenders are the starting point of all building projects with public funding. Schools, government office buildings, town halls and museums are most common projects for public tenders. The design of these kind of projects differ in complexity and architectural challenging features. Judging architectural quality relates to the complexity of the design assignment: the more complex a design, the harder it is to judge the potential qualities. The definition of design quality will always be widely debated because of the intangible and subjective character. So far there are no general criteria to measure design quality. The judgement about quality is usually based on the criteria established by the brief. Every project uses different criteria to define what kind of quality is required. Because of the great influence of the context on the judgement of design quality and the importance of explaining the reasoning behind the phenomena studied in this research, we think that qualitative methods are more appropriate than quantitative research methods in this matter.

This research has an explorative character. Hardly ever research in the field of design or construction management focuses on the measurement of the intangible aspects of design quality in the context of contracting and tendering. Design competitions are seldom studied scientifically (Fisher et al., 2007). The accepted models, guidelines and standardized forms for competitions inform us by derivation about assumptions in judging design quality. These guidelines talk about an experienced panel of assessors, equity of information, anonymity of the designers and hardly any interaction between the competitors and the client. Therefore we usually assume that experts are better at judging design quality than novices. We also think that being familiar with the origin of a design and the way a design is presented could influence our bias about the quality of that design. Next to that we assume that having an interactive dialogue with the designer during the judging procedure could affect our perception of the design. A discussion is going on about addressing points and the use of weighing factors in decision making. The use of weighing factors implies rational decision making during the judgement process. Some of these findings can be derived from similar studies or theories about decision making, marketing and environmental psychology. Further research is needed for explanation of this particular phenomenon.

We decided to explore different kind of research methods because of the uniqueness of the criteria used in the tendering procedures and the lack of sound theories about judging design quality in the context of competitions. Case studies suit this kind of needs (Flyvbjerg, 2004). Case studies can be done by using document analysis, interviews and/or observations and can be performed on current or past activities (Stake, 1995). It appeared relatively hard to find clients or architects willing to fully participate in this kind of research. We assume that this is related to the political sensitivity of the research theme. Therefore we searched also for other cases in our environment that included an element of competition with a (sketch) design and a judgment about design quality by a panel. This led to a random sample of six different kind of case studies in the Netherlands. All cases included at least five designs that were judged by experts during the procedure. The first three cases are examples from practice for selection of a contracting party. The other three cases were for competition and educational purposes only.

So far we have studied six different cases:

1. One case about a the second stage of a limited design tender for a new building for the Institute for the Blind;
2. Three second stages of restricted tenders by public clients; a town hall, a cultural institution and a housing project;
3. Several restricted tenders organized by the Chief Government Architect for the design of two museums, three government offices and a Dutch Expo pavilion;
4. The competition for the best Dutch renovation project of the year 2007;
5. The selection round and the prize winning phase of an international student design workshop competition at the university;

6. An evaluation by a independent expert jury of BSc design work.

The first study about the Institute for the Blind has been found through an acquainted architectural firm. We followed the preparations of this firm by observing the design team and joining the presentation with the client. Then we interviewed the client about the decision making procedure and quality judgements. During this interview the client was not very open about this, probably because our acquainted architectural firm didn't win the tender and the client thought we were going to use the information otherwise. So this interview with the client did not lead to valuable empirical data at all. On the other hand we have concluded that the observations and the method of observation were useful for our research. We used the same method of observation in some of the other cases. The results from this case study are published in Volker & Heintz (2007).

We studied one of the restricted tenders with a pre-selection (the design of a town hall from case 2) very thoroughly using observations during the public presentations and discussion of the designs, reflecting interviews with all the participants (clients, architects and project manager) and analysis of all the documents that were published about the tender. The two tenders about the cultural institution and the housing project and the prize competition of the best renovation project were analysed based on the extensive jury reports. The tenders of the Chief Government Architect (CGA) were studied in case 3 by investigating the files in the archive about communication between the architects, the public client represented by the CGA and the CGA himself and their final report.

Case 2 and 3 about EU design tenders focus on the justification of the decision without being involved in the preparations of the organisation. The case about the town hall provided a lot of information about design perceptions of different stakeholders, because these groups were involved in the decision making by using written surveys and general advisory reports. In the case of the town hall the final decision was made by the clients' steering committee behind closed doors. They did however debate with the city council about their visions so this debate can be seen as a partial substitute of the final decision making.
Most of the jury reports from case 2, 3 and 4 describe the judgement of the jury about the submitted designs very thoroughly. Sometimes the procedure of how the jury reached their decision was described, but the actual considerations between the members of the jury weren't really mentioned. Because these reports have been edited, we assume that the reports only partly reflect the actual process of judgment and comparison with the criteria established in the brief. The communication files from archives of the Chief Government Architect in case 3 did not lead to additional information of use for this project.

Only the student competitions (case 5 and 6) gave us an opportunity to actually study the decision making and quality judgement process of the experts. The internal student design workshop in case 5 started with a first selection round. The student entries were judged on their portfolio by a small panel consisting of the organizer of the competition (a professional architect), the dean of the faculty and a professional designer. The selected students then joined the workshop and produced billboard designs in group formation. These designs were judged by an official jury with known architects and designers from the field. During both rounds of the student competitions we observed the jury members. We also interviewed the dean about his experiences in this competition. Striking about this case was the lack of rules and regulations in the judgement process, while during EU tenders the rules and regulations seem to determine the judgement process. Both the small panel and the official jury weren't really familiar with the objectives of the competition. The organizing committee did not inform the panel members about the procedures to be followed during the judging and the chair of the committee had to be assigned on the spot. The panel members seemed used to this kind of chaotic processes.

This same relaxed attitude was shown by the professional jury at the BSc case in case 6. The jury assigned to judge the BSc design projects was equipped with a description of objectives of the course, the criteria for decision making and their weighing factors. We observed this jury during their considerations. Then we had a short group discussion to evaluate the process. Finally we compared the grades of the teachers with the opinion of the jury. It seemed that the jury agreed with the teachers on most projects. The projects with high grades were also nominated by the jury. The jury members, however, had hardly used the judgemental criteria. These criteria were used only by the teachers who were obliged to structure their judgements into schemes associated with the learning goals.

4. RESULTS AND DISCUSSION

In total we conducted six cases about the judgement of architectural design in a period of one year. The cases differed in aim of the competition, nature of the design but also in depth and the use of research methods to collect empirical data. Not all of the case studies concerned a traditional design competition or a restricted tendering procedure. We increased the sample by using opportunities in our circle of acquaintances. With that we enlarged our research scope and explored different research methods. A point for consideration in this research approach is to keep track of the original research proposal but also be open for more innovative research approaches.

Exploring this phenomena with different kind of cases provided us with a lot of insight in the benefits and disadvantages of the different qualitative research approaches. We evaluated each case study with regard to reaching the research objectives to actually understand the judgement of architectural quality and to register the differences between assessors. The research method should provide data which contributes to building a scientific model about decision making and judging design quality. Based on this kind of evaluation we conclude that the document analysis provided us with a lot of information about differences in quality perceptions by different stakeholders in a relatively limited period of time. However, the kind of information that was collected in the jury reports seemed to be somewhat politically correct and edited, and therefore not reflecting the real considerations of the jury members. The data seemed to lack information which would lead to the actual answer to our research question about decision making. Therefore we conclude that document analysis could is more relevant to study differences in perception than for decision making and should only act in triangulation with other research methods.

During the interviews we collected a wide range of data about the ways of decision making by the client and the preparations and general experiences with the architects.

By interviewing all participants of the project, differences in the perception of some critical elements of the project appeared. Therefore reflecting interviews showed to be of great use, but only if the interviewees are open, qualified and aware of the trustworthiness of the interviewer. We experienced important side effects of conducting interviews. These are the personal relationship of the researcher with the interviewees (and therefore contact with the field of research) and the snowball effect of gathering persons who might be of interest for our research. For this kind of research, interviewing showed to be a powerful instrument when one is exploring a topic *or* when one knows exactly what to ask for. Next to that, the moment of interviewing and the person to be interviewed need to be free of political sensitivities.

The non-participant observations proved to be of most use for our research on decision making individual judgements of the panel members, as well as the group processes. The same advantages as with interviewing were shown: we gathered a lot of contacts and increased our insights in these kinds of processes relatively fast. The most difficult part of doing observations is to find the right cases and the right people who will participate in your research. One of the reasons we decided to enlarge our scope was because, after numerous requests, we still couldn’t find more than one case to observe in an official tendering procedure. Of course it takes a lot of time to note the observations and analyse them. This requires some experience and the development of a reliable noting system. We experienced during the student cases 5 and 6 that working with two observers really improved the quality observations, like is taught in numerous publications about research methods (Mason, 2002; Baarda et al., 2001; Stake, 1995). It also opens up the possibility to discuss the analysis of your data more thoroughly then you would normally do by yourself. As a result the validity of the data increased.

5. CONCLUSION

The EU rules and regulations to select design services seem to stimulate public clients to combine elements of the traditional selection procedures (like design competitions) into one client specific procedure without considering the original role or intent of the procedure, or assessing the effects of the change. Studying decision making during tendering procedures with an element of design competition certainly appears relevant. However, at the moment the field of architectural design lacks a theoretical framework which provides a thorough basis. By using more qualitative research methods, especially case studies based on non-participating observations and reflecting interviews, we think we found a way to study the intangible and complex process of judging design in the context of selecting an architect. The explorative nature of these cases increased our insight on this phenomenon.

Based on the results of this case exploration, we defined three next steps.

1) We will try to find an official restricted tendering procedure in which we are allowed to observe the discussion of the assessors about design quality. We intend to use document analysis and interviews with the panel members to confirm the findings of the observations (triangulation). Based on these findings and the finding of the explorative cases, a conceptual model will be drawn up about the process of judging quality and deciding for a winner of a selection process.

2) To test the conceptual model, we will set up an interview protocol to ask independent experienced jury members about the process of decision making during design competitions and restricted tendering procedures.
3) Depending on the results of the interviews and the status of the conceptual model, we will design a simulation of a judging process in the context of a design competition. We will ask professional clients as well as architects to participate in this simulation.

These three steps will hopefully provide us with guidelines to solve for the growing tension between the architectural practice and the client organisations in architecture about the tendering procedures for selection of design parties. These guidelines will be based on a theoretical framework about decision making in the context of judging design quality. Insight in these kinds of complex and somewhat elusive processes would facilitate the process of collaboration between partners in design. In the end it is the client, the citizen as well as the architect who benefit from a well designed built environment.

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INTEGRATING THE CONSTRUCTION SUPPLY CHAIN BY APPLYING SYSTEMS THINKING

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Abstract: Construction has been dominated by project-based production. As a consequence, the construction supply chain is relatively fragmented, and industry performance has been low. Application of supply chain integration has been deemed a solution to resolve many problems. The work presented in this paper is aimed at building a model of supply chain integration enabling construction parties to develop repetitive and integrated strategies in the supply chain. The model of supply chain integration is built applying a systems approach to the supply chain viewed as a system. First, a generic model is built applying theoretical 'building blocks'. The theoretical building blocks are taken from four theoretical perspectives: social, economic, organisation and production theory. Next, the generic model is being specified and verified by adding empirical 'building blocks'. The empirical building blocks are found based on the analysis and comparison of examples of supply chain integration outside and inside construction. The work will result in a supply chain integration model including corresponding guidelines shifting construction from being project-based towards a repetitive and integrated approach, i.e. from project delivery by occasional coalitions of dispersed firms towards integrated delivery within extended enterprises of aligned firms.

Keywords: construction, integration, model building, supply chain, systems thinking.

1. INTRODUCTION

In construction, the production system, and the supply chain in particular, have been deemed to be disintegrated and inefficient. A more integrated approach to construction has been coined very often as a solution for the many problems and deficiencies existing in construction. On the other hand also the restrictions of integration in construction have often been discussed, particularly because of the temporary nature and dispersed structure of the industry.

In essence, construction can be typified as a specific kind of project-based industry dominated by a project-based and capability-oriented production system. The construction process has previously been observed as a make-to-order, design-to-order, or even concept-to-order kind of delivery process (Winch, 2003). The industry mainly delivers one-off engineer-to-order products (ETO), rather than repetitive assemble-to-order (ATO), make-to-order (MTO), or make-to-stock (MTS) products as delivered by manufacturing types of production systems (Wortmann, 1992). Production system types of construction as well as manufacturing can be dominated by either (one-off) designing or (repetitive) making (Figure 1). Both types of systems are fundamentally different, and 'treating construction as a type of manufacturing obviously neglects design, and arguably subordinates value generation to waste reduction, which inverts their proper relationship'. However, 'certain aspects of construction should move into the realm of repetitive making' (Ballard, 2005).

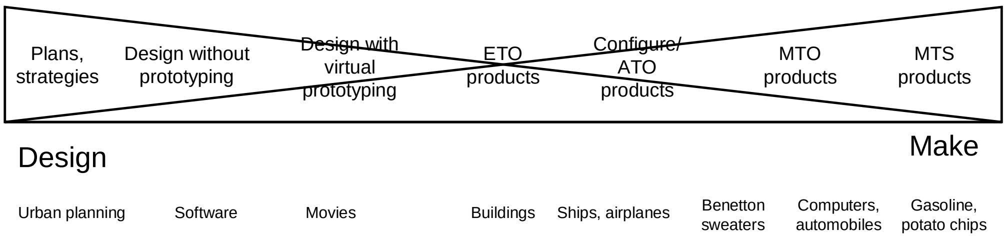

Figure 1: Production system types (Ballard, 2005)

The phenomenon that construction is predominantly a demand-driven process, and design is often disconnected from production, lead to various problems of production. In addition production involves many crafts and many relatively small firms. The mechanisms of causality and interdependence within the supply chain cause problems originating upstream the supply chain to persist and often become worse downstream.
This notion leads to the main idea of the work presented aimed at the development of a model for integrated construction supply chains. This touches on the basic peculiarities of construction as a disintegrated industry, and the negative effects of this on the performance of the construction supply chain. The premise here is that the construction supply chain would function better when approached and (re)built as a single entity, an extended enterprise. In a way, the broader issue is whether construction could or should develop towards the standards of a "normal", more integrated, supply-driven industry.
In contrast to most previous research in this area, the research reported in this paper explicitly endeavours to build a multi-aspect supply chain integration model and corresponding guidelines to enable the integration of multiple firms in the construction supply chain. This paper gives an overview of the status of the research, which is currently underway. In particular, the paper tries to give an insight in the 'building blocks' found in theory and practice, to be used in the process of building the envisaged model further on in the research.

2. VIEWING THE SUPPLY CHAIN AS A SYSTEM

Systems theory views the world in terms of collections of resources and processes that exist to meet subordinate goals. Two aspects of systems theory are of particular importance for supply chains: synergy and entropy. Synergy means the parts of a system working together can achieve more than the sum of achievements that each one would achieve separately. Entropy refers to the necessity of feedback across the chain to prevent debilitation of the system (New & Westbrook, 2004). Hassan (2006) suggested the application of system engineering to the design and formation of supply chains. The structurist character of systems thinking can be helpful building the structure and operations of the supply chain in a systematic manner, assuring its effective functioning.
In terms of systems typology, supply chains are human activity systems and social systems, consisting of actions performed by individuals and groups of individuals, i.e. firms (Checkland, 1981). Supply chains can be characterised as networks between economic actors (e.g. firms), engaged in a voluntary relationship to produce and deliver a product or service. Rouse (2005) considers the nature of firms as systems, and supply chains as 'systems of systems'. This is essential to fully understand and thus be able to find integrated solutions to improve firms and systems of firms, i.e.

supply chains. Rigby et al. (2000) underline the importance of systems thinking for organisational change and improvement, but warn for the risk of underestimation of the complexity of reality when translating this reality into a mental model. Systems approaches are not fully capable of capturing 'soft factors' such as power, trust and human factors.

3. UNDERSTANDING THE CONSTRUCTION SUPPLY CHAIN

3.1 Industry structure

Often the construction industry has been characterised by complexity, referring to the demography of the industry (many SMEs and specialist firms) and the organisation of construction, including the configuration and coordination of construction supply chains. Indeed construction as such is a less structured industry compared to other industries, with a vast network of actors of different kinds around a project, i.e. the development and construction of a built object (Figure 2).

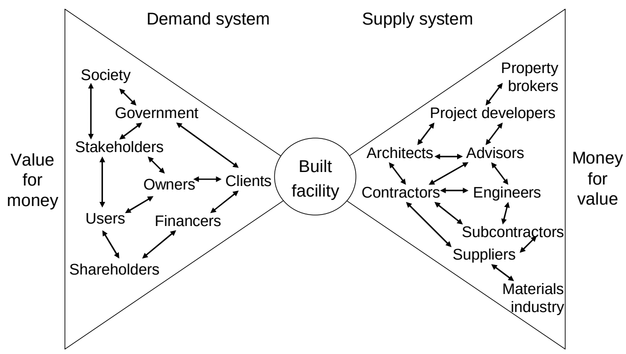

Figure 2: Demand and supply systems in construction (Vrijhoef & De Ridder, 2005)

3.2 Make-to-order delivery and craftsmanship

Construction supply chains are make-to-order supply chains, where project management and engineering are important issues. The fact that construction is often a demand-driven make-to-order process, and design is often disconnected from production lead to various problems of production. The producer is not the designer, and production is very much influenced by craftsmanship. Moreover production involves many crafts and many relatively small firms. This causes problems originating upstream the supply chain to persist and often become worse downstream, because of the mechanisms of causality and interdependence within the supply chain.

