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**ARCOM Declaration:**

The papers in these proceedings were double refereed by members of the scientific committee in a process that involved detailed reading of the papers, reporting of comments to authors, modifications of papers by authors and re-evaluation of re-submitted papers to ensure quality of content.

## FOREWORD

Welcome to Reading for the 29<sup>th</sup> edition of the Association of Researchers in Construction Management's annual conference. After our very successful event in Edinburgh, Scotland in 2012 we return to England and to Reading for the second time in ARCOM's history. In 1998, ARCOM held its 14<sup>th</sup> conference at the University of Reading and now, 15 years later, we return.

The conference initially attracted a very high amount of interest, possibly the largest ever, with more than 350 abstracts submitted. But we are fortunate at ARCOM that we are able to focus on research quality and, after an intensive three-stage review process over approximately five months the Scientific Committee determined that 126 papers were finally acceptable for inclusion in these conference proceedings.

I have made a big point about 'quality' over the last 18 months in my time as both conference editor and ARCOM chair. ARCOM has matured over 29 years and we are able to shift our attention not just from supporting and showcasing the very wide range of research that is undertaken in the development, delivery and maintenance of the built environment but now to promote excellence in the design, execution and reporting of research. I should emphasise the word 'research'. Not only is it a key part of this organisation's name but it is something that ARCOM above all else wants to promote. This means that every paper in the proceedings should be the result of work that has attempted to increase our understanding and knowledge through a process of rigorous and systematic investigation.

Of course the type of work that constitutes systematic and rigorous investigation comes in many different forms. This to me is what makes the research on our field so exciting and vibrant – we are the product of a vast range of disciplines, of methods and methodologies and of problems and applications. The result is that the proceedings you hold contain papers on very empirical and positivist numerical simulations that rub shoulders with works of a much more interpretive and constructivist nature. This ontological and epistemological diversity is something that is rarely seen in other fields.

And as we turn to the venue for this year's conference we can reflect on how this diversity has matured and changed in the fifteen years since our last outing in Reading. I have just picked up the proceedings from 1998, edited and prepared by Professor Will Hughes, and am struck by the quite clear shift from a predominance of numerical and objective work in 1998 to more interpretive and discursive nature in 2013. Both types of work are in evidence at each end of these fifteen years but the balance has changed. It is interesting to note, however, that some of the same subjects of investigation have remained. We see works on procurement processes, on innovation and on decision-making in the design process. We see such general areas of Information Management, Procurement and Risk remain. But of course we also now see the new or more highly developed subjects of Sustainability, Health and Safety and Building Information Modelling, subjects that were simply not conceived or were not the focus of attention. Perhaps most satisfying though, as I look at the Table of Contents from the 14<sup>th</sup> conference, is that many of the authors from then are also authors today. Some names are very familiar to us and some have shifted from 'first-author' to second or third, which of course in our field

implies they have moved from PhD student to Supervisor. And, to conclude, this is perhaps the most lasting legacy of ARCOM, that it is an arena for support and development, for sustained progress and tenacity of investigation, and maintains a core of enthusiastic and highly motivated people that should ensure that in 2028, at ARCOM's 44<sup>th</sup> Annual Conference, similar reflective observations will be made.

I shall plagiarise myself from 2012: go forward and enjoy. Engage in debate, make new friends, renew old acquaintances, advance and further our field and have a good time doing so!

*Dr Simon D Smith and Dominic D Ahiaga-Dagbui, University of Edinburgh, UK  
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# **PUBLIC PROCUREMENT AT LOCAL LEVEL IN THE NETHERLANDS: TOWARDS A BETTER CLIENT-CONTRACTOR COOPERATION IN A COMPETITIVE ENVIRONMENT**