3.3 One-of-kind and on-site production

Most production in construction is one-off and done on site. The 'factory' is organised on site, and mostly very few materials and components of the end products are prefabricated or preinstalled off site. The logistics in construction are converging, meaning relatively many suppliers are directly involved for the production of an end product for one or very few customers. On the other hand, buildings are physically, economically and socially linked with their environment in terms of use of space and surface, availability of resources and capital, local design and construction practices.

3.4 Role of the client and user

In most construction projects the end-customer is of the start as well as the end of the entire process, and therefore the customer and end-users play a dominant role in construction. This also causes the make-to-order mechanism and the need for reactivity in construction supply chains. This is the reason why in construction products are rarely 'launched' and 'marketed' as in other industries, and why construction is different than most other industries, e.g. consumer goods. Most contractors are no manufacturers of integrated end-products. Most products are not standard, and processes are not repetitive, and often causing high levels of waste (Vrijhoef & Koskela, 2000).

4. AIMS OF SUPPLY CHAIN SYSTEMS ENGINEERING

The low levels of integration and repetitiveness in construction add to the problems and underperformance of the construction supply chain (e.g. Vrijhoef & Koskela, 2000). Concepts that increase integration and repetition within and between project supply chains such as in partnering arrangements should help resolving this (e.g. Bresnen & Marshall, 2000). Systems engineering can help in a sense that systems engineering's goal here is supply chain integration, and to 'engineer problems out' of the supply chain i.e. the production system (Hassan 2006). Stevens (1989) points out the importance and possibilities of supply chain integration for companies to react to market conditions and reduce cost levels. In order to do so, 'virtually all firms and functions' in the supply chain should be connected, operating as it were a 'factory without walls'. However, in many cases, it is simply impossible to fully integrate an entire supply chain (Fawcett & Magnan, 2002). This is particularly true for temporary and fairly disintegrated construction supply chains.

This all means that supply chain integration should be able to contribute substantially to the overall performance improvement of construction, enabling to deal with the diversity of demand, and reduce the instability of the production environment. It also improves the efficient integration of construction inputs and new technologies, and harnesses the delivery process against the impact of 'environmental turbulence'. This more centralised mode of process control calls for a central role in the supply chain: the system integrator. This role could be divided in two partial roles: the demand system integrator and the supply system integrator (Figure 3). For instance the client or his representative could take up the demand integrator role; the main or prime contractor could take up the supply integrator role (Vrijhoef & De Ridder, 2005).

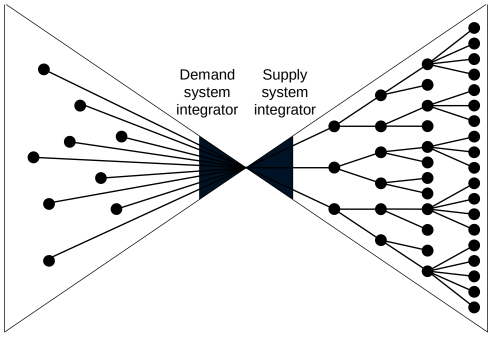

Figure 3: The role of the demand and supply system integrator (Vrijhoef & De Ridder, 2005)

5. RESEARCH APPROACH

The research presented follows the ideas of theory building from case studies as introduced by Eisenhardt (1989). The approach is semi-inductive starting from theory and case studies (building blocks), shaping hypotheses, and from there building a theory (model). This corresponds with the ideas of 'constructive research', which combines the analysis of existing phenomena and building new concepts at the same time. This kind of research is aimed at designing 'solution-oriented research products', rather than deducing 'analysis-based explanations', while viewing management research as design or engineering science (Van Aken, 2005).
The research approach could be summarised as an engineering approach, i.e. engineering a supply chain integration model as it were a system that should be functional and useful. This engineering process starts by building the generic supply chain integration model using the theoretical 'building blocks' found in the four theoretical perspectives presented below: social, economic, organisational and production. The generic model built from the theoretical building blocks will next be validated by confronting it with empirical evidence from case studies of supply chain integration, outside and inside construction.

6. THEORETICAL BUILDING BLOCKS

6.1 Supply chain viewed as a social system

In construction the relations between firms are typically maintained for the duration of the project. Supply chains are not merely directed towards minimizing transaction costs, but also towards enhancing the transfer of expertise and systematic feedback between parties, and ultimately towards joint value maximization. Increased co-operation and integration between supply chain parties enables delivery of a total product with quality guarantees to the market. Bounded rationality and differences in know-how between firms would be resolved by joint product development. Opportunistic behaviour is then replaced by mutual trust, which obviously is necessarily for an open dialogue, and an optimal knowledge sharing.
On an industry scale, Dubois and Gadde (2002) distinguish tight couplings in individual couplings in projects and loose couplings in the permanent network within the industry as a "loosely coupled system". The pattern of couplings influence productivity and innovation, and the behaviour of firms. In terms of organizational

behaviour, cultural and human issues such as trust and learning have been indicated as major implications on construction supply chains (Love et al., 2002). The social systems approach therefore lays the socio-organizational basis for improved inter-firm relationships within the supply chain.

6.2 Supply chain viewed as an economic system

In economic terms a supply chain is a series of economic actors, i.e. firms buying from and selling to each other. From an economic perspective the choice of a co-ordination or governance structure is made by economizing on the total sum of production and transaction costs (Williamson, 1979). Transaction cost economics (TCE) provides an explanation for the existence and the nature of co-ordination within a supply chain (Hobbs, 1996). When transaction costs are low, contracting is used (i.e. market structure), while internalization will prevail for high transaction costs (i.e. hierarchy). Intermediate modes are often referred to as hybrid modes (Williamson, 1991).

TCE recognises that transactions do not occur without friction. Transaction costs arise from the interaction between firms. These include costs for supplying information, negotiating, and monitoring or enforcement (Hobbs, 1996). Transaction costs would be zero if humans were honest and possessed unbounded rationality. Transactions costs for a particular transaction depend on the three critical dimensions: asset specificity, uncertainty and frequency (Williamson, 1985). Besides, Milgrom and Roberts (1992) add two more items: difficulty of performance measurement, and connectedness to other transactions. Both are relevant from a supply chain viewpoint, and influence the possibilities to reduce transaction costs. Obviously improved collaboration and communication in the supply chain will reduce transaction costs.

6.3 Supply chain viewed as a production system

The supply chain is aimed at the delivery of a product or service to an end market or a single customer. This implies a production process which is purposive. The management of the production process needs to ensure the purpose of the process is achieved effectively and efficiently by addressing the transformation (conversion), flow and value aspects of production in an integrated manner (Koskela, 2000). Following the analogy of the firm, all primary and support activities must be aligned and aimed at the delivery of customer value, and as a result profit of the supply chain (Porter, 1985).

6.4 Supply chain viewed as an organisational system

Firms as well as supply chains are organisational systems built from various vital elements that make them function as they do. By viewing organisations as systems of flows, Mintzberg (1979) identifies four system representations of organisations together making up the structure and infrastructure of organisations; the organisation as a system of formal authority, regulated flows (material, information), informal communication, work constellations, and ad-hoc decision processes.

Typically, the supply chain is a ‘system of systems’, or a ‘superstructure’ of organisations’. Firms along the supply chain perform distributed production activities and business functions. This raises the issue of core competences of firms (Prahalad & Hamel, 1990), together making up an ‘extended enterprise’. In construction this relates to the idea of the ‘quasi-firm’ coined by Eccles (1981).

7. EMPERICAL BUILDING BLOCKS

Based on the theoretical building blocks, first a generic supply chain integration model will be built. The generic model will next be specified and validated by adding empirical ‘building blocks’ from few case studies of supply chain integration outside and inside construction. These case studies include multiple cases including the four cases below, i.e. two companies outside construction (truck manufacture and shipbuilding), and two construction firms (housing and commercial building). For reasons of limited space in this paper, below the four cases are described very briefly.

7.1 Two examples of supply chain integration outside construction: truck manufacture and shipbuilding

In the early 90s the Dutch truck industry went to a crisis. After drastic reforms most companies recovered, and are currently doing quite well. One of the measures was to reform and integrate the supply chain. Suppliers have been integrated in product development, planning and logistics. Towards the clients, in Europe, an integrated dealer network has been established, which assures direct follow-up of defects to trucks, and 24h on-road maintenance.
In the Dutch shipbuilding industry, few producers have improved their businesses drastically. They are globally leading companies in few product categories. For those products they have introduced strict standardisation and modularisation, and imposed this on their suppliers. This has improved the profitability and quality dramatically. Some suppliers have become ‘external business’ units, guaranteeing the close links.

7.2 Two examples of supply chain integration inside construction: housing and commercial building

In the Dutch housing sector, few builders have transformed their business and became suppliers of completely pre-engineered house. They deliver houses from their catalogues to be built in 1 week. The different types of houses can be customised completely according to clients’ wishes. The fully integrated in-house production and pre-installation of the houses assure a smooth process, and prevent delays and quality problems. In addition to the delivery of the house itself, they arrange for the permissions from local governments, mortgage, and other additional issues.
In the Netherlands, many project developers have moved their business towards the ‘front end’ of the supply chain. They have acquired land and existing building to be developed and redeveloped. Additionally they deliver all services desired by their clients including finances, maintenance, facility management and operations such as security and restaurants of offices. Some project developers have integrated the supply

chain to such an extent that they actually became their own clients, in order to find users of their projects after completion.

7.3 Comparing supply chain integration outside and inside construction

When comparing the examples of supply chain integration inside and outside construction, one sees differences as well as similarities. Differences can be found in the possibilities to pre-engineer products, and integrate the supply chain. Outside construction the levels of pre-engineering and integration are higher, because levels of repetition are generally higher. Similarities can be found in the mechanisms to integrate design, follow-up clients, and offer additional services to clients. Apparently these issues are generally valid and play a role in most industrial sectors.
However, the characteristics of industries vary from industry to industry. The production system of each industry has been shaped by the industry characteristics and history. Project production systems in project-based industries such as construction are aimed at a product mix that is 'one of a kind or few', process patterns are 'very jumbled', processes segments are 'loosely linked', and management challenges are dominated by 'bidding, delivery, product design flexibility, scheduling, materials handling and shifting bottlenecks' (Schmenner, 1993). The fragmentation of the construction industry has been identified since decades as a major point of the complaints about the state of practice (Turin, 2003), reflected most characteristically by the predominant one-off approach in construction projects, or 'unique-product' production (Drucker, 1963).

8. IMPLICATIONS OF SUPPLY CHAIN INTEGRATION

8.1 Implications from a demand system perspective

Traditionally, clients have played an important and dominant role in construction (Cherns & Bryant, 1984). Also with regard to supply chain integration, the client's role can be rather critical, while he makes the initial decision to procure construction works and the way in which procurement takes place (Briscoe et al., 2004). Clients who have the power to shift their procurement strategies vis-à-vis the market are in the position to align the supply chain effectively, and implement supply chain integration successfully (Cox & Ireland, 2001). In these cases, procurement strategies must therefore be aimed at establishing long-term relationships in the supply chain. Few advanced and professional clients with "buying power" have created multi-project environments and manage their procurement through a portfolio approach (Figure 4), aimed at the increase of repetition and creating similarities between multiple projects, and thus increasing the degree of project certainty and "supply chain stability" (Blismas et al., 2004). Often these clients have successfully introduced a strategic long-term approach to procurement, which has proved to be particularly effective for certain sectors in construction (Cox & Townsend, 1998).

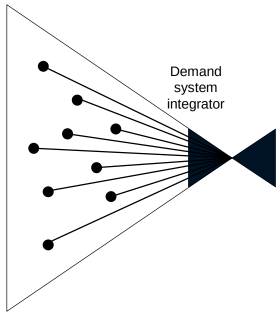

Figure 4: The role of the demand system integrator (Vrijhoef & De Ridder, 2005)

8.2 Implications from a supply system perspective

At the supply side, parties have evolved towards more integrated arrangements through project-independent collaboration with other parties in the supply chain as well as internalisation of neighbouring activities or businesses. In both cases operational and competitive advantages, through higher levels of productivity and efficiency as well as delivering better client value are the drivers for this kind of supply chain integration. Normally this development is lead by a focal firm, the system integrator; this could be a main contractor, but also an architect or engineering firm (Figure 5).

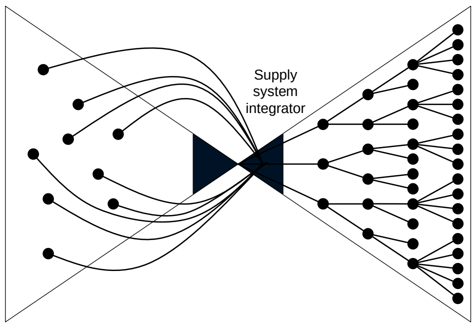

Figure 5: The role of the supply system integrator (Vrijhoef & De Ridder, 2005)

9. CONCLUSIONS

Theory as well as examples from other industries claim and demonstrate the value of supply chain integration. This is also true for construction. Due to the characteristics of construction, a specific model for supply chain integration in construction must by adapted and built, including guidelines for firms along the supply chain in different types of construction. A systems approach as proposed in this research is helpful to build the integration model and improve construction supply chains. This exercise includes a 'building exercise' using theoretical building blocks (concepts) and empirical buildings blocks (cases) leading to a 'change model' of 'organisational rebuilding' of existing construction supply chains. In order to do so all functions along a supply chain in fact need to be decomposed, followed by reconfiguration of the functions and the interfaces between these functions. By doing this, the endemic problems and irrationalities should be 'engineered out' of the construction supply chain, and eliminating existing problems including their negative symptoms. The side effect must be that the control of different functions will get more aligned and centralised, transforming the supply chain into an integrated structure, i.e. extended enterprise.

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VIBRATIONAL BEHAVIOUR OF TIMBER FLOORS — EXPERIMENTAL INVESTIGATIONS

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Abstract: Vibration of timber flooring systems in dwellings often causes inconvenience to the occupants. In particular, this happens due to the wide use of engineered timber beams for constructing large-span floors. This problem is not well addressed in the present design codes, such as the British Standard BS5268 or the Eurocode 5 (EC5) with the UK National Annex to EC5. Comprehensive parametric and experimental investigations are being carried out at Napier University to examine the influence of parameters including varied decking materials (boards), fixing methods, boundary conditions, joist dimensions and arrangements, varied dead weights and floor size. A range of tests on full-scale timber flooring systems with over 50 different configurations have been accomplished. This paper presents the variation in dynamic response due to some modifications on the flooring systems. The final aim of the project is to provide recommendations and enhanced guidelines for appropriate design of timber flooring structures with respect to dynamic response.

Key words: Dynamic response, EC5, serviceability, timber floor, vibration.

1. INTRODUCTION

The development of composite timber materials has widely led to the construction of relatively large-span flooring systems. This has resulted in serviceability issues such as undue floor vibrations, causing inconvenience to the occupants. The current design criteria cannot provide adequate solutions for all cases. The vibrational response of flooring structures has to be considered in more detail during the design process. Intensive experimental and analytical investigations on timber flooring systems are undertaken at Napier University to assess the parameters that influence the dynamic response. According to EC5-1-1, unit point load deflection and unit impulse velocity response of the flooring structure shall be within their limits, and its fundamental frequency shall be over a threshold, say 8 Hz, to obtain satisfactory dynamic performances. The unit impulse velocity response originally proposed by Ohlsson (Ohlsson, 1982, 1988) is difficult to be measured directly (Hu, 2002). An approach to vibration amplitude can be made by consideration of the damping ratios, as part of the undertaken research.

This paper, however, focuses on the variations in natural frequencies and unit point load deflections of two-side supported flooring systems of varied configurations. It concentrates on those modifications which are related to current common construction practices in the UK. These and further investigations follow the results of an extensive experimental study on the appropriate design criteria (Weckendorf et al., 2005) while earlier preliminary experimental results were partially compared with the calculated ones based on the EC5-1-1 design criteria (Weckendorf et al., 2006). To undertake the research detailed in this paper, full-scale timber flooring systems with two different dimensions and I-joist depths were built by Oregon Timber Frame Ltd. Potential benefits of using adhesives in addition to screws to fix decking boards to the joists and enhancing fixity at the supports were examined. The impact of increased floor span has also been studied. The preliminary results of these experimental investigations are presented here.

2. EXPERIMENTAL INVESTIGATIONS

Twelve configurations of the full-scale timber flooring systems were tested, with six variations for each of the two dimensions. Alterations were made for the fixing methods and boundary conditions. Floor 1 had dimensions of L×B = 3.7×4.4 m with the I-joists which are 200 mm deep and 400 mm spaced. The decking boards were connected to the joists using either screws of ϕ3.9×55 mm, or water resistant wood glue complying with the requirements for Durability Class D3 defined in BS EN 204:2001. Floor 2 had dimensions of 5.0×4.4 m with 302 mm deep I-joists. The same joist spacing and variations as Floor 1 were adopted. The floors were supported along two sides at the joist ends. For simply supported systems the floor was laid on the top of the supports with no connection. For other cases, the rim-boards were screwed to the supports to enhance rigidity, with two screws equally placed between two adjacent joists. This condition is termed as "semi-rigid" although the condition "semi-rigid" may have not been obtained at all. Figure 1 shows the steps of constructing a typical floor. The floor configurations are presented in Table 1.

(a) A timber frame was fixed to the concrete floor using nails.

(b) Supports were fixed onto the timber frame using screws.

(c) The floor structure was constructed before placing decking boards.

(d) A floor, decked with OSB and supported along two edges, was completed.

Figure 1: Construction of timber floor cassettes

Table 1: Floor configurations

Floor	Size [m]	Configurations
FT-1A-Pa	3.7×4.4	simply supported along two edges, particleboard screwed to joists
FT-1A-Pb	3.7×4.4	simply supported along two edges, particleboard glued + screwed to joists
FT-1A-O	3.7×4.4	simply supported along two edges, OSB screwed to joists
FT-1B-Pa	3.7×4.4	semi-rigidly supported along two edges, particleboard screwed to joists
FT-1B-Pb	3.7×4.4	semi-rigidly supported along two edges, particleboard glued + screwed to joists
FT-1B-O	3.7×4.4	semi-rigidly supported along two edges, OSB screwed to joists
FT-2A-Pa	5.0×4.4	simply supported along two edges, particleboard screwed to joists
FT-2A-Pb	5.0×4.4	simply supported along two edges, particleboard glued + screwed to joists
FT-2A-O	5.0×4.4	simply supported along two edges, OSB screwed to joists
FT-2B-Pa	5.0×4.4	semi-rigidly supported along two edges, particleboard screwed to joists
FT-2B-Pb	5.0×4.4	semi-rigidly supported along two edges, particleboard glued + screwed to joists
FT-2B-O	5.0×4.4	semi-rigidly supported along two edges, OSB screwed to joists

2.1 Dynamic Tests and Data Processing

A laptop, a data recorder and sensors were the main parts of the test equipment used with the *natural input modal analysis technique*. This technique is so called because ambient noise can be used as excitation force. However, earlier trials showed that brushing the floor surface is the better exciting method with regard to timber floors. The software ARTeMIS Testor was used for test preparation and accomplishment. A grid (mesh) was generated in the software to represent the floor system, and the same grid was drawn on the floor surface. The node points served as the measurement points. Sensors were attached to these node points and connected to the data recorder, which was connected to the laptop. Thereafter the floor structure was excited by brushing. The vibrational motion of the structure was detected by the sensors and converted into electrical signals, which were then recorded by the data recorder. The vibration in vertical direction was of interest and thus was measured.

The Enhanced Frequency Domain Decomposition (EFDD) is one of several analysis techniques and can be used to analyse modal data from vibration response measurements where only the output of the structure is recorded. The software ARTeMIS Extractor was used for this investigation. The movement was recorded over a period of time, normally 100 seconds. The recorded signals were processed by the Fast Fourier Transform (FFT) and displayed in the frequency domain. The peaks, likely to present the natural frequencies, could be selected (Figure 2). The vicinity region of the selected peak, the modal peak, was used to establish the spectral density function on which an inverse FFT was performed. The frequency was finally estimated in the time domain.

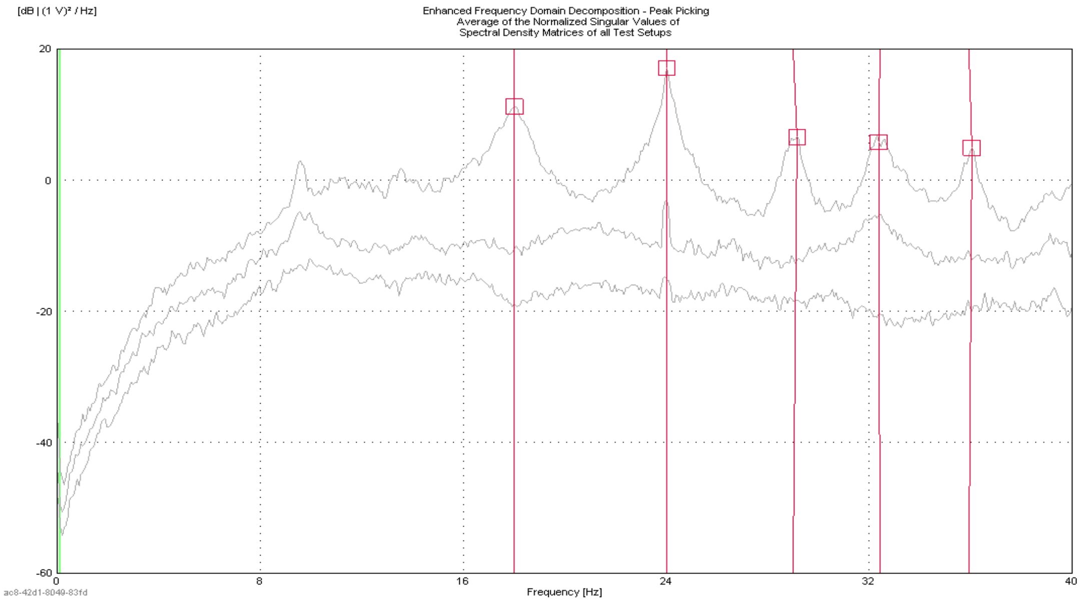


Figure 2: The response of floor FT-1B-Pb in the frequency domain with the first five natural frequencies selected

2.2 Static Deflection Tests

The floors with a width of 4.4 m and a joist spacing of 400 mm required twelve joists, which means that no joist was running along the centre line. The deflection was, however, measured in the centre of the floor. The load was positioned onto the two joists placed 200 mm away from the centre line.

Ten steel I-sections, each weighing 100 N, were used to apply a load of 1 kN to the floor centre. A dial gauge with an accuracy of 0.01 mm was fixed to a scaffold post running across the floor and placed at the centre point on the top floor surface. Four more dial gauges were used to measure the displacements at the middle point of each edge (Figure 3). This was to examine if there were noticeable movements at the edges when the central point of the floor was deflected by loading. Movement at the edges perpendicular to the joist direction would have to be deducted for calculating the net deflection of the floor.

The results were easily influenced by slight movement of the dial gauges or the steel sections. To obtain stable results, the deflection tests were repeated up to two times when the floor recovered after unloading. The averaged deflection values are used for the comparison.

Figure 3: Setup for the deflection test

3. RESULTS OF DYNAMIC AND STATIC TESTS

The results were compared with regard to the first three natural frequencies and unit point load deflection to study the impact of varied floor span, end fixity and composite effect of decking and joists on the floor performance.

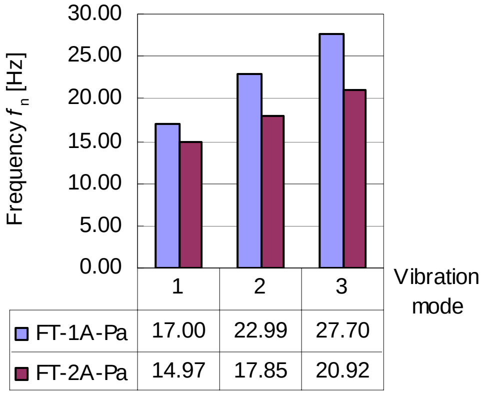
3.1 Effects of Floor Span

The floors of two different dimensions have been compared for all configurations. The results are shown in Table 2 and Figures 4 and 5. A significant decrease in the natural frequencies can be observed for an increase in the span from 3.7 to 5.0 m.

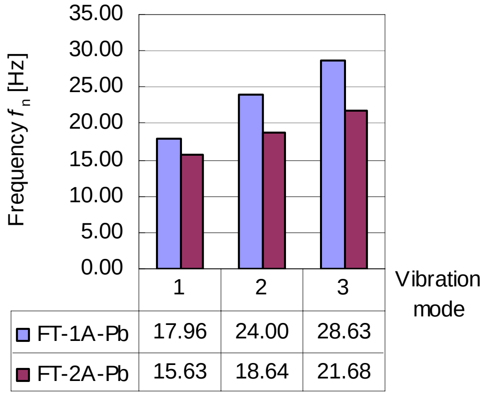
Table 2: Comparison of different floor spans

Floor	Frequencies of first three bending modes			Deflection
	f_1 [Hz]	f_2 [Hz]	f_3 [Hz]	a [mm]
FT-1A-Pa	17.00	22.99	27.70	0.97
FT-2A-Pa	14.97	17.85	20.92	1.44
Variation [%]	**-11.94**	**-22.36**	**-24.48**	**+49.22**
FT-1A-Pb	17.96	24.00	28.63	0.72
FT-2A-Pb	15.63	18.64	21.68	0.90
Variation [%]	**-12.97**	**-22.33**	**-24.28**	**+25.00**
FT-1A-O	19.71	25.87	29.98	1.32
FT-2A-O	15.80	19.76	21.63	1.79
Variation [%]	**-19.84**	**-23.62**	**-27.85**	**+35.61**
FT-1B-Pa	17.53	23.58	28.06	0.96
FT-2B-Pa	15.24	18.51	21.48	1.29
Variation [%]	**-13.06**	**-21.50**	**-23.45**	**+34.55**
FT-1B-Pb	18.01	24.04	29.00	0.72
FT-2B-Pb	15.63	18.53	21.66	0.87
Variation [%]	**-13.21**	**-22.92**	**-25.31**	**+20.74**
FT-1B-O	20.12	27.17	30.39	1.04
FT-2B-O	16.21	20.53	22.29	1.26
Variation [%]	**-19.43**	**-24.44**	**-26.65**	**+21.15**

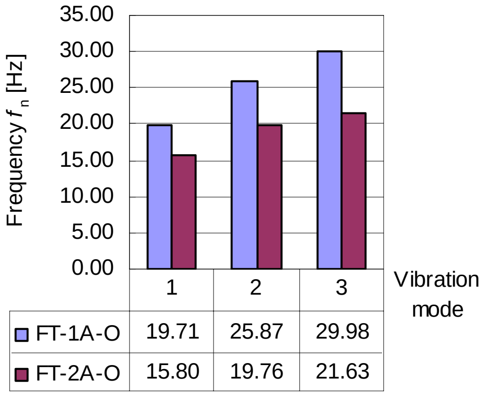
This significant negative variation in frequencies occurred although the joists for the larger floors were over 50% deeper (200 mm to 302 mm) than those of the smaller floors and thus stiffer. The decrease in fundamental natural frequency was up to 13.21% for the chipboard decking and up to 19.84% for the OSB decking. The higher frequencies were less influenced by the deck properties. The raise in deflection was above 20% in all cases.



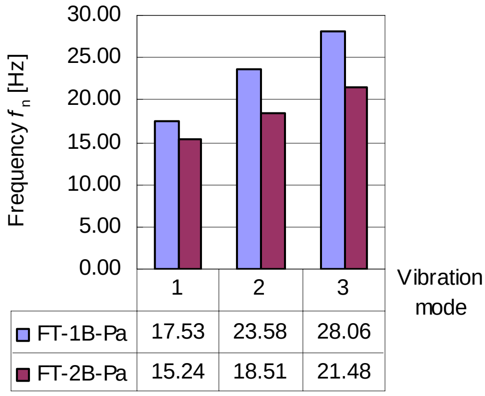
(a) FT-1A-Pa versus FT-2A-Pa



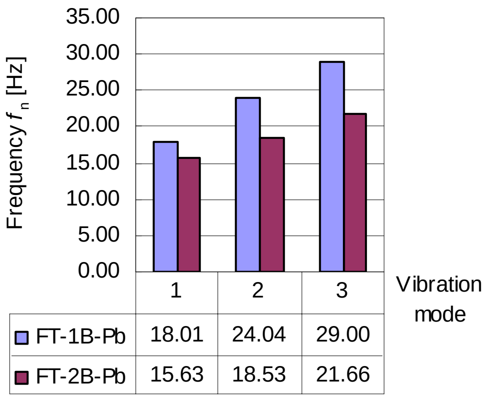
(b) FT-1A-Pb versus FT-2A-Pb



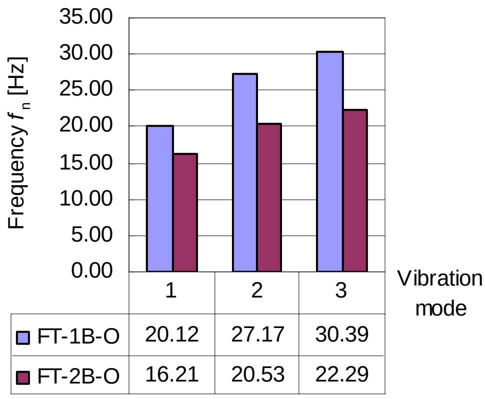
(c) FT-1A-O versus FT-2A-O



(d) FT-1B-Pa versus FT-2B-Pa



(e) FT-1B-Pb versus FT-2B-Pb



(f) FT-1B-O versus FT-2B-O

Figure 4: Comparison of the first three bending modes of small- and large-scale floors with six varied configurations

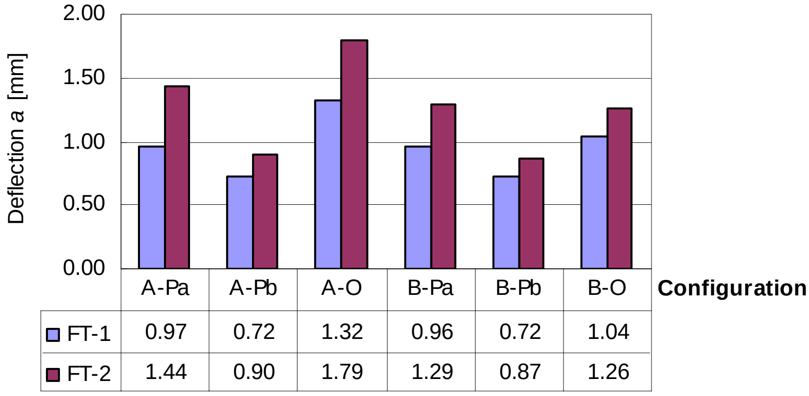


Figure 5: Comparison of the deflections of the floor with varied configurations for the two spans

3.2 Effects of Adhesives in Addition to Screws

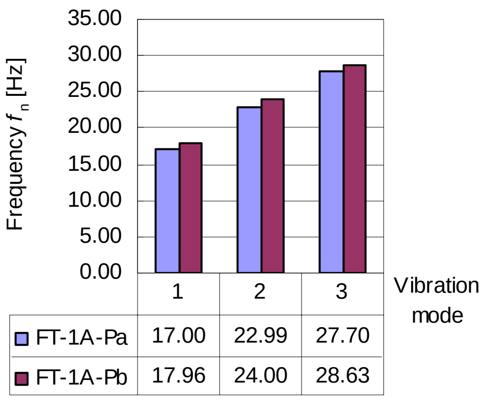
For each span, four floors were compared to study the influence of adhesives in addition to screws at a spacing of 300 mm for fixing the decking to the joists. In all cases the frequencies rose slightly. The results show clearly that deflections were lowered when glue was used. There are improvements of at least 24.26% for the short-span floor and up to 37.50% for the long-span floor. Table 3 and Figures 6 and 7 illustrate the test results.

Table 3: Comparison of different fixing methods

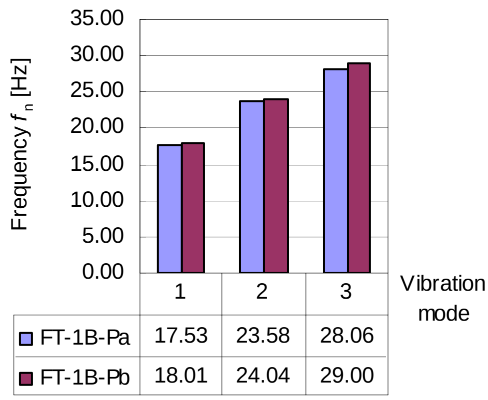
Floor	Frequencies for the first three bending modes			Deflection
	f_1 [Hz]	f_2 [Hz]	f_3 [Hz]	a [mm]
FT-1A-Pa	17.00	22.99	27.70	0.97
FT-1A-Pb	17.96	24.00	28.63	0.72
Variation [%]	**+5.65**	**+4.39**	**+3.36**	**-25.39**
FT-1B-Pa	17.53	23.58	28.06	0.96
FT-1B-Pb	18.01	24.04	29.00	0.72
Variation [%]	**+2.74**	**+1.95**	**+3.35**	**-24.26**
FT-2A-Pa	14.97	17.85	20.92	1.44
FT-2A-Pb	15.63	18.64	21.68	0.90
Variation [%]	**+4.41**	**+4.43**	**+3.63**	**-37.50**
FT-2B-Pa	15.24	18.51	21.48	1.29
FT-2B-Pb	15.63	18.53	21.66	0.87
Variation [%]	**+2.56**	**+0.11**	**+0.84**	**-32.04**

3.3 Effects of End Fixity

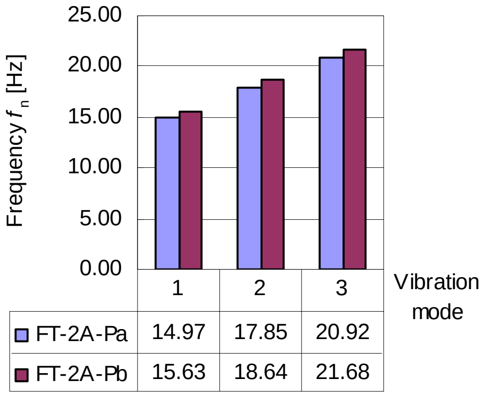
The influence of providing some end fixity by screwing the rim-boards onto the supports can be seen from Table 4 and Figures 8 and 9. Comparisons of six configurations for each span with regard to the support conditions show that frequencies mainly increased for the floor fixed onto the supports, but the variation was relatively small. There was some improvement in deflection for the floors decked with chipboard but a considerable improvement for the floors decked with OSB. In cases where the deck was glued and screwed to the joists, there was little variation in the natural frequencies and deflection.