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In the early 1990s, Dutch municipalities procured works mainly by invited tenders. The drive behind this policy was to maintain continuity of the relationship and cooperation between client and contractor(s). Towards the turn of the century the procurement policy moved to more public tendering. This was supposed to ensure more competitive pressure and to minimize suspicion over ‘cosy’ contacts between client and contractors. This ‘more competition’ policy was promoted even more after the exposure in 2001 of widespread collusion in the Dutch construction industry. For a number of years after this, client-contractor relationships remained distant and formal under the process of traditional contracting, open tendering and low cost selection. In 2009 representatives from the municipalities and contractors mutually expressed the wish to explore more integrated and cooperative contracts. These municipalities became participants in Pioneering<sup>1</sup> to start pilot projects focusing on relational contracting or partnering for design and execution. The assumption was that more cooperative problem-solving would lead to less conflict and greater added value. The first pilot project is finished and the results are promising, but there are also some lessons. The willingness to cooperate between client and contractor existed during design and execution phase. The cooperation produced better solutions than the initial client solutions. Also, the focus on cooperation produced a more open atmosphere between client and contractor. However, this atmosphere sometimes hampered a critical attitude and influenced the process efficiency negatively. The delivery of reliable information by the client was especially critical and held back due to the time constraints caused by other projects also being executed. The tendering for qualitative criteria only and no prices led to competitive discussion about the budget. The new procurement law implemented on the 1<sup>st</sup> April 2013 no longer allows this form of tendering. Furthermore, the cooperation intention in the execution phase was supported by traditional Design-Bid-Built) legislation. Therefore, extra costs were allocated according to the traditional client contractor framework. The future management of the process and further development of the cooperation concept into the execution phase both need attention.

Keywords: cooperation, municipality, procurement, project management

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<sup>1</sup> Pioneering is an organization for public clients, contractors, suppliers and consulting firms which aims to make Twente the outstanding region and an example for the Netherlands with regard to the construction industry

## INTRODUCTION & LITERATURE REVIEW

In the early 1990s Dorée (1996) studied the way competition was organized by municipalities. Continuity of relations and cooperation was, for a long time, the favoured procurement policy and followed the third transaction costs economics safeguard of Williamson (1975, 1985). This strategy restrained opportunistic behaviour by contractors. A more cooperative way of working, e.g. partnering based on trust, was favoured above competitive tendering. Towards the end of the century the procurement strategy by local authorities slowly changed towards more public tenders, e.g. a stronger price competition, and, on a small scale, the use of innovative and more integrated contracts forms like Engineering & Construct and Design & Construct (& Maintain).

The first change was due to an increased concern over legitimacy and transparency. This coincided with the introduction of the ‘Market, unless,...’ policy by the Dutch State’s Department of Economic Affairs in the late 1990s. This policy was aimed at early contractor involvement to stimulate innovation.

After the 2002/2003 parliamentary inquiry into collusion in the construction industry distrust towards contractors escalated (Dorée, 2004). National organizations like P*Si*Bouw and RegieRaadBouw were formed to institutionalize and support the overall reform and change of procurement policy in the construction industry. These organizations were also used as platforms for restoring a working relationship between clients and contractors.

The Dutch reform initiatives followed the “rethinking construction” format. The Egan (1998) report in the United Kingdom provided indicators for the way forward. Five driving forces, which apply to the Netherlands also, were anticipated to spearhead any reform initiatives and improve construction. These were: issues of leadership; a focus on the customer; integrated process and teams; a quality driven agenda; and, a commitment to the people.

In the Netherlands the exposure of collusion influenced the procurement policy and cooperation between parties for a number of years. However, a study by the contractors association Bouwend Nederland (2009) showed that clients, as well as contractors, preferred a more cooperative way of working and were seeking a way to move from competitive relationships towards cooperative partnering. Also, the national introduction of Innovative Procurement Program and new contract models ensured that the Economically Most Advantageous Tender (EmaT) was used more often. EmaT seeks the best quality/price ratio by outsourcing design, in combination with construction and, sometimes, even maintenance, to develop new products, creative solutions and process efficiency (Drechsler, 2009).

A widespread introduction of a more collaborative framework was hampered due to three factors: difficulties of translating the client’s problem into clear functional requirements; the collusion history; and, the complications caused by the non-quantifiable bid evaluation criteria related to legal obligations for ‘objectivity’ (Veldink, 2007, Bouwend Nederland 2009).

The use of non-quantifiable, subjective criteria is not a problem in a well-formalised tender procedure, but the fear of a legal discussion is often a motive to choose the lowest price selection and traditional Design-Bid-Build contracts with design responsibility for the client. (Koper, 2006; Bouwend Nederland, 2009).

Cooperation (or collaboration, partnership) faces competition and competitive behaviour. Gray (1989) compares competitive and cooperative ways of handling a problem. The main characteristics of cooperative problem-solving that he distinguished were: shared problem-solving; shared search for facts; underlying interest in workable solutions; satisfactory outcome for all the parties; integration of interests; and, integrated collaborative negotiations.