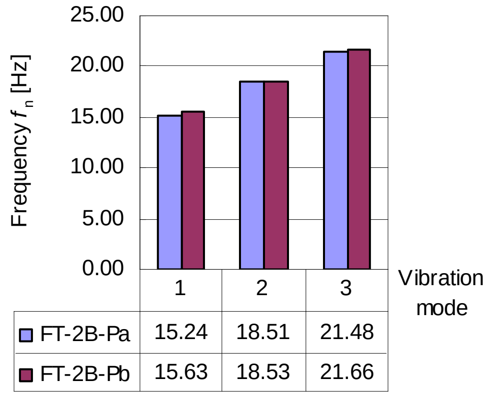
(a) FT-1A-Pa versus FT-1A-Pb



(b) FT-1B-Pa versus FT-1B-Pb

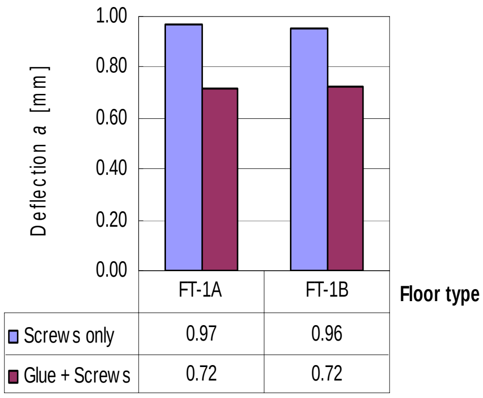


(c) FT-2A-Pa versus FT-2A-Pb

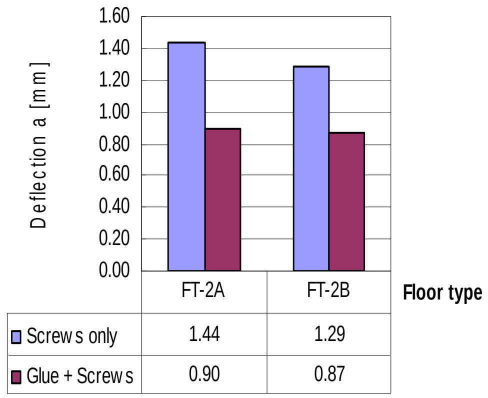


(d) FT-2B-Pa versus FT-2B-Pb

Figure 6: Comparison of the first three bending modes of the floors with four varied configurations for different fixing methods



(a) Small-scale floor configurations

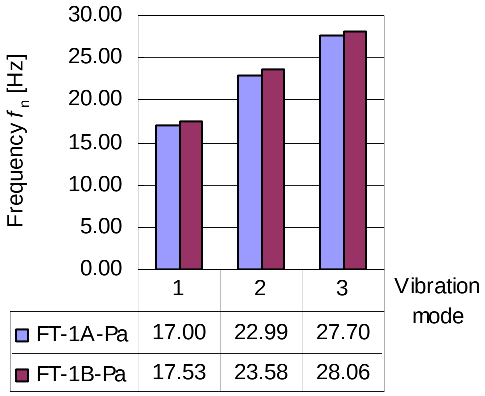


(b) Large-scale floor configurations

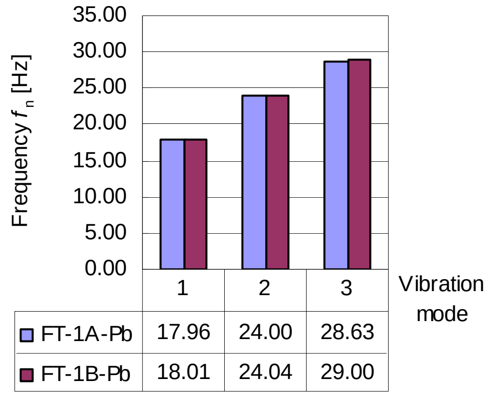
Figure 7: Comparison of deflections of small- and large-scale floors under varied support conditions for different fixing methods

Table 4: Comparison of different support conditions

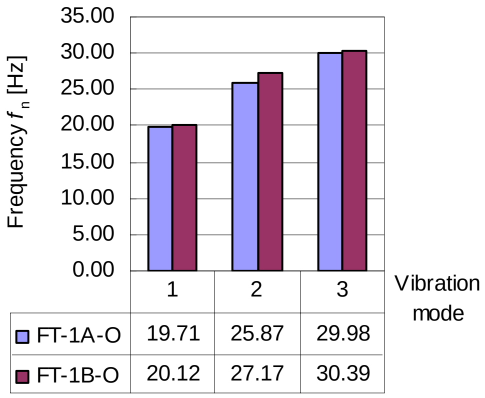
Floor	**Frequencies for the first three bending modes**			**Deflection**
	f_1 [Hz]	**f_2 [Hz]**	**f_3 [Hz]**	**a [mm]**
FT-1A-Pa	17.00	22.99	27.70	0.97
FT-1B-Pa	17.53	23.58	28.06	0.96
Variation [%]	**+3.12**	**+2.57**	**+1.30**	**-1.04**
FT-1A-Pb	17.96	24.00	28.63	0.72
FT-1B-Pb	18.01	24.04	29.00	0.72
Variation [%]	**+0.28**	**+0.17**	**+1.29**	**0.00**
FT-1A-O	19.71	25.87	29.98	1.32
FT-1B-O	20.12	27.17	30.39	1.04
Variation [%]	**+2.08**	**+5.03**	**+1.37**	**-21.21**
FT-2A-Pa	14.97	17.85	20.92	1.44
FT-2B-Pa	15.24	18.51	21.48	1.29
Variation [%]	**+1.80**	**+3.70**	**+2.68**	**-10.76**
FT-2A-Pb	15.63	18.64	21.68	0.90
FT-2B-Pb	15.63	18.53	21.66	0.87
Variation [%]	**0.00**	**-0.59**	**-0.09**	**-2.96**
FT-2A-O	15.80	19.76	21.63	1.79
FT-2B-O	16.21	20.53	22.29	1.26
Variation [%]	**+2.59**	**+3.90**	**+3.05**	**-29.61**



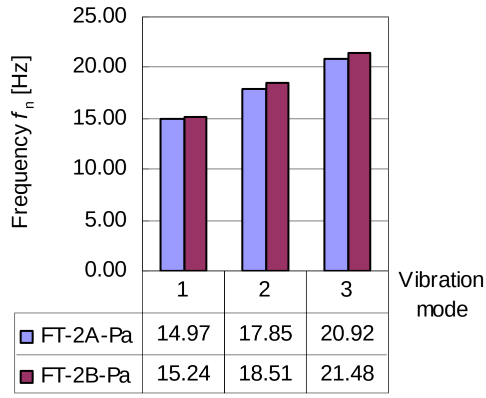
(a) FT-1A-Pa versus FT-1B-Pa



(b) FT-1A-Pb versus FT-1B-Pb

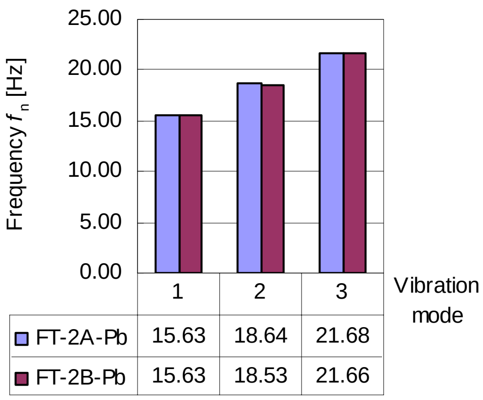


(c) FT-1A-O versus FT-1B-O

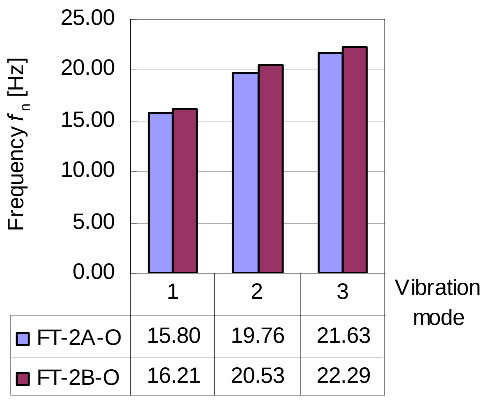


(d) FT-2A-Pa versus FT-2B-Pa

Figure 8: Comparison of the first three modes of the floors with six varied configurations for different support conditions

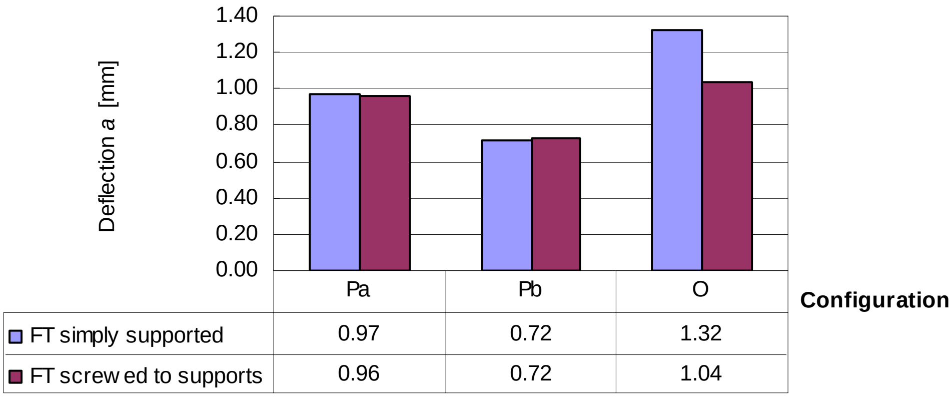


(e) FT-2A-Pb versus FT-2B-Pb

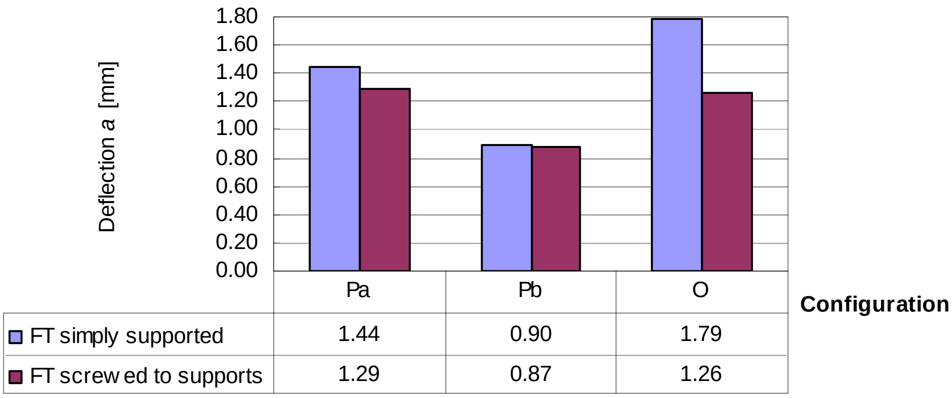


(f) FT-2A-O versus FT-2B-O

Figure 8: Comparison of the first three modes of the floors with six varied configurations for different support conditions (cont.)



(a) Small-scale floor



(b) Large-scale floor

Figure 9: Comparison of the support conditions for the small- and large-scale floors with varied configurations

4. SUMMARY AND CONCLUSIONS

The vibrational performance of two-side supported timber flooring systems has been investigated for varied floor span, fixing methods and end fixity. The results for the first three bending modes of the structure and the unit point load deflection at floor centre have been presented and analysed.

Increasing the floor span by 35% largely reduced the first three natural frequencies although at the same time the flexural rigidity of the joists had been increased by about 175%. The first mode was also clearly dependent on the decking board properties but this was less sensible for higher modes. The unit point load deflection was drastically increased for all examined configurations. Varying the floor span from 3.7 to 5.0 m was not beneficial with respect to these two design criteria.

From the experimental work described above, it can also be seen that the use of adhesives in addition to screws for fixing the decking boards to the joists is a practically reasonable option to enhance vibrational performances. The natural frequencies could be increased, and the deflection of the flooring structure could be reduced dramatically. The achievable improvement is indeed dependent on the floor size. For a small-span floor of 3.7 m the deflection decreased by more than 24%, compared with a decrease of more than 32% for a large-span floor of 5.1 m.

A method of enhancing end fixity has been investigated whereas the rim-boards were screwed to the supports. In construction practice, the floors often are nailed down in a similar manner. A possible impact on vibrational floor behaviour was to be observed. The performance was again influenced by the decking properties. In the case of screwed and glued particleboard decking, there was no appreciable variation in frequencies and deflection. In general, only for the floors decked with thin OSB layer the deflection could be considerably reduced when fixed to the supports.

Some results show that the effectiveness of structural modifications was dependent on other floor characteristics. It could also be noted that a composite effect of boards and joists was present. This effect is not fully taken into consideration in the current design rules in EC5-1-1 and the UK NA to EC5-1-1 but could make a significant contribution to altered vibrational timber floor behaviour. This is especially true for the method of fixing boards to the joists. Variations in decking properties are also influential whereas in the investigated cases the OSB layer was unusually thin.

Whenever possible, the timber flooring structure should be rather spanned in the shorter directions. Using glue in addition to screws to fix the decking layer to the joists is a simple way to enhance dynamic properties. The examined method of altering end fixity has only small effects.

5. FURTHER WORK

This paper has summarised part of the research work carried out at Napier University. Further to the investigations presented in this paper, the effects of varied decking materials (boards), added dead weights, joist dimensions and arrangements, blocking between joists and boundary conditions have also been experimentally investigated.

The dynamic performances of these flooring structures are being analysed, focusing on unit point load deflections and low frequency vibration modes, including the corresponding natural frequencies, damping ratios and modal shapes. The measured responses are compared to theoretical predictions and numerical simulations using finite element software. The final objective is to produce useful guidance for common timber floor construction practices and to provide valuable recommendations for the enhancement of the existing serviceability design criteria to ensure a more satisfactory dynamic performance of timber floors.

6. ACKNOWLEDGMENTS

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IMPROVING THE PERFORMANCE OF THE CONSTRUCTION INDUSTRY THROUGH THE USE OF BENCHMARKING AND INDUSTRY MATURITY MODELLING

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Abstract: Benchmarking is currently used as an approach to improve the performance of the construction industry in various countries throughout the world. One of its main limitations is that it provides only a partial understanding of the industry's performance and therefore promotes performance improvement plans that are myopic in their approach.

Maturity modelling at the industry level, when used in conjunction with benchmarking will provide a solution to this problem. This paper reports on the methodological approach of a proposed research seeking to verify this hypothesis through the use of project and industry data from Guyana, a developing country. The strengths and weaknesses of the proposed methodological approach are discussed and where possible examples of the expected deliverables are presented.

The benefits of this research include: providing an indication of the performance of Guyana's construction industry as well as providing a repeatable and holistic method of construction industry performance assessment.

Keywords: Benchmarking, Guyana, Industry Maturity Model, Industry Performance, Performance Measurement.

1. INTRODUCTION

Academics and construction industry researchers have long recognized the importance of the construction industry and have endeavoured to find ways of assessing and improving its performance. Recently, benchmarking has been used as a mechanism for the assessment and by extension the improvement of the performance of the construction industry. Benchmarking is a management tool which has its genesis in the copier industry, being pioneered by Xerox (McCabe, 2001) and is defined as a "systematic process of measuring and comparing an organization's performance against that of other similar organizations in key business activities" (Costa *et al.*, 2006). Benchmarking is currently implemented in the construction industry at the project and organizational levels through various schemes in countries such as the US, UK, Canada, Australia and the Netherlands. (Bakens, 2005; Benjamin, 2007)

The application of benchmarking in the construction industry, being relatively new, has some unresolved issues. The major unresolved issue is it is not clear as how to aggregate aspects of project performance so as to represent the performance of the entire industry (CCIC, 2007), which would allow for a holistic approach to improving the industry's performance.

A recent innovation in the field of project management has been the introduction and use of the Organizational Project Management Maturity Model (OPM3) by the Project Management Institute (PMI). (PMI, 2005) OPM3 enables organizations to measure their maturity in organizational project management and uses this as a basis in the development of plans for continuous improvement in organizational project management. This approach to performance improvement has not been attempted at the level of the industry, in particular at the level of the construction industry.

This paper reports on the methodology of a proposed doctoral research aimed at developing a method of assessing and improving the performance of the construction industry based on benchmarking and maturity modelling, and testing the method using data from Guyana as a case study. The research is based on the old axiom 'you can not improve what you do not measure' and hypothesizes that maturity modelling, when used in conjunction with benchmarking will provide a context in which the performance of the construction industry can be interpreted and plans for improvement developed.

The remainder of this paper discusses the methodological approach which will be used to benchmark the performance of construction projects in Guyana and to model the maturity of Guyana's construction industry. The strengths and weaknesses of the proposed methodological approach are highlighted and the findings of other relevant studies are mentioned.

2. BENCHMARKING CONSTRUCTION PROJECTS

The methodological approach of this research with respect to benchmarking the performance of construction projects in Guyana has three main elements. These are: identifying construction activities / objectives to be benchmarked, data collection and data analysis.

2.1 Identifying Construction Activities / Objectives to be Benchmarked

In order to identify construction activities to be benchmarked a review of previous studies on the use of benchmarking in construction will be done. Two previous studies which are of relevance are the Fisher *et al.* (1995) benchmarking pilot study and the Canadian Construction Innovation Council or CCIC (2007) benchmarking pilot study. The Fisher *et al.* (1995) pilot study identified the construction activities that were of importance when benchmarking the performance of the US construction industry. These were, in order of importance: "actual versus authorized costs, actual schedule versus estimated schedule, scope changes, engineering rework, actual construction labour versus estimated construction labour, field rework, worker hours per drawing, project cost distribution, field defects, and percent of rejected welds" Fisher *et al.* (1995). CCIC (2007) in their attempt at benchmarking the performance of the Canadian construction industry identified: "capitol cost, project delivery time, predictability, defects, accidents, productivity, revenue and profit, research and innovation investment, projects with sustainability in the procurement process and projects procured based on life cycle cost" (CCIC, 2007) as being important to the stakeholders of the Canadian construction industry. Of the two studies, CCIC (2007) highlights the current concerns of the construction industry in developed countries where there is currently increased emphasis on improving the construction objectives /

activities of innovations and sustainability given their potential positive impacts on the industry's performance. Based on this, the performance of construction projects in developing countries as it relates to cost, time, quality, scope, safety, innovations and sustainability should be benchmarked as a means of improving the industry's performance. In addition, construction objectives / activities that are unique to the construction industry in developing countries should also be benchmarked. These will be determined through the use of a questionnaire survey which will require construction industry players in Guyana to rank the importance of a set of construction objectives / activities as well as comment on those which they believe are important to the performance of Guyana's construction industry. This will allow for an understanding of the construction objectives / activities that are important in Guyana as well as provide an indication of the extent of commonalities between developed and developing countries in this regard.

2.2 Data Collection

The data collection phase is often the most critical and time consuming phase of the benchmarking process and should be carefully planned in order to be effective. The CCIC (2007) benchmarking pilot study based its data collection on the use of personal and telephone interviews as well as on the review of project files at study participants' sites. CCIC (2007) found that their approach resulted in the impact of the workload on the participants being kept to a minimum thereby encouraging cooperation in the execution of the study. Also, it was found that "there was little difference in the completeness and accuracy of the information collected between the in-person interviews and the telephone interviews" (CCIC, 2007). The in-person interviews according to CCIC (2007) provided an opportunity to have an interactive discussion with study participants and to clarify issues related to their interpretation of the benchmarking data being requested, which added to the strength of the data collection approach. The CCIC (2007) pilot study identified the main issues associated with the collection of data as being those concerned with availability and accuracy which in turn affected the overall reliability of the performance metrics used to benchmark the performance of the construction projects.

Based on the findings of the CCIC (2007) pilot study, this research proposes to use a two step data collection process which will firstly collect data through the use of direct contacts and secondly through the use of a questionnaire survey. The direct contacts will provide access to project documents and correspondences which will be mined so as to extract data relating to the performance of various construction projects. It is expected that this part of the data collection process will be time consuming as the data will neither be in the required format nor will it be located in single document or correspondence. The sources of the documents and correspondences as it relates to the direct contacts are the project funding agencies, project procurement and execution agencies, design consultancies and contracting firms. The sources can be arranged hierarchically as shown in Figure 1 based on the level of detail of their records. Funding agencies such as the Inter-American Development Bank (IADB), which finances a large number of public sector projects in Guyana, is likely to have a record of project performance data that has a low level of detail in comparison to the project performance records kept by consultancies and contracting firms.

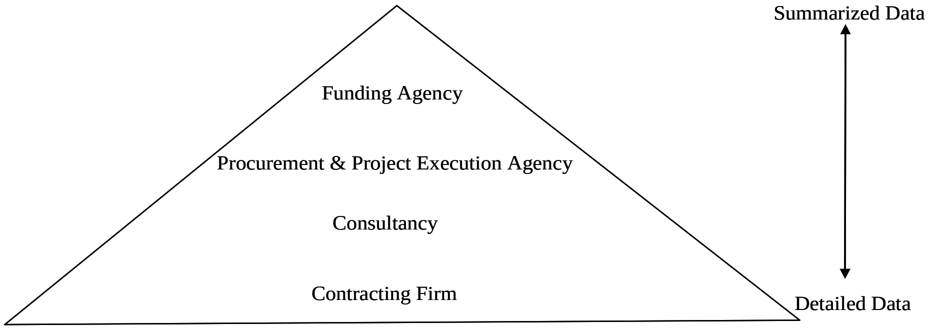

Figure 1: Hierarchy of the sources of benchmarking data based on level of detail of their records

The data from the project documents can be associated with the project timeline shown in Figure 2. Project development documents and correspondences will provide data emanating from phases A, B and C of the construction project. The actual construction contract document will provide data for phase D, while construction financial documents will provide financial data for phases D, E and F. Construction change order documents will provide data emanating from phases D and E.

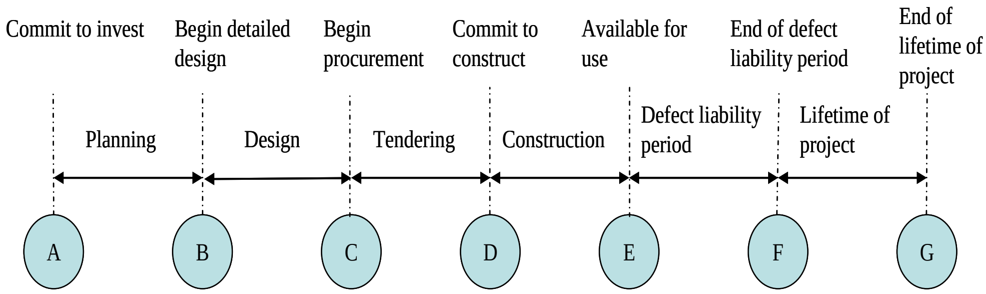

Figure 2: Project timeline showing the phases of a construction project (copied from CCIC (2006), figure 2, page 9)

The data from the project documents and correspondences will be assessed to determine their completeness and relevance. The assessment will form the basis of a questionnaire survey which will be administered in person to project participants such as project coordinators, project managers and project engineers, and will seek to address deficiencies in the data extracted from the project documents. Aspects of performance which will be targeted in the questionnaire survey include: time, cost, quality, client satisfaction, innovations, safety and sustainability.

2.3 Data Analysis

The data analysis aspect of the benchmarking process relies on the manipulation of performance data using a collection of performance metrics. The comparison of the performance metrics for various projects and types of projects is done using suitable graphs and charts. The CCIC (2007) pilot study used a collection of performance metrics which utilized data from the various phases of the project timeline (shown in Figure 2) and provide a substantial indication of the performance of construction projects in Canada. These metrics are shown in Appendix 1 and measure the performance of construction projects using data from the initial investment phase (point A on the project timeline) to the end of the useful life of the project (point G on the project timeline). Most of the metrics utilize quantitative data and for the parameters of cost and time most of the metrics are simply ratios that can be translated into percentages.

The comparison of the performance metrics is done using radar charts and box plots which have been described by Benjamin (2007) and CCIC (2007) as the being the most applicable methods of comparison in construction benchmarking. According to Razmi *et al.* (2000) a radar chart is capable of either displaying and comparing the performance measurements of one organization / project / industry or displaying and comparing the performance measurements of many organizations / projects / industries. A box plot or whisker diagram according to the Construction Industry Institute (2007) is developed based on a statistical sample of data and is a convenient way of displaying data without having to assume a statistical distribution. In addition to radar charts and box plots, some construction benchmarking schemes and studies use cumulative distribution curves and data envelopment analysis. Both cumulative distribution curves and data envelopment analysis require very large data sets that are not always available when benchmarking the performance of construction projects. Also, although data envelopment analysis has been used by researchers such as Pilateris and McCabe (2003) in benchmarking the financial performance of Canadian contracting firms, it has been described by CCIC (2007) as being "rarely used in the construction industry and does not appear to be as intuitive as other methods" (CCIC, 2007).

Through the use of the performance metrics in Appendix 1 as well as radar charts and box plots, the CCIC (2007) pilot study found that the Canadian construction industry was performing reasonably well in the areas of predictability of design and construction time and cost. With regards to quality, CCIC (2007) found that owners were satisfied with the quality of service they received from contractors and consultants, and in terms of innovations and sustainability it was found that there was a bias towards implementing technological innovations as opposed to innovations in procurement and management. It was found that there was some form of sustainability in the design and construction process in 50% of the projects sampled.

It is being proposed that the metrics developed and used in the CCIC (2007) benchmarking pilot study will be adopted and adapted to benchmark the performance of the construction industry in Guyana. This will also allow for a comparison of the performance of construction projects in Guyana and Canada using a common set of metrics, effectively benchmarking the performance of the two construction industries.

3. CONSTRUCTION INDUSTRY MATURITY MODELLING

The technique of maturity modelling has its genesis in the software manufacturing industry and has rarely been adopted and used in the construction industry. One of the earliest attempts at maturity modeling in the construction industry has been through the application of the Fuzzy Industry Maturity Grid (FIMG) by Tay and Low (1994). Briefly, the FIMG is a qualitative approach to analyzing the maturity of the construction industry according to three fundamental dimensions, i.e. markets, technologies and structures (Tay & Low, 1994). The FIMG is based on the Industry Maturity Grid (IMG) first developed by Cambridge University and is a "qualitative model offering diagnostic and descriptive analysis of a subject industry" (Tay & Low, 1994). The FIMG uses fuzzy set theory to analyze the maturity of the industry and is therefore a weak approach as fuzzy set theory is based on approximations and imprecise data. Also, because FIMG is a qualitative approach it is difficult to replicate results when assessments are carried out by different individuals.

Another attempt at maturity modeling in the construction industry has been by researchers at Salford University who developed the Standardized Process Improvement for Construction Enterprises (SPICE) based on the Capability Maturity Model (CMM) developed by Carnegie Mellon University. (Finnemore *et al.*, 2000) Unlike the FIMG as discussed by Tay and Low (1994), SPICE focuses on the organizational level as opposed to the industry level and seeks to improve the processes of an organization. SPICE is a five step process improvement framework in which immature organizations are characterized by the unpredictability of their projects and are plagued by negative issues as it relates to cost, time and quality. Mature organizations on the other hand, perform better and are able to align technology, people management and process improvement efforts. (Finnemore *et al.*, 2000) SPICE considers the maturity of a process to be "the extent to which a specific process is explicitly defined, managed, measured, controlled and effective" (Sarshar *et al.*, 1998).

A recent attempt at maturity modeling is PMI's OPM3 which is similar to the approach used by SPICE. PMI's OPM3 is used by organizations to measure their maturity in relation to organizational project management best practices, with the results being used in the development of plans for organizational improvement in project management. PMI OPM3 assesses the maturity of an organization in project management practices by determining the capabilities that are present within the organization. A best practice is comprised of two or more capabilities which are identified by the presence of specific outcomes and indicators. PMI OPM3 places the maturity of an organization at one of four levels of the performance improvement process, i.e. continuous improvement, control, measure and standardize. An organization is least mature in a project management best practice when it is capable of only standardizing that practice whereas it is most mature in a particular practice when it is capable of continuously improving its performance as it regards that particular practice.

The approach to maturity modelling as done in PMI OPM3 is yet to be applied at the industry level. While there are similarities between SPICE and OPM3, OPM3 appears to be a stronger approach and one that is more suitable for application at the industry level as it assesses maturity based on practices as opposed to processes. Construction industry practices are likely to be universal whereas construction industry processes are likely to be unique.

3.1 Modelling the Maturity of Guyana's Construction Industry

This research proposes to assess / model the maturity of Guyana's construction industry using the approach developed by PMI OPM3. The research will firstly develop a 'standard of construction industry best practices' which will list the best practices of the construction industry, the capabilities associated with each of the best practices and the outcomes and indicators that identify the individual capabilities.

The process of developing the 'standard of construction industry best practices' will include a literature review as well as focus group / brainstorming sessions. The literature review will help to identify existing documented industry best practices which will serve as a reference for the focus group / brainstorming sessions. A draft of the ‘standard of construction industry best practices’ will be sent out to various construction industry experts in Guyana and North America who will check the applicability and practicality of the standard. An example of a section of the proposed ‘standard of construction industry best practices’ is shown in Appendix 2. The section of the standard lists the industry best practices as it relates to Health and Safety and has 4 directories which list the best practices, capabilities, outcomes and indicators. The standard will match the elements of the four directories using unique 4 part identification numbers as is done in PMI OPM3. This helps to ensure accuracy and consistency in the assessment process.

The actual modelling / assessment of the maturity of the construction industry will be done in six sequential steps. Firstly, specific practices from the ‘standard of construction industry best practices’ along with their observable / measurable indicators will be selected and used as a reference in interviews to determine their existence in the industry. Once it has been established in the interviews that the indicators exist in the industry, their existence will be further verified via documented evidence. Once successfully verified, the indicators will be associated with the outcomes in the standard which will then be associated with the capabilities relating to the practices being investigated. The assessment process is summarized in Figure 4 below.

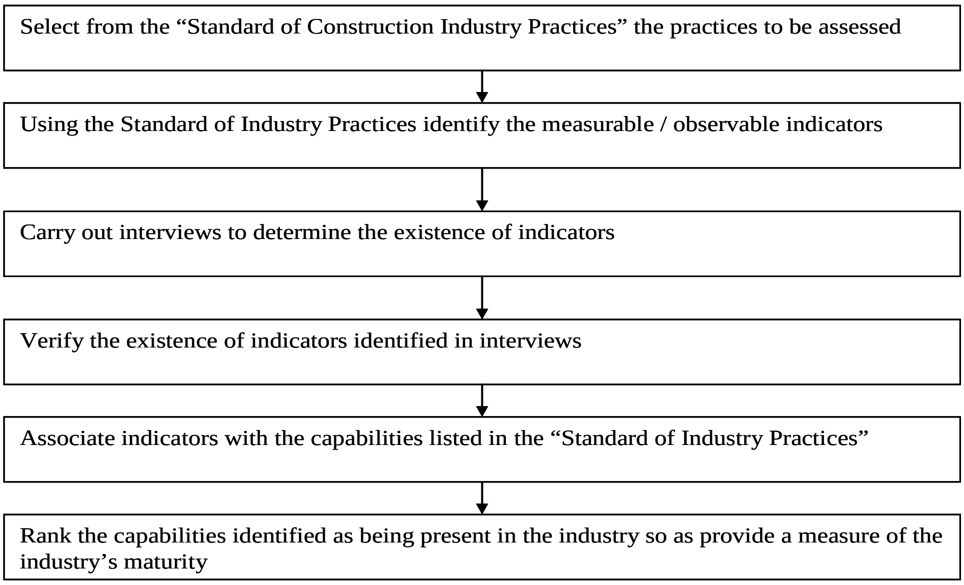

Figure 4: A schematic of the process to assess the maturity of the construction industry

As part of the assessment process, interviews will be held with senior industry players such as project coordinators, project managers, as well as directors and managers of contracting and consulting firms. It is expected that the interviews will provide guidance in identifying the presence of indicators associated with the industry’s capabilities.

The maturity of the industry as it regards a particular practice will be based on the rank of the capabilities associated with that practice. The overall maturity of the industry will be based on the position of its recognizable practices as it relates to the phases of the performance improvement process, i.e. standardize, measure, control and continuous improvement. The greater the number of industry practices that are classified as belonging to the continuous improvement phase the higher will be the level of maturity of the construction industry.

It should be noted that a major strength of the proposed assessment approach is the reliance on documented evidence to prove the existence of a specific capability. This translates into a method of assessment that is more objective than it is subjective and is therefore likely to provide realistic and consistent results when properly applied.

4. CONCLUSION

This paper has highlighted aspects of the methodological approach of a proposed research aimed at assessing and improving the performance of the construction industry through the use of benchmarking and maturity modelling. The research hypothesizes that through the combined use of benchmarking and industry maturity modelling, a comprehensive understanding of the construction industry's performance will be provided. The research also intends to show that in order for the construction industry to be innovative and serve as a mechanism for sustainable development, the industry must attain a certain level of maturity.

Some of the strengths and weaknesses of the proposed approach have been highlighted along with the findings of previous relevant studies. It is foreseeable that the most challenging aspects of this proposed research will be the data collection phase of the benchmarking process and the development of a 'standard of construction industry best practices'. Developing countries such as Guyana stand to benefit from this type of research given that the role of the construction industry is more pronounced and the performance of the construction industry in developing countries significantly lags behind that of the developed countries.