The acknowledged factors for a successful start of cooperation are commitment; self-assessment; the qualitative way in which partners are selected; the determination of mutual objectives; problem resolution mechanisms; and, the identification of responsibilities and risks. These factors do not easily fit into a competitive price procurement paradigm.

Furthermore, the success of cooperative partnership during the process relies on aspects such as: communication; teamwork; an understanding of each other needs; trust and openness; and, early involvement in the process (Walker, 2003; Erikson, 2010). Further factors stated by Chan (2003) which were believed to be significant underlying features leading to success were: the establishment and communication of a conflict resolution strategy; a willingness to share resources among project participants; a clear definition of responsibilities; a commitment to a win-win attitude; and, regular monitoring of partnering process.

In partnering relationships different types of cost incentives are used. A guaranteed maximum price for the client or a target cost with sharing of gains and losses (Walker, 2003; Broome & Perry, 2002) in combination with financial incentives to align business goals (Rose & Manley, 2010).

Commitment to partnering may be, and often is, only skin-deep. It can often disguise traditional attitudes and power relationship (Wolstenholme, 2009). Also, the problem of establishing and maintaining collaboration between client and contractor is complex given the dynamic interactions between the contracts, relationship management and attitudes of individuals (Kadefors, 2004; Bresnen, 2007; Rose and Manley, 2010; Laan et. al., 2011).

While cooperation can be profitable, its success is influenced by many factors. It requires some conviction and perseverance to implement. The way competitive pressures of different procurement methods are dealt with and contractual arrangements managed, these both set the stage and climate for how well cooperation develops, or not. How the representatives of the client and contractor deal with these pressures is pivotal for how actual partnership and cooperative problem solving emerge during the execution of a project.

This paper documents the structure and unfolding cooperation of a pilot project in the Eastern Region of the Netherlands. The aim is to learn about the practicalities of procurement and contractual incentives; the dynamics of cooperation; and, the potential added value of cooperative problem-solving.

The next section briefly introduces the pilot project and explains the research approach. The third section presents the findings and insights. These are reflected upon and discussed in the fourth and final section finishes with our conclusions.

## RESEARCH APPROACH

This paper describes the monitoring results of a civil engineering project which was deliberately procured and contracted to experiment with more cooperative arrangements.

The project started in 2010 to replace a pumping station and to reconstruct the sewer and mainly residential street in Daarlerveen, a small village. The project was tendered on 'problem description' with a minimum of functional and technical requirements and a target budget. The main activities of the project were the design and execution of a sewer and street work.

### Method

A longitudinal study was applied to study the project. This aimed to achieve the following ends: to characterise the cooperation; to examine the cooperation during the process; to assess how the parties and team members dealt with the success factors and aspects of cooperation; and to identify threats associated with the cooperation concept.

We chose to combine different methods of qualitative data collection to create a reliable picture of the process and factors influencing the cooperation as supported by all the team members. Also, as cooperation is mainly about behaviour, a qualitative approach seemed the best way to identify the important factors. The results from this research project will be used in forthcoming projects to combine a quantitative and qualitative research approach.

A first list of the factors influencing the cooperation process was identified by attending the meetings and studying the meeting reports. In-depth research of the resulting factors was then carried out. The concept report based upon this data was sent to all the team members and discussed in a final meeting with the intention to create a consensus about the cooperation process and factors influencing the functioning of the team. The final comments from this session were included in the final report.

We attended various meetings including: through the preparation phase; whilst the audit team met to discuss the bids and select a contractor; and, during meetings of the design and execution team. We studied information from the contracts, reports, bids and meeting minutes.

After the project execution phase in-depth interviews were held with the parties involved to look back and analyse the whole process. We interviewed the main players from clients, contractors, advisors and bidders. The monitoring results (e.g. meeting reports, the tender documents and contract) were compared with the characteristics, the success factors and aspects of cooperation. The discussions and choices were shared during the interviews to deepen the experiences of the parties involved.

The project finished in November 2012. The concept report was discussed in March 2013 and the final report soon after.

Table 1 summarises the different methods of data collecting. Semi-structured questionnaires are used for monitoring.