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Appendix 1: A list of the performance metrics used in the CCIC (2007) benchmarking pilot study

Metric No.	Category Metric	Cost Phase	Definition
1.1	cost predictability-design	A to C	(actual design cost-estimate design cost) / (actual design cost)
1.2	cost predictability-construction	D to E	(actual construction cost-estimate construction cost) / (actual construction cost)
1.3	cost per unit	at D (award)	(tendered cost) / (capacity measurement)
1.4	cost for defects-warranty	E to F	(construction cost of rectifying all defects) / (final cost for construction)
1.5	cost in use	E to G	(annual operating cost arranged over years) / (final cost for construction & design)
	Category	**Time**	
2.1	time predictability-design	A to C	(actual design time-estimate design time) / (actual design time)
2.2	time predictability-construction	D to E	(actual construction time-estimate construction time) / (actual construction time)
2.3	time per unit	at D (award)	(contract time for construction) / (capacity measurement)
2.4	time for defects-warranty	E to F	time taken to rectify all defects
3.1	client satisfaction-product	at E (available)	impacts on condition of facility w.r.t defects
3.2	client satisfaction-design service	at E (available)	assessment of professional services
3.3	client satisfaction-construction service		assessment of professional services
3.4	quality issues-available for use	at E (available)	number of opened non-conformances
3.5	quality issues-warranty	at F	number of opened non-conformances
	Category	**Safety**	
4.1	reportable incidents	D to E	(number of reported incidents) / (100,000 hours worked)
4.2	lost time	D to E	(amount of lost time to incidents) / (100,000 hours worked)
	Category	**Scope**	
5.1	cost for change-demand	D to E	(approved cost for change originating from client) / (total project cost)
5.2	cost for change-supply	D to E	(approved cost for change originating from contractor) / (total project cost)
5.3	time for change-demand	D to E	(approved time for change originating from client) / (total project time)
5.4	time for change-supply	D to E	(approved time for change originating from contractor) / (total project time)
	Category	**Innovation**	
6.1	procurement	A to D	checklist of practices compared against standard
6.2	technological	D to E	checklist of practices compared against standard
6.3	management	A to E	checklist of practices compared against standard
	Category	**Sustainability**	
7.1	design	B to C	measured against LEED Canada-NC Version 1.0
7.2	construction	D to E	measured against LEED Canada-NC Version 1.0

Appendix 2: A section of the proposed 'standard of construction industry best practices'

STANDARD OF CONSTRUCTION INDUSTRY BEST PRACTICES (Health & Safety)	
Directory 1: Best Practices (Health and Safety)	
ID# 100	The construction industry has mechanisms in place to continuously improve H&S
ID# 101	The construction industry regulates H&S compliance
ID#102	The construction industry maintains a database of accidents
ID#103	The construction industry uses a H&S standard
Directory 2: Capabilities (Health and Safety)	
ID#100.1	There are H&S training programs within the industry
ID#100.2	The industry has active H&S awareness campaigns
ID#101.1	The industry checks whether firms are complying with H&S regulations
ID#101.2	The industry enforces laws governing compliance
ID#101.3	Industry allocates funds towards H&S compliance
ID#102.1	Contractors keep track of accidents occurring on their sites
ID#102.2	Consultants discuss H&S issues in their monthly progress reports to the client
ID#103.1	Aspects of a H&S standard are included / referred to in construction contracts
ID#103.2	Contracting firms prepare H&S management plans for their individual projects
Directory 3: Outcomes (Health and Safety)	
ID#100.1.A	Workers receive training in H&S Workers receive training in H&S
ID#100.2.A	Workers are aware of their rights as it relates to H&S issues
ID#101.1.A	Firms are acknowledged as complying with regulations
ID#101.2.A	Firms are taken to court and fined for non compliance
ID#101.3.A	Contracts include a provision for H&S compliance
ID#102.1.A	Records of accidents are kept in site log book
ID#102.2.A	Progress reports contain a section dedicated to H&S issues
ID#103.1.A	Contract documents include clauses addressing H&S on the project
ID#103.2.A	Projects have H&S management plans
Directory 4: Observable Indicators (Health and Safety)	
ID#100.1.A.x	% of industry workers trained in H&S
ID#100.1.A.y	No. & frequency of H&S training programs within the industry
ID#100.2.A.x	No. of H&S brochures produced
ID#100.2.A.y	No. of H&S advertisements in the print and electronic media
ID#101.1.A.x	No. of acknowledgement letters and certificates issued
ID#102.1.A.x	No. of firms fined for non-compliance
ID#102.1.A.y	No. of H&S related cases heard in court
ID#103.1.A.x	No. of contracts which have a provision for H&S compliance
ID#102.1.A.x	No. of sites with a log book for recording accidents
ID#102.2.A.x	No. of progress reports which report on H&S issues
ID#102.2.A.y	Extent to which H&S issues are included in monthly progress reports
ID#103.1.A.x	No. of contracts which address H&S issues
ID#103.2.A.x	No. of projects with H&S management plans

ARE SITE PROJECT ORGANISATIONS POISONOUS FOR INFORMATION AND COMMUNICATION TECHNOLOGIES?

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Abstract: This paper examines the numerous attempts to implement ICT to assist information and project management in construction. It looks at project web systems and mobile technology as examples. Project web systems store, mediate and distribute documents in digital form to make information handling of construction more effective at project and construction levels. Mobile ICT should enable more effective and consistent exchange of information, thus rationalising building and work practices, subsequently increasing mobility on site and tightening logistics. The paper is part of a current research project aiming at developing better practices of implementing and running ICT in building projects. The paper draws on several case studies of Danish project organisations in construction, and highlights that the attempt to implement these two types of technology hits numerous barriers. The paper highlights more subtle issues not addressed properly prior to organising and configuring project organisations in terms of user information, instructions, roles and support while using the Project Web platform. Mobile ICT seems to be hindered by wage issues, usability as well as technical problems. Our conclusion is, that although the two technologies have matured the later years, implementing and integrating these ICTs into projects still needs more systematic attention and especially so from the companies' ICT- responsible. A better integration between firm and project is thus needed.

Keywords: mobile ICT, project web, projects, work practices.

1. INTRODUCTION

A construction project has three predominant characteristics; it is a production unit, the constellation is temporal, and it is quite often carried out under heavy pressure of time, cost and quality issues. Juxtaposed to this, construction, at least in the Danish sector, is lagging behind with implementing ICT (Danmarks Statistik 2006). Since many reported practical experiences seem to point at serious problems implementing ICT in construction projects, the assumption behind the present paper is that construction projects might involve specific barriers and problems ("poisonous"), which need to be addressed.

Embracing construction projects as both production units, temporal constellations and at times hectic, usage of a project web system as a main ICT system is believed will more efficiently enhance and standardise information management, while encapsulating a variety of repetitious tasks and possibilities in managing drawings, minutes and other documents.

In this line of thinking alteration, or the smoother ‘adjusting’, of mental models and traditional work practices and work organisations is one of the mayor obstacles to overcome, when so-called technical ‘problems’ furthermore inhibit socio-technical problems juxtaposed with wage issues. Thus abandoning a rigid dichotomy between the ‘technical’ and the ‘social’ is to be challenged (Hutchby 2001).

However, as far as problematic ‘problems’ just get technical, the socio-technical aspects are often not discussed neither investigated, nor presented, in depth as samples of the case material on present usage of project web systems should indicate. This is something to remedy. Thus, the aim is to investigate what the documented experiences are so far using project web in construction projects for information management.

In doing so, we investigate the socio-technical aspects of project webs, which include the (social) actors, the start meeting, filing methods, parallel systems, costs and the interaction between the enterprise and the site project, and if possible, which moreover is the secondary aim, to compare the project web results with the affordances of mobile technology (Hutchby 2001), where mobile technology in this context is limited to the use of handheld ICT, such as PDAs, Blackberries, Tablet PCs, mobile phones etc.

The structure of the paper commences with a presentation of the method. Upon this, an established definition of what constitutes a project web is presented before listing the criteria for critical reading of the reports. The reading is framed into eight main themes believed to be vital for understanding the barriers, the ’problems’ and the socio-technical dimensions of project webs and to assess if selected ICTs are maturing technologies in construction. These aspects lead to a brief discussion on what is ‘poisonous’ to site project organisations in construction, from which our concluding remarks will be presented.

2. METHOD

The point of departure is a current Danish research project – “Digitalisation of Construction Projects” (running 2006-2008) – which aims at seeking knowledge about how, exclusive in a Danish context, all project sides in construction projects are digitised and, in doing so, are taking full advantage of the potentials of digital information management by conducting timely intervention. The present research is a contextual frame of comparison and reference, but it is not used directly.

The research is a desk research of samples of reports with empirical research material. This material represents fairly recent empirical research (since 2003). It covers four main contractors in Denmark; MTH Højgaard, NCC, Pihl and Hoffmann, all incorporated enterprises. And noting, all cases, but one, are turnkey contracts.

The most recent sample of reported material was conducted through autumn 2006 and comprises of four independent cases in contract of ‘Bedst i Byggeriet’ (Andresen 2006, Bruun 2006, Jørgensen & Olsen 2006a, Jørgensen & Olsen 2006b); the aim was to evaluate if project web as a system was effective in exchanging drawings, minutes and other documents. An important denominator was that a lead contractor was in charge of implementing ICT throughout all these cases. Another 16 cases in BiBS ('Bedst i Byggeriet') were conducted, but the subject of the study was not in any sense related to project web systems.

One of two slightly 'older' cases is the construction of a dog kennel at the Airport in Karup (spring 2006); 4 telephone interviews and one focus group interview with the architect and the project owner were conducted; for the latter the consultant engineer and lead contractor could not find time to participate. The other, and last, case is the construction of the Tietgens College, Copenhagen (summer 2005). The architecture was inspired by architectural ideas from the Chinese Tulou settlements (Hegelund Jensen & Bjørnlund 2005); 7 interviews were conducted respectively with a project manager (the architect link), two system developers from Byggeweb (title name of the generic project web system and the name of the developer), one consultant in planning and three contract managers from three different companies.

Juxtaposed with project web systems the next case material is an evaluation of a beta testing of Internet-enabled, handheld PDAs using a proprietary quality assurance system developed by Danish E TJEK (Vogelius 2005), which represents the link to mobile technology. The reporting was on two bricklayers working at a line of bathrooms, until the PDA system was abandoned due to time constrains.

Our most recent ongoing research (see the introduction) on usage of project web systems encompasses 9 semi-structured interviews conducted through December 2006 till May 2007 with actors having acknowledged experiences with ICT in construction projects. At least 3 more are planned in the fall of 2007. 6 interviewees are from current construction projects and 3 are from organisations ranging from contracting companies over subcontractors to sub-suppliers.

This material and our current research stand as a contextual frame of reference and comparison for the status elaborated on the documented material. However, there are several remarkable weaknesses with the presented empirical material. Foremost, they represent snapshots of construction projects rather than longitudinal research, possibly leaving out a number of issues as the building project develops. Second, all sources only cover a limited set of actors preferably with main contractors, with architects and with consultants and to some lesser extent the building owner, possibly leaving out a significant proportion of ramifications to sub-contractors and (sub-)suppliers. Moreover, the use of e-mail is not covered, neither is the de-commissioning.

3. WHAT IS A PROJECT WEB?

A general definition of project web is found in Andresen & Christensen (2002: 6); a project web is hosted somewhere on the Internet on an internet server where members or users (of a building project) make information accessible to each other on a website, thus sharing information and documents (related to the building project). This kind of definition makes project web as a system or concept more or less independent of i.e. generic and proprietary software vendors. Furthermore, project web may also be known as an Extranet.

However, usage of project webs is subject to rules on who may have access to what. These issues must be agreed upon amongst the actors prior to embarking on a project web system in terms of what system to implement, what terminology to be used, and which organisation to support the project web system. In 2002, Byggeweb was reported as the dominant supplier (Andresen et Al. 2003), and this has not changed significantly, but competitors or generic variants do exist in congruence with different needs, i.e. raising security levels and other features; Rambøll uses CTSpace's Citadon; other consultants are selling their own system etc.

4. THE CRITERIA FOR THE CRITICAL READING OF THE REPORTS

In 2002, Andresen & Christensen (2002) investigated what the experiences of project web systems in building projects so far could tell, and more importantly, why were they not both more widespread and used with success in the line they are promising benefits in (1) project management, (2) functionalities in project webs in regards of storing, mediating, distribution, and decommissioning of information, and (3) cost/ benefits of usage of the project webs. These were the main tracks in our reported cases so far.

While acknowledging that these aspects may be of notable importance in facilitating the coordination of work practices and adjusting both work processes and work flows in project organisations using a project web system, the implementation and usage of a project web system as a main pillar for information and communication sharing, still needs careful attention in the socio-technical aspects, since our cases do exhibit "problems" and barriers not thoroughly addressed neither scrutinized.

Thus integrating project web systems is not, as the cases indicate, a straightforward process if not properly prepared, introduced, conducted, supported, administrated, (re-)evaluated, and linked to a working temporal, cross-organisational infrastructure to support (virtual) communication, project and information management thus underpinning prospects of actual benefits to the site project organisation.

4.1 Actors

An actor is a person involved in the construction site and project planning. In the case material the actors are represented by the project owner, architects, consultants in planning, building or lead contractor, and also the empirical under-represented sub-contractor and sub-supplier.

4.2 Start Meeting

Prior to the construction project it is recommended to assemble a start meeting with (all) the expected actors. The meeting may be executed as a kick-off, an introduction, a seminar or a workshop with the primary agenda to both educate and inform the actors affiliated to the construction project. The secondary agenda is to solidify and agree upon 'ground rules' and terminology. Elements agreed to which en route appears irrelevant or unrealistic, should on an ongoing basis be revised (Andresen & Christensen 2002:18).

4.3 "Spaces"

"Spaces" is a place where documents or files are either categorised as "work-in-progress" or "approved-for-production". This distinction is a matter of legal consideration which suggests a requirement of 'strict' classification of submitted files (Andresen & Christensen 2002: 21; Hegelund Jensen & Bjørnlund 2005:68).

4.4 Filing Method

Two predominant methods exist, of which both refer to how one search for files on the project web. One is arranging folders as a tree structure while the other is arranged according to metadata (Hegelund Jensen & Bjørnlund: 88-89). The structure of folders may, according to Andresen & Christensen (2002:20), be arranged by a 'self-explanatory' nomenclature adhere to respectively file type, name of the company, building and / or process. Furthermore, it is of significance to define life cycles of documents in regard of archival storage; thus operating with either a static or dynamic principle (Andresen & Christensen (2002:24). The static principle is limited to a specific interval of time or an established deadline, while in the dynamic principle files – when ready for production – are uploaded on an ongoing basis. The dynamic principle requires, however, that one is both online and observant. Another issue is when interfacing data across boundaries.

4.5 Push / Pull

Distribution of information, data and documents is either executed by push or pull, where the first is pushed to all users without discrimination or with minimal interaction required, while in the latter the user retrieves the information when needed, either by search or by topic base approach. Pros in push are that all recipients get the information while the cons are information-overload, thus receiving (a lot of) irrelevant information. Project web supports pull indeed, while push is not supported in full, due to the fact that the concept of attached files are not supported (as) in emailing, which would render the concept of project web somewhat redundant.

4.6 Parallel Systems

In this context parallel systems are used at the simple procurement of information and also the support of (direct) communication whilst running concurrently alongside the project web. Examples of parallel systems are emailing, telephony and also mail, or mail by correspondence sent by a courier service. These systems come into practice when i.e. companies demand use of their own quality assurance standards. Thus in respect of the project web system both may represent interface problems and 'double-entry book keeping', or the project web system may inhibit intuitive or flexible use due to slowness of the system (typing metadata, slow connection, outdated hardware), troublesome usability (small terminals or miserable user interfaces) or even lack of competence (hiring unskilled work, no need-to-know etc.) and adaptability of the actors (resistance to change, wage, age, gender etc.), and therefore return to traditional, known practices and habits. As stated earlier, the start meeting may prevent some of these 'problems'.

4.7 Costs / Economy

The case material on costs and economy on implementing project web systems wages more or less strictly relies on yet unwarranted believes of gains in both efficiency in information sharing, in communication and savings in printings, thus encompassing a rationale of rationalisation benefits on both construction sites and in planning - all somewhat tangible and understandable goals. However, many have tried to conjure a calculus on these savings. But the cases indicate that not much more than implementation and usage costs are calculated alongside reduced costs for plots. The specifics on licensing a project web may be framed into numbers of users, storage capacity (in megabytes) and support. Unfortunately, as an interviewee expressed, costs regarding project web systems have unfortunately fallen, subject to grocery billing and unwarranted perceived as 'expensive'. This is why the system often is sold to its (cheap) price pr. user – often presented as one price. Support, administration, delays, education, storage, terminals etc. are difficult to integrate into a generic calculus on costs and savings of using project webs.

Implicitly, construction sites and projects do propagate an image of itself as hectic, unique and one-of-a-kind on a tight budget and schedule, which leaves almost no room for 'trial-and-errors'. However, interfacing data and information between design, planning, execution and de-commissioning phases should be brought into consideration too, since operating the building is by far the longest period of time of its lifecycle. What the specifics of the information must feature should be settled in an accord prior to the start of the project web. Just to ensure not to store redundant data, information and files thus agreeing on what to actually store, so it is applicable to i.e. the facilities management of the building.

4.8 Interplay Enterprise and Project

Interfacing is the theme when speaking of the interplay between the enterprise and the site project organisation. According to Andresen & Christensen (2002:1) each single company in the building industry was biased towards optimising their own IT capabilities instead of optimising the interplay between the actors, too. This interplay presents at least two predominant challenges in interfacing; one is of synchronising the site project organisations' data and information, while the other is, according to Apelgren et Al. (2005: 5), aligning the different interfaces intermediately between the project functions. If not both are respectively synchronised or aligned properly unintended errors might occur or important processes stall, or get to be hindered, thus returning to known practices and habits (use of parallel systems) is justified due to time constrains and costs.

5. EXPERIENCES IN DENMARK USING PROJECT WEB

As far as our material goes on assessing use of or implementation of project webs into the construction phase, we unearth, that there is a rather imbalance of inclusive actors portrayed as sub-contractors and sub-suppliers in all the empirical material on project web, which might affect our presentation. However, we recognise as an example that sub-contractors may pull unskilled workforce into the construction site for installing plaster walls; in our view installing plaster does not require any (trained) skills, contact or use of a project web. This perspective is not discussed at all in any instant except in Vogelius (2005). This is somewhat surprising. As a rule of thumb any typical turnkey enterprise involves approximately 20 sub-contractors and sup-suppliers.

The empirical material is represented by one main contract (EMCON 2006) and nine turnkey contracts. Partnering is not mentioned explicitly, but Bruun (2006) uses the term a “partnering-like form of collaboration”. 3 out of 4 BiB’s accounts were conducted by the lead contractor’s own people.

There is a strong indication that it is the contractor who has to take the initiative on implementing a project web, and therefore it is reflecting the following discussion on known and discussed barriers. Those not so well discussed may, on our account only, be a result of limiting the scope of the reporting from the case material, and that the case material mostly discusses functional, technical and beneficial aspects of project webs.