Table 8: *Methods of Data Collection*

Teams/Project Phases			
Tender Team		Design Team	Execution Team
Preparation Phase	Tender Phase	Design Phase	Execution Phase
Document study contracts	Document study bids	Monitoring design team	Monitoring execution team
Monitoring internal process	Selection meeting	Meeting reports	Meeting reports
Interviews with internal stakeholders	Interviews project manager client and tender managers bidders	Interviews project manager client and design manager contractor	Interviews project manager, client, design manager contractor, and members of execution and design team

An overall analysis of the different steps performed includes: the development and execution of the (functional) requirements and contracts; the tender strategy, the tender process, the award of the bids and the selection of a contractor and the contract; the design and execution process.

## FINDINGS

The procurement characteristics for this project are shown in Table 2.

Table 2: *Project Characteristics*

Tender Form	Award On	Influence Of Price	Main Criteria
Public	Quality	Not applicable as target budget determined	Organization, project organisation and references

### *The tender team*

The project manager and the central purchaser of the municipality were the important people to prepare the contract and tender documents. The tender team was provided with an advisor from an engineering firm who had experience with innovative contract forms, and a student from Pioneering for monitoring. The client used personality assessments to form the team, but not to select a contractor. The selection of a contractor was based only upon the documents of the bidders.

The contract award criteria and the tendering procedure concentrated on selecting the bidder on qualitative criteria, as is discussed below. The information provided to the interested parties consisted of a description of the problem in general; a limited technical specification; and, a description of the procedure by which the bids would be evaluated.

The client chose an EmaT tender procedure using three main qualitative criteria, with each divided into several sub-questions, e.g. the organisation quality (i.e. the way the bidder would organise the project internally with subcontractors, suppliers and the client); the project quality (i.e. the way the bidder would organise the project with regard to the process); and, reference projects.

These three parts were weighted 30%, 40%, and 30%. Also, the target budget was announced and a financial incentive implemented in the contracts such that the further below the target budget the bid was, the higher the profit.

The client received six bids. The contractor with the best offer, according to all the tender team members, described an integral approach to the project and its organisation. The others answered the questions in chronicle order, analogous to the (post-by-post) calculation of a traditional Design-Bid-Built contract.

The main point and criticism put forward by four of the six bidding parties was their concern as to whether the quantitative criteria would be able to assess whether a bid would fit the client's requirements and wishes. These bidders also feared subjectivity: "the one with the best talk gets the job" was a common reflection. However, the second placed contractor did not support these statements and urged for qualitative criteria to be used to differentiate between bids.

According to all the bidders, if cooperation is the aim, then two improvements would be: the use of face-to-face interviews; and, having sufficient time together to learn about each other. Both these were seen as being important criteria to create commitment in line with the partnering conditions.

We note from this that the improvements suggested above by the contractors simultaneously contradict their criticism on the selection method used.

#### *The design team*

The client, contractor and advisors formed a design team<sup>2</sup>. The client is responsible for the technical requirements, the data of the actual situation, and communication to the environment. The contractor is responsible for the design and calculation, and the advisors are responsible for technical support and detailed requirements.

Instead of the planned one year to design and execute, the design phase alone took almost one year. The delay was due to client's lack of capacity to provide reliable location data and requirements, as well as a bottleneck created by unexpected soil pollution at the site.

The gathering of reliable data conflicted with the other divisions of responsibility and tasks of people within the municipality. The project manager and planner followed the traditional long-term approach in compiling data. This frustrated the progress of the design. The experienced design manager noted the problem, but hesitated to bring this forward for discussion. As he stated later, he put this down to the lack of experience of the client in outsourcing the design, as well as a fear that this might undermine the cooperation.

The unexpected soil pollution in fact was the responsibility of a private citizen and the province as the responsible authority. Since the project had to remedy the on-site pollution problems in advance, this became an issue for the client with the contractor (as expert and certified executor of such remedial works) in an advisor role. The preparation for this extra work was executed in the traditional client-contractor relationship mode. This change of role was not in line with the cooperation concept, but was inevitable to abide with the environmental regulations that defined the required responsibilities very strictly.

Instead of the intended systematic, regular time-based way of scheduling meetings by the design team, following the winning bid of the contractor, the progress of an activity and the planning of a meeting became contingent upon, for example, the deployment of a team member or external stakeholders. The upside of such delays was the improvement of the design, but the downside was the lack of dynamic action in the process as there were sometimes long gaps of time between the meetings. The resulting lack of integrated teamwork was indicated by six months of hesitancy by the contractor over the technical requirements for the capacity of the sewer.

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<sup>2</sup> e.g. the regional water board to secure the input of the necessary project constraints and technical specifications, and a consultant firm to support the client

The contract contained no detailed information about the tasks or responsibilities of the advisors. At the start-up meeting, the role of the team was discussed, but not the individual roles of the team members. The project manager described the role of the advisors in finding solutions as passive, rather than a preferred active one. The manager of the consulting firm, who had widespread knowledge about the situation from his prior involvement, referred to his limited role in being able to support the client and the contractor in finding solutions.

The expected cost escalated from the target budget for the preliminary draft design to almost a 20% budget overrun for the final design. A short negotiation between client and contractor ended with an offer by the contractor to finish the job for the target budget. The time between preliminary design, final design and the signing of the execution contract was within a month. The focus on an optimum solution created a lack of attention on the budget controls according to the project and design manager.

The project and design manager stated that the financial incentive in the contract had no influence on the willingness to cooperate by the contractor. Instead, a discussion about the reliability of the target budget occurred. In the new Procurement Law (implemented 1<sup>st</sup> April 2013) the use of a target budget without any further price agreements is no longer allowed. However, the early involvement of the contractor in the design phase, and the close cooperation between client and contractor to optimise technical requirements, did result in a significantly improved design compared with the initial design which was used to determine the target budget for the project.

#### *The execution team*

As stated above, negotiations between client and design contractor resulted in an execution contract for the target budget. However, the pollution issue caused a delay which itself was created by unforeseen procedural discussions between the private citizen and the province. Works that should have started in September 2011 were postponed until March 2012, by which time the project manager of the municipality had fallen ill and had to be replaced by the planner.

The rapid completion of the design phase to allow a start in September 2011, together with the delays by the municipality in supplying information, meant design changes were necessary in the execution phase. Although the municipality had intended to follow a cooperation model in the design and execution phase, the execution contract turned out to be a traditional Design-Bid-Build contract. As a result, the extra cost for extra work and rework became the responsibility of the municipality. A lawyer specialised in procurement law (a member of Pioneering) noted the gap between contract and intentions.

## **DISCUSSION**

This project in the Eastern region of the Netherlands emanated from a wish of various parties to work in a more cooperative manner to promote better working relations and to obtain the benefits of collaborative problem-solving. The results are promising, but various points for discussion arise also.

Following on from the literature review we can pull out three areas for discussion,

#### *Factors for a successful start of cooperation*

The use of qualitative criteria only to select a partner is less favourable for some traditional contractors. An on-going discussion between clients and contractors about appropriate criteria is necessary to preserve competition, expectations and developments.

The lack of early widespread discussion on these issues at the beginning created some problems with regard to the determination of mutual objectives, problem resolution and identification of responsibilities and risks in the design and/or execution phase. The winning bid and client expectations should be discussed to create a common framework and support effective cooperation.

A late check of (dated) information of the current situation is risky and a standard procedure should be a meeting at the beginning of the design phase to identify essential information required.

#### *Characteristics of cooperative problem-solving*

The shared gathering of information for the design requirements during the design phase stimulated cooperation and discussion as the team searched for an optimum solution. Clarity is needed over which information should be a shared responsibility and which information should be the responsibility of each team member.

This project has shown that a fully reliable cost calculation is only possible after the final detailed design. Therefore, any cost estimation of a target budget in the beginning must be viewed as approximate only. Thus, any financial incentives linked to an initial target budget do place the potential benefits at risk.

The price negotiations for the execution contract are competitive. The contractor had to offer to match the target budget, or else the contract would have been tendered for and awarded at the lowest price. In the current market situation prices are under heavy pressure. So, although an improved design was the result of the cooperation, the contractor had to offer a (traditional market) project discount in order to succeed in being awarded the execution contract. Therefore, the benefits for the contractor to cooperate were less than expected. This might influence unfavourably their view about participating in future cooperation scenarios. The determination of a cost price should be competitive, but a discount to get the contract actually undermines cooperation and should be avoided. Thus, following the literature, the lesson is that cooperation should be supported by the use of 'smart' financial incentives.

#### *Process success*

An early discussion about the organisation, but also an early involvement of future team members, is highly recommended to support and further the process efficiency and effectiveness of the team in the different phases. Also, an open discussion about the role of the advisors is important to connect the needs and expectations of the team members and investigate possibilities for a more active role and a closer cooperation between advisors and client/contractor.