5.1 The following Barriers are the well Discussed

Firstly, there is a small implicit consensus of bias towards competence, willingness, and IT mature-ness or readiness of both sub-contractors and sub-suppliers to embrace project web systems. Mostly, they have no saying and no choice if they at all are invited to the start meeting to familiarise themselves beforehand with the system and concepts. However, there is an acknowledgement of the fact that they seldom (all) are invited to the start meeting and therefore, which includes newcomers too, consequently receive little or no instructions as to how to use the system properly. Berard & Hansen (2005) reports this observation too juxtaposed with an explicit lack of competences in handling digital documents. If this position prevails it is expected that these actors will not use or stop using the system, simply because there is nothing gained from it. Adding respectively, traditions, cultures and some companies’ set of rules on i.e. quality assurance may foster barriers also both on which documents are legal and which are current. When in doubt, actors tend to return to proved practices, processes and tools, which then may foster the actual use of parallel systems thus rendering the project web system and its content somewhat redundant and prone to errors in the operation phase.

Hegelund Jensen & Bjørnlund (2005) noticed a stronger need for division of roles. Empirically, they reported that several actors did not know who saw what, and as consequence, some actors consciously stopped uploading files, keeping sensitive documents from prying eyes or made convictions of malice secrecy up, while exercising judgement on behalf of their own agenda or company, keeping files, such as peer-to-peer correspondence and contracts, internally or to themselves. In Bruun (2006), there is a mentioning of dedicating a project secretary, but nothing is uttered on the specifics that this function / position should hold. In Hegelund Jensen & Bjørnlund (2005), an administrator is appointed, but not in a dedicated manner.

Furthermore, Andresen (2006) points to development of an industry standard of structuring the organisation of information and migrating to a database-oriented approach facilitating dynamic and efficient information and data interfacing.

Finally, there are the expected benefits of usage of a project web system. The expenses are merely calculated as implementation and usage costs supplemented with savings on plot costs, but none of the cases dwell further deeper into effects on neither coordination or corporation of work practices and work flows, and subsequently what lies beyond the construction phase – hence facilities management mentioned earlier – or roughly calculating the added value per employee. Taking man-hours into account is not mentioned either.

These barriers are altogether all good points, but solving the problems of information management seems only to pivot on a syntactical level, thus leaving little space for interpretation when emerging novel conditions arise. Thus, new conditions require different kinds of knowledge (Carlile 2002) and competences.

5.2 Several Issues are not well covered in the Research so far

There is scarcely no discussion of the requirements of establishing project webs as an integral part of construction. What kind of project is suitable? Interview responds suggest that not all kinds of project webs are suited for any kinds of construction projects. Thus, when establishing and sustaining a proper organisation to administrate it, there is a general conception amongst project managers in planning, that there is a certain need for critical mass to justify the spending on it in terms of the price tag of the contract, its complexity and type.

Prior to the start meeting, the preparation of implementing the project is not discussed very intensely. We mentioned previously a project secretary, but this does hardly suffice. To our knowledge, one main contractor, Pihl inc., has over the past year established a dedicated ‘half ‘n half’ function constituting two employees, while sharing the function of preparing education material, handbooks and teaching for the start-up meeting. They have made it ‘institutional’, so to speak, and commenced a strategy for IT governance of the usage and administration of project web in (all) their construction projects, and by doing so taking pre-emptive precautions of losing vital employees.

As far as the quality of the documents provided to the project web goes, there has been no tangible discussion on how to secure the quality of the uploaded files provided by the participant actors. This is an important detail, since turnkey contracts more or less are characterised by overlaps in the planning and construction phase, which implies that documents are exchanged on an ongoing basis between both actors and enterprises. This requires, however, that the actors need to be both on-line and observant to be up-to-date with the latest files and documents. This is a significant change of accountability and responsibility on behalf of the receiving part.

In war, truth is the first victim; in construction, it is quality (when no time is). Next in line are costs. If no one feels ownership of, is being hindered by or does not see any tangible gains from the project web, it risks being treated stepmother-like. Here the potential of real ‘problems’ lies in communication, safety, quality etc., which again may be connected to the nature of site project organisations as both temporal, hectic and in close to all cases suggest configuring project constellations of actors anew. ICT requires the actors to conform to (codified) ‘best practices’ or the given standards provided by the generic platform, while site project organisations need ICT to conform to its practices, which may be portrayed as an image of tensions of opposites.

Finally, mobile technology is very scarcely scrutinized, but on one account only. It seems that this subject is not thought of as an integral part of the project web system yet. Nevertheless, according to Hegelund Jensen & Bjørnlund (2005) a system developer from Byggeweb wages new opportunities in interfacing and data-mining information on project webs using PDA’s, tablet PC’s or the like, thus making it independent of time and space, which may have prospects on saving time on behalf of the operating level in logistics and accounting. Another aspect, while overcoming conditions such as weather, sunlight, dust, dirt, noise, extensive (or careless) use of machinery (Koch & Larsen 2007), and mechanical breakdowns etc. using PDAs may improve quality assurance and on the operating level increase the quality of self-checking, when usability, stability and QOS issues are jointly solved. As an illustrative example, the bricklayers in Vogelius (2005) came up with an excellent and far-reaching proposal on integrating working environment schemes (Vogelius 2005: 27) into their practice, using dedicated PDAs thus enabling on-field decisions of denial if a task prescription is seriously defective or flawed. This proposal does to some extent foster a slight migration to the self-management of actors on the shop-floor.

6. DISCUSSION

Elaborating on our notion of tension of opposites of ICT and site project organisations, Berard & Hansen (2005: 151-152) points respectively to resistance in regard of change, instructions must be short and easy to read and understand, and actors guarding both access to knowledge and in respect of determining what is essential knowledge. Furthermore, a survey (Danmarks Statestik 2006) stated that project members in construction are overrepresented in having IT functions as their secondary function, and thereby more or less sidelining (Laasonen 2006).

Our research stipulates to intervene at an appropriate state. But in coming so far to necessitate intervention, and thereby questioning what the actors undertake, that is, denying and mocking altogether their accords, skills, experience and status, measures taken prior to executing the construction program in terms of organising both a proper infrastructure on the technological level and organising super users, whom we term ‘half ’n half users’, to administrate the project web system are necessary to facilitate ready-to-read instructions on how to use the project web system followed by a (kick-off) workshop for and by, if possible, all affiliated participants.

While seeking to integrate ‘Digital Building’ into construction projects, introducing the project web system as a ‘democratic’ platform and common tool to the construction phase, it may yet prove volatile and require a slight shift in contemporary paradigms to succeed, supposedly due to a tendency to encapsulate opportunities and seek shelter in old practices, traditions, cultures, norms and company policies, when coping with a lack of (ICT) maturity and an unreadyness in socio-technical terms, rather than seeking new ways of doing things.

If ICT is not to be poisonous to site project organisations in construction, as the cases may suggest, it is essential, when dispersing and pertaining an efficient use of Project Web, that project organisations should not solely rely on, or hope for sideliners or field furies, but should arrange for proper preparing of, execution of, adjusting to and governance of the project and its members.

This may implicate far-reaching consequences for the industry in an unsettled manner. To ensure that site operatives and managers embrace the project web system, the stakeholders must find common ground on the specifics of structuring the project web system in regards of user information, education and division of roles beforehand, which points to the importance of a planned and prepared start.

7. CONCLUSIONS

The examination of current attempts on implementing a project web system in construction project showed that there are various barriers, which to some extent are recognised in the reporting, but lack an in depth perspective on how to address them. The common denominator on a successful project web implementation and usage was if the exchange of documents were faster, consistent and cost effective, while migrating from paper based plots and document management to a digitalisation of the construction project, altogether having all documents one place, thus reducing or eliminating parallel systems.

The functional and technical aspects were relatively well covered, though not reporting successes in all cases nor in depth. The analysis shows, that none of the cases actually investigated if the requirement of implementing a project web was adequately planned, prepared or supported. This observation is somewhat underpinned of the fact, that a large portion of the site operatives (sub-contractors and sub-suppliers) are almost, but in one empirical sample, under-represented, which leaves our case material somewhat weak in comparison, but fruitful to pointing at gaps in the reporting of relevant matters.

The present research helped to pinpoint wider aspects of the requirements of what a project web needs by dedicating a project web administrator, thus implicating better IT-governance of the system at hand, and, as a consequence, to secure closer relations between ICT responsible, projects and actors. Our belief is that this enhances the quality of, and bring to order the content of the project web in concert by using mobile technologies to support self-checking and perform quality assurance on the site.

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MEAN VALUE FORECASTING FOR EARLY CONSTRUCTION COST – BEST DATA POOLING

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Abstract: In the early feasibility study stage, the information concerning the target project is very limited. It is very common in practice for Quantity Surveyor (Q.S.) to use the mean value of the historical building price data (with similar characteristics to the target project) to forecast the early construction cost for a target project. Most of the clients rely heavily on this early cost forecast, provided by the Q.S., and make their investment decision and advance financial arrangement. This paper concentrated on how to maximizing the accuracy and performance of cost forecasting by making the best use of the data available. Three types of mean value forecasts are considered: (1) the use of the target base group (relating to a source with similar characteristics to the target project), (2) the use of non-target base group (relating to source with less or dissimilar characteristics to the target project) and (3) the use of a combined target and non-target base group. A formulation of mean square error is derived for each to measure the forecasting accuracy. Base on forecasting performance, the best pooling arrangement of the available data can be selected to suit the characteristics of the target project. Typically, this will involve pooling available data by groups according to the (1) project type (i.e. Residential, Commercial centre, Car parking, Social community centre, School, Office, Hotel, Industrial, University and Hospital), (2) building floor area and (3) project specification.

Keywords: data group pooling, mean value forecasting, homogeneity, forecasting accuracy, mean square error.

1. INTRODUCTION

During the feasibility study stage, most of the clients or building owners rely heavily on the early stage construction cost forecasts, provided by the Quantity Surveyor (Q.S), for their investment decisions and advance financial arrangement. In this early stage, most of the information concerning the new target project is very scarce, only available information is: (1) project type (i.e. Residential, Commercial centre, Car parking, Social community centre, School, Office, Hotel, Industrial, University and Hospital), (2) building floor area and (3) preliminary project specification. In this context, it is very common in practice for the Q.S. to use historical building cost data on which to base the forecast of the new project - typically basing the forecast on the known price of a similar project to the new one. Earlier researchers have pointed out the issues concerning forecasting accuracy with this and the advantages of using a group of similar projects instead of a single project. This paper aims to propose a method to define the best pooling arrangement of available data to suit the characteristic of the target project and by making the best use of available data to maximize the accuracy and performance of the cost forecast. For clarity, we shall refer to a new project as the target-project; a single similar project as the base-project; a group of similar projects as the base-group of projects; and the process of selecting the projects that comprise the base-group is called data pooling.

1.1 Family of prices

Statistician Beeston (1975) states that a potentially more powerful method than the base-project approach is to use the mean price of suitably composed base-group on the rationale that the target project price is one of a "family of prices" for that project, and for which the prices of those in the base-group are a proxy. In this case, the mean of the base-group provides the best estimate of the prices (observations) in the base-group by minimising the standard error involved (and maximum likelihood if the sample is normal). This being the case, it is easy to why this may be extended to a (future) observation outside the sample.

1.2 Homogeneity of cost data

The major difficulty with data pooling is what Flanagan (1980) has termed the "homogeneity" problem, in that the bigger the base-group the less similar are the projects in the base-group. In statistical parlance this means that, although the increased sample size reduces the standard error of the mean at the same time, the sample becomes less representative of the population from which the target project is conjectured to belong. In other words, making the best use of available data involves a trade off between the need to restrict the base-group used to that most relevant to the target project while at the same time maximizing the base-group size.

In 2001, Skitmore offered an approach to solving this in the risk analysis context by empirically examining the effects of all possible pooling combinations on forecasting errors with a view to selecting the data pooling arrangement that best minimises the spread of errors.

2. PROPOSED POOLING OF AVAILABLE HISTORICAL PRICE DATA

The research described in this paper aims to propose a method to define the best pooling arrangement of available data to suit the characteristic of the target project and by making the best use of available data to maximize the accuracy and performance of the cost forecast. Making the best use of available data involves: (1) a trade off between the need to restrict the base-group used to the most relevant to the target project, while at the same time (2) maximizing the size of the base-group involved.

2.1 Clustering of large data sets

There are different ways to organise the data source for forecasting the construction cost of the target project. Zupan (1982) has defined that clustering of large data sets are groups of objects linked together according to some rules. The goal of clustering is to find groups containing objects most homogeneous within these groups, while at the same time the groups are heterogeneous between themselves as much as possible.

2.2 Data sampling

450 projects from Hong Kong Private Sector and Public Sector (Housing Authority) were collected for this research. Information regarding (1) project type (2) construction floor area (CFA), (3) tender date and (4) cost per HK$/m2 (1000) of the collected projects are recorded. The entire project data sets are clustered as a hierarchical tree listed in Figure 1 (Ref: Appendix 1), and their project construction costs (HK$/m2) are recorded under their categories for further analysis as described in paragraph 3.

2.3 Pooling of historical cost data

In Skitmore's pooling study (2001), it is proposed to group the cost data into 5 groups for reviewing; they are (1) Construction floor area, (2) Contract sum, (3) Nature of works, (4) Project type, and (5) Number of bidders.

In this study, we restrict ourselves to just three of these: (1) Building type,, (2) Project specification and (3) Construction floor area (CFA). These data sets are clustered into two levels (hierarchical tree illustrates in fig.1): (1) Level 1: according to its project nature; (2) Level 2: according to its (i) specifications and (ii) CFA.

2.3.1 Level 1: Project nature base group pooling

For 450 projects collected, it is pooled into ten different building natures groups (i.e. Residential[R], Commercial centre[CC], Car parking[P], Social community centre[SO], School[S], Office[O], Hotel[HT], Industrial[I], University [U]and Hospital[H]). In Table 1, for example, the target project [TG] is a Residential project, this project use the following base groups as forecasting data pool: (1) the same target base group data (R), (2) target base group (R) combine with any <u>one</u> of the other base group (i.e. CC,P,SO,O, HT, I, U, H), (2) target base group (R) combine with any <u>two</u> of the other base group, (3) target base group combine with any <u>three</u> up to <u>eight</u> base group, and (4) target base group combines with all remained nine groups together. The MSQ (I), MSQ(II) or MSQ(III) values are then measured for all these sub-groups. Similarly, all the other target groups (i.e. CC,P,SO,O, HT,I,U and H) carry out the same process. Total 5120 base groups are generated

Table 1: Level one – project nature group pooling

T G	Sub groups										Forming of base groups		Nos. of BG	
	R	CC	P	SO	S	O	HT	I	U	H				
R											Target R it-selves		1	
		BG1.1	BG2.1	BG3.1	BG4.1	BG5.1	BG6.1	BG7.1	BG8.1	BG9.1	TG R pooled with any ones SG	C^{9}_{1}	9	
		BG2.1	BG2.1								TGR pooled with any two SG	C^{9}_{2}	36	
		BG2.2		BG2.2										
		BG2.3			BG2.3									
									BG2.36	BG2.36				
		BG3.1	BG3.1	BG3.1							TG R pooled with and three SG	C^{9}_{3}	84	
		BG3.2		BG3.2	BG3.2									
		BG3.3		BG3.3		BG3.3								
								BG3.84	BG3.84	BG3.84				
		BG4.1	BG4.1	BG4.1	BG4.1						TG R pooled with and four SG	C^{9}_{4}	126	
		BG4.2		BG4.2	BG4.2	BG4.2								
							BG4.126	BG4.126	BG4.126	BG4.126				
		BG5.1	BG5.1	BG5.1	BG5.1	BG5.1					TG R pooled with any five SG	C^{9}_{5}	126	
		BG5.2		BG5.2	BG5.2	BG5.2	BG5.2							
		BG5.3			BG5.3	BG5.3	BG5.3	BG5.3						
						BG5.12 6	BG5.126	BG5.126	BG5.126	BG5.126				
		BG6.1	BG6.1	BG6.1	BG6.1	BG6.1	BG6.1				TG R pooled with any six SG	C^{9}_{6}	84	
		BG6.1		BG6.1	BG6.1	BG6.1	BG6.1	BG6.1						
					BG6.84	BG6.84	BG6.84	BG6.84	BG6.84	BG6.84				
		BG7.1	BG7.1	BG7.1	BG7.1	BG7.1	BG7.1	BG7.1			TG R pooled with any seven SG	C^{9}_{7}	36	
		BG7.2		BG7.2	BG7.2	BG7.2	BG7.2	BG7.2	BG7.2					
				BG7.36	BG7.36	BG7.36	BG7.36	BG7.36	BG7.36	BG7.36				
		BG8.1	BG8.1	BG8.1	BG8.1	BG8.1	BG8.1	BG8.1	BG8.1		TG R pooled with any eight SG	C^{9}_{8}	9	
		BG8.2		BG8.2	BG8.2	BG8.2	BG8.2	BG8.2	BG8.2	BG8.2				
			BG8.9	BG8.9	BG8.9	BG8.9	BG8.9	BG8.9	BG8.9	BG8.9				
		BG9.1	BG9.1	BG9.1	BG9.1	BG9.1	BG9.1	BG9.1	BG9.1	BG9.1	TG R pooled with nine SG	C^{9}_{9}	1	512 Nos. BG for Target R
CC	For Target CC repeat the pooling process as Target R above													512 Nos. BG for Target CC
P	For Target P repeat the pooling process as Target R above													512 Nos. BG for Target P
SO	For Target SO repeat the pooling process as Target R above													512 Nos. BG for Target SO
S	For Target S repeat the pooling process as Target R above													512 Nos. BG for Target S
O	For Target O repeat the pooling process as Target R above													512 Nos. BG for Target O
HT	For Target HT repeat the pooling process as Target R above													512 Nos. BG for Target HT
I	For Target I repeat the pooling process as Target R above													512 Nos. BG for Target I
U	For Target U repeat the pooling process as Target R above													512 Nos. BG for Target U
H	For Target H repeat the pooling process as Target R above													512 Nos. BG for Target H
											Total: 5120 Nos. of Base Group (BG)			

2.3.2 Level 2 - Project specification group pooling

In level 2, all target groups (i.e. R,) are sub-divided into different base groups according to (1) preliminary specification and (2) CFA. In table 2, for example, Residential base group is split into: (i) average standard [Ra], (ii) luxury standard [Rx],(iii) public housing standard [Rp], and (iv) public housing for singleton standard [Rps]. As described in paragraph 2.3.1, for the target project Ra, the forecasting data pool can be used are: (1) the same target base group (i.e. Ra group only), (2) target base group (Ra) combines with any one of the other three base groups (i.e. Rx, Rp,& Rps), (3) target base group combine with any two unto three of the other base groups. Similarly, all other target groups (i.e. Rx, Rp & Rps) carry out the same process and extend to other level one target groups (i.e. CC,P,SO,O, HT,I,U and H) which is not mentioned here.