Furthermore, frequent meetings help to monitor and to support the process of collaboration and force partners to work together. A place to work together is highly recommended to create three opportunities: to allow people to escape from the traditional environment and engage in the new 'cooperative' space; to support shared communication; and, to stimulate commitment, informal contacts and openness.

Although the cooperation was legally limited to the design phase, a discussion about the way to lengthen the cooperation to the execution phase should be considered. A change halfway towards traditional client contractor roles, as in this case, hampered future cooperation. A parallel and critical review of the current legislation is necessary to better support the cooperation and to identify such possibilities with regard to the newly implemented Procurement Law.

## CONCLUSION

The tendering for a cooperation partner is, in a way, a return to the situation of the mid-1990s of invited tender, cooperation and long-term relation between client and contractors. However, nowadays the Dutch municipality's procurement preference practice is less cooperative and long-term more towards public tenders, transparency and objective price tendering.

In the case of the project discussed in this paper, the intention for cooperation was not a long-term relationship, but to get experience and insight as to whether cooperation could offer benefits compared with the traditional client contractor relations in single projects.

The results are interesting. The cooperation studied produced a better solution than the initial design which was used to calculate the target budget. The open atmosphere, which is characteristic of the cooperation required, was extended into the execution phase. However, the degree of cooperation was legally restricted to the design phase.

The study found various differences and views on the success factors, the characteristics and the cooperation process. The majority of the bidders, except the contractor and second choice contractor in the tender, preferred the use of measurable criteria to be able to measure their bids which, in a way, is a traditional way of thinking. However, the success of cooperation is highly dependent upon various factors: the composition of the team; the willingness to cooperate; the mission and priority given to a project; and, the employment of the less measureable criteria as used in this tender procedure.

The idea that a financial incentive stimulates cooperation is not proven. A lack of experience means that not all the documented guidelines for creating and monitoring a cooperation project have been worked out or put in place.

We observed various other responses. For example, there were: no in-depth discussion to create a common framework; less commitment and sense of priority given the lack of time and other responsibility outside of the project; the limited role of advisors in the design phase; and, differences between the parties' intentions and the legal framework to which they had to adhere.

In general the escape from the daily traditional working environment in the design phase was sometimes problematic for the municipality involved. Also, external stakeholders influenced the progress and threatened the cooperation. The lack of actual and reliable information caused changes and, due to the legal context, provided a return to the well-known traditional, client contractor relation in the execution phase. The only way to reduce and off-set these disturbances would be through a thorough investigation of the conditions and the required preparations.

For the future, the managing of the process needs attention, as does the need for further development of a proper supporting legal framework for design and execution under a cooperation model.

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# INCENTIVE CONTRACTING IN CONSTRUCTION

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The question of how best to incentivize the parties in a construction contract, particularly contractors, to deliver maximum possible outputs and thus help reduce costs and risk in contracts has been of constant interest to construction researchers and practitioners. There is thus a significant body of literature around incentive contracting but this needs to be critically evaluated for perspectives and future directions. Although the evolving nature, merits and use of incentive contracts within the construction industry has been considerably discussed by practitioners and researchers over several years, there seems to be a lack of critical review of the incentive contracts literature that contextualises and critiques the various perspectives, directions and applications in the construction industry. More importantly it is important to discover what we do not know yet about incentive contracting in construction to provide a means for further scientific enquiry into those aspects. This paper seeks to offer an evaluation and critical review of the current literature on the theory and practice of incentive contracts. Based on articles published in highly rated built environment journals, the issues and challenges of balancing risks, cost incentives and performance incentives that minimise or maximise the effectiveness and performance of incentive contracts are systematically reviewed and critically evaluated. The paper identifies trends in incentive contracting and concludes that the underlying needs of a client and the motivations of a contractor can be jointly put at the heart of the design and structuring of contract mechanisms and incentives to provide an appropriate infrastructure for incentivising innovative and sustainable delivery of contracts. The paper offers new directions for incentive contracting research and its application in construction

Keywords: contracting, incentive contracting, literature review, procurement.

## INTRODUCTION

In an increasingly competitive construction procurement environment, there is a growing interest in the use of incentive contracts to efficiently balance risks between the client and contractor. Since the mid 1960s, attention has been directed towards the need to use incentive contracts that motivate contractors to improve project performance and balance risks appropriately wherever possible in theory and practice (Baron 1972, Laffont and Martimort 2002). Much of the incentive contracting literature suggests that incentive contracts can foster a balance of risk between clients

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and contractors, leading to cost reductions, increased contractor performance and the alignment of objectives of the contract parties (Bower *et al.* 2002, Meng and Gallagher 2012). Accordingly, much of the studies and articles have been investigating incentive factors, mechanisms and measures in terms of performance (Gruneberg *et al.* 2007, Kaarbøe and Olsen 2008, Kauhanen and Napari 2012, Meng and Gallagher 2012). However, some of the literature disagree and suggest that incentive contracts can create distorted incentives due to the implicit nature of contracts and the subjective nature of some performance measurements (Baker *et al.* 1994, Baker 2000, 2002, Gibbons 2005, Kaarbøe and Olsen 2008). Furthermore, all contracts are incomplete mainly due to difficulty in interpretation of its implicit and explicit components.

Bresnen and Marshall (2000a, 2000b) suggest the debate within construction management literature has remained at a largely prescriptive level. It is difficult to prove that any monitored improvement in performance, in terms of cost, time, quality, fit for purpose and other criteria are solely due to the incentive contracts (Gruneberg *et al.* 2007). There seems to be a lack of critical review of the literature that contextualises and critiques the various perspectives and applications in the construction industry. Consequently there is still a need for more in-depth studies of the nature and form of incentives incorporated into contracts and their likelihood of incentivising contractors to improve performance, reduce cost and suitably allocate risks. Structuring an effective incentive scheme can be complex due to the consequences of variation in organizational and environmental contexts that cannot be controlled by the parties to the contract. Arguably, understanding the behavioural outcome of explicit incentives, where the client pays for objectively measured performance, and of implicit incentives, where the contractor gains repeat business from the client is key to structuring and administering incentive contracts successfully.

The aim of this review is to explore some of the critical issues and debates about incentive contracting. Our objectives are to offer an evaluation and critical review of the current literature on incentive contracting, drawing on the integration of the theories of incentives and motivation used in organisational economics. Thus the review seeks to contribute new understandings of the relationship between academic theory and practical action and address the different assumptions underlying incentive contracting. It concentrates on enquiring into what makes organisations perform well in the long term rather than individual contracts. Thus while there numerous aspects of incentive contracts; we focus our review on the alignment of goals, balancing risks, cost incentives, performance incentives, delivery incentives as a starting point.

In the next sections we provide a systematic and critical review of the specific areas of alignment of goals, balancing risks, cost incentives, performance incentives, delivery incentives, types of incentive contracts and administration incentive contracts. Prior to discussing these main concerns, the review begins with the concept of incentive contracting.

## **INCENTIVE CONTRACTING**

Contracting, often regarded as an important aspect of all business relationship, is going through significant changes in theory and practice (Williamson 1979, Macneil 1980). The changes address existing and desirable structures and functions of contracts. An important focus in the continuing movement from classical contracting (where contracts are typically fixed-price and parties to the contract have competing goals) to neoclassical (modern) contracting (where contracts are used to improve joint

welfare of the parties to contract by efficiently shifting risk from one party to another through collaboration and long-term relationships) is the use of incentives to motivate and improve performance and allocate risk appropriately in the contractual relationship.

The important role of implicit and explicit incentives in contractual relationships has long been acknowledged in several economics and organizational fields of studies (Scherer 1964, Weitzman 1980, Bresnen and Marshall 2000a, Laffont and Martimort 2002). Much of the literature is underpinned by neoclassical theories of uncertainty, risk, asymmetric information and incentives such as the Principal-Agent framework (Laffont and Martimort 2002), Agency theory (Eisenhardt 1989), Transaction Cost Economics (Williamson 1979, 1996). Although these theoretical issues are fairly understood, Weitzman (1980) points out that “results are at a rather high level of abstraction, somewhat removed from the realm of practical application”.

### **Incentive theory**

Much of the literature on Incentive Contracting suggests that the main purpose of incentive contracts is to appeal to a contractor’s (agent) self-interest to perform in a particular way to maximize its profit by adopting the client’s (principal) objectives to an extent (Meng and Gallagher 2012). Stukhart (1984) suggests that “contract incentives are the means by which an owner intends to secure certain project goals through the contracting process” and advocates that incentive contracting is designed primarily to reduce cost in negotiated contracts through profit sharing ratios. Building on the work of Blyth (1969), Bower *et al* (2002) state that the basic principle of incentive contracting is simply to take advantage of a contractor’s general objective to maximize his profits by giving him the opportunity to earn a greater