Table 2: Level 2 – Project specification group pooling (for residential project nature)

TG	Sub groups				Forming of base groups		Total Nos. of base-groups	
	Ra	Rx	Rp	Rps				
Ra					Target Ra it selves		1	
		BG1.1	BG1.2	BG13	TG Ra pooled with any 1 SG	C^3_1	3	
		BG2.1	BG2.1		TGR pooled with any two SG	C^3_2	3	
		BG2.2		BG2.2				
			BG2.3	BG2.3				
		BG3.1	BG3.1	BG3.1	TG R pooled with three SG	C^3_3	1	8 Nos. Base Group for Target Ra
Rx	Repeat the pooling process as Target Ra							8 Nos. Base Group for Target Rx
Rp	Repeat the pooling process as Target Ra							8 Nos. Base Group for Target Rp
Rps	Repeat the pooling process as Target Ra							8 Nos. Base Group for Target Rps
							Total	32

2.3.3 Level 2 - Project CFA group pooling

As described in paragraph 2.3.2, level 2 base group pooling also involves the requirement of sub-dividing the target groups (i.e. R,CC,P,SO,O, HT,I,U and H) into various base groups according to its CFA.

In table 3 below, for example, Residential base group are split into: (i) small CFA [RS], (ii) medium CFA [RM], and (iii) large CFA [RL]. Again, for the target project RS, the available base groups for forecasting are: (1) the same target base group (i.e. RS group only), (2) target base group (RS) combine with any one of the other base groups (i.e. RM, &RL), (3) target base group combine with all base groups. Similarly, all other target groups (i.e. RS, RM & RL) carry out the same process and extend to other level one target groups (i.e. CC,P,SO,O, HT,I,U and H).

Table 3: Base group for level 2 clustering (Project CFA)

TG				Forming of base groups		Total Nos. of base-groups	
	Rs	Rm	Rl				
RS				Target RS it selves		1	
		BG1.1	BG1.2	TG Ra pooled with any 1 SG	C_1^2	2	
		BG2.1	BG2.1	TGR pooled with any two SG	C_2^2	1	4 Nos. Base Group for Target RS
RM	Repeat the pooling process as Target Ra						4 Nos. Base Group for Target RM
RL	Repeat the pooling process as Target Ra						4 Nos. Base Group for Target RL
						Total	12

Based on the above, the total numbers and the summary of permutations are tabulated in table 4.

Table 4: Summary of base-group permutation

Levels	**1**	**2**	
	Building Type	**Project Specification**	**Project CFA**
Nos. of Target groups	10	19	30
Nos. of Combined Base groups	5120	44	81

3. PROPOSED METHOD TO IDENTITY THE BEST DATA POOL TO BE USED FOR EARLY STAGE COST FORECASTS

The proposed method comprises three stages: (1) calculation of mean value forecast for the target-project via different base-groups, (2) measuring the error of ensuing forecasts and (3) identifying the best base-group by the value of the mean square error. The details are:

3.1 Mean value forecast for target-project via different base groups

Base-groups can be divided into three types: (1) those with exactly the same characteristics as the target (e.g., for a target-project as residential project, the base-group comprises only those projects of residential project nature), (2) those with totally different characteristics to the target (e.g., for a target-project as residential project, the base-group comprises only those projects that is not a residential nature), (3) those with both the same and different project nature to the target (e.g. for a target-project as residential project nature, the base-group comprises those projects as residential project nature and other project nature as office building or others). Let X and Y be independent random variables representing the data with the same and different characteristics, respectively, to the target. X contains observations $x_1, x_2, \ldots, x_n$ and Y contains observations $y_1, y_2, \ldots, y_m$. The forecast is needed of the future, as yet unknown observation x_{n+1}. That is, letting $\hat{x}_{n+1}$ = forecast cost of the target-project,

Type I: using the base-group with exactly the same characteristic as the target

$$\hat{x}_{n+1} = \overline{x} \tag{1}$$

Where $\overline{x}$ = mean of the base-group with same characteristic

Type II: using the base-group with different characteristic to the target

$$\hat{x}_{n+1} = \overline{Y} \tag{2}$$

Where $\overline{Y}$ = mean of the base-group with different characteristic

Type III: using the base-group with both the same and different characteristics to the target

$$\hat{x}_{n+1} = \frac{n\overline{x} + m\overline{y}}{m+n} \tag{3}$$

Assume $$\frac{n\overline{x} + m\overline{y}}{m+n} = \overline{Z} \tag{4}$$

Where $\overline{Z}$ = mean of the source data group with less similar characteristic
m = Nos. of data for Y data source group
n = Nos. of data for X data source group

3.2 Forecast error between the target project and the mean forecast

The mean square error (MSQ) is used to measure the accuracy of the forecast construction cost. To simulate the forecast error, the out of sample MSQ is used. Therefore:

For **Type I**, the simulated forecast error is:

$$MSQ_{(I)} = \frac{1}{n}\sum_{i=1}^{n}\left(x_i - \overline{x}_i\right)^2 \tag{5}$$

Where $\overline{x}_i$ denotes the mean of the $x_1, x_2, x_3,........, x_n$ observations excluding the ith observation

For **Type II**, the simulated forecast error is :

$$MSQ_{(II)} = \frac{1}{n}\sum_{i=1}^{n}\left(x_i - \overline{y}\right)^2 \tag{6}$$

Where $\overline{y}$ denotes the mean of the $y_1, y_2, y_3,........, y_n$ observations.

For **Type III**, the simulated forecast error is:

$$MSQ_{(III)} = \frac{1}{n}\sum_{i=1}^{n}\left(x_i - \overline{z}_i\right)^2 \tag{7}$$

Where $\overline{z}_i$ denotes the mean of the $z_1, z_2, z_3,........, z_n$ observations excluding the ith observation

3.3 Identifying the best data-pooling arrangement

To identify the best data-pooling arrangement, simulated forecasts are made for each and every project in the target-group for a base-group composed by candidate data-pooling arrangement. These are then subjected to an error test and the mean square error values are recorded. The base-group that generates the least mean square error value is the best base-group for the target project and the associated data-pooling arrangement is therefore the best data-pooling arrangement.

4. ANALYSIS ON THE PROPOSED METHOD

In this paper, analysis only focuses on "Level 1: Project nature group". 450 projects are pooled into sub-groups according to its project nature as described in paragraph 2.3.1. The permutations of the base-groups are: (1) Residential Group [R], (2) Commercial Centre Group [CC], (3) Car parking Group [P], (4) Social Community Centre Group [SO], (5) School Group [S], (6) Office Group [O], (7) Hotel Group [HT], (8) Industrial Group [I], (9) University Group [U] ,(10) Hospital [H] and (11) combination of different base-groups as stated in table 1 (totally 5120 numbers of based groups). The mean square error values of MSQ(I), (II) and (III) for each base group are calculated.

4.1 Result of Mean Square Error for different target groups (project nature)

From the analysis result, it is noted that: (1) the traditional way of forecast using exactly the same characteristic data source (Type I-MSQ(I)) cannot always generate the most accurate result, (2) using the base-group with different characteristic to the target (Type II-MSQ(II)) never generate the most accurate result and (3) using the base-group with both the same and different characteristics to the target (Type III-MSQ(III)) in some cases can generate more accurate result. Detail of each target groups are discussed as below:

4.1.1 For Residential nature group

Residential target project has a simulated mean square error (MSQ(I))of 6.7122 when using only residential target project base-group, while using the combined base-group (Residential [R], Commercial [CC], Carpark[P], Social Community Center [SO], School [S] and Industrial [I]), the lowest mean square value of 6.6937 is obtained. This indicates that the (R,CC,P,SO,S,I) base-group provides the best pooling arrangement for forecasting residential projects. In fact, there are 46 out of 512 Nos. base groups can provide better data pooling for forecasting the residential projects. The MSQ performance for these 46 base groups is tabulated in table 5.

Table 5: MSQ result for Residential target group

TG	MSQ(I)	Base Group	MSQ(III)	TG	MSQ(I)	Base Group	MSQ(III)
R	**6.7122**	**R**	**nil**				
R	**6.7122**	**R CC P SO S I**	**6.6937**	R	6.712	R P SO S HT U	6.7054
R	6.7122	R P SO S HT I U	6.6951	R	6.712	R CC P SO S I U	6.7056
R	6.7122	R SO S I U	6.6957	R	6.712	R SO I U	6.7062
R	6.7122	R P S I U H	6.6957	R	6.712	R P SO S H	6.7064
R	6.7122	R P SO S U H	6.6959	R	6.712	R P S I H	6.7065
R	6.7122	R P SO S HT I	6.6966	R	6.712	R P SO S O I	6.7065
R	6.7122	R P S HT I	6.6968	R	6.712	R CC P I	6.7068
R	6.7122	R P SO S HT	6.6972	R	6.712	R CC P SO I U	6.7073
R	6.7122	R P SO S I U H	6.6979	R	6.712	R CC P SO	6.7075
R	6.7122	R S I	6.6987	R	6.712	R P SO O I	6.7077
R	6.7122	R SO S	6.699	R	6.712	R P HT I	6.7078
R	6.7122	R CC P SO I	6.7	R	6.712	R P SO HT	6.708
R	6.7122	R P S U H	6.7003	R	6.712	R P U H	6.7081
R	6.7122	R P S H	6.7007	R	6.712	R P HT I U	6.7085
R	6.7122	R P SO HT I U	6.7024	R	6.712	R P I U H	6.7087
R	6.7122	R SO S I	6.7027	R	6.712	R I U	6.7088
R	6.7122	R S	6.7037	R	6.712	R P SO U H	6.7088
R	6.7122	R S I U	6.7037	R	6.712	R P SO HT U	6.7092
R	6.7122	R CC P S I	6.7037	R	6.712	R SO U	6.7095
R	6.7122	R P S HT	6.7045	R	6.712	R SO S I H	6.7098
R	6.7122	R SO S U	6.7045	R	6.712	R P SO S HT I H	6.7101
R	6.7122	R CC P SO S	6.7045	R	6.712	R P HT	6.7107
R	6.7122	R P S HT I U	6.7046	R	6.712	R P S U	6.7116

4.1.2. For Commercial Centre nature group

Similarly, pooling the [CC,O,HT] as the base-group provides the forecast for commercial project the best MSQ(III) result of 1.7895 instead of using the same project base group (MSQ(I)=1.8229). There are 3 out of 512 Nos. base groups can provide better data pooling for forecasting the commercial project. The MSQ performances for these 3 base groups are tabulated in table 6.

Table 6: MSQ result for Commercial target group			
TG	**MSQ(I)**	**Base Group**	**MSQ(III)**
CC	**1.823**	CC	
CC	1.823	CC O HT	**1.7895**
CC	1.823	CC O HT U H	1.7938
CC	1.823	CC O H	1.8055

4.1.3 For other remaining target group

The other target groups of SO, S, O, HT, I, U, H similarly have the situations that the MSQ(III) is performed better than the MSQ(I) except car parking target group. Their performance details are tabulated in table 7.

Table 7: MSQ result for SO, S,O HT,I, U & H				
TG	**MSQ(I)**	**Base Group**	**MSQ(III)**	**Nos. of groups perform with better MSQ(III) Values then MSQ(I)**
P	0.3897	P	nil	0
SO	0.5528	SO I	0.5349	1 out of 512
S	1.1692	S R P O I U	1.1567	29 out of 512
O	2.6417	O C U	2.6235	4 out of 512
HT	7.0722	HT H	7.0105	1 out of 512
I	0.8332	I SO	0.8081	2 out of 512
U	12.087	U C SO S O HT I H	10.652	163 out of 512
H	12.892	H HT	11.904	1 out of 512

5. CONCLUSIONS

In the feasibility stage for construction project, there are situations where only such basic information as project type, project size and preliminary project specification are known concerning a new (target) project, forecasters have to resort to either using the price of a very similar project or mean price of a (base) group of projects. As is known, enlarging the size of the base-group lessens the variability of the forecast made this way but, at the same time, also lessens its appropriateness (homogeneity). An empirical method is proposed for identifying the base-group that provides the best trade-off of these opposing features. An analysis on project nature group is described involving the analysis of 450 actual Hong Kong construction projects in terms of its project nature (i.e. Residential, Commercial centre, Car parking, Social Community centre, School, Office, Hotel, Industrial, University and Hospital). This demonstrates that using the historical data with the same characteristics may not generate the best forecasts in the early stage, with some of the base group project data (as listed in table 5,6 & 7) providing the best forecasts for different targets project.

The analysis provided above is not comprehensive, the analysis only concentrated on one grouping category (project nature grouping). The proposed method should easily extend to other possible grouping categories (as mentioned in paragraph 2 above) to have further analysis .

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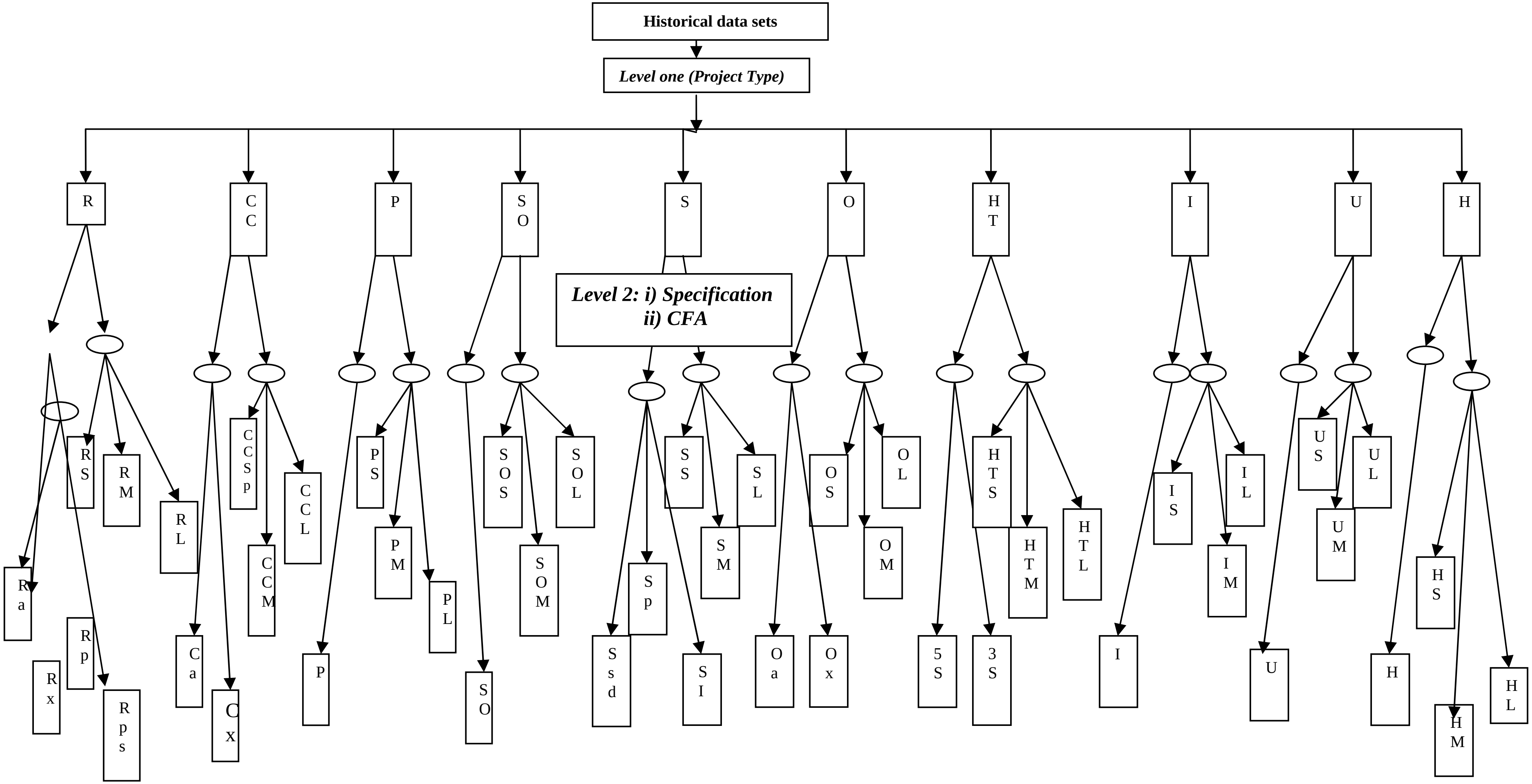

Figure 1: Clustering of data sets

Appendix : 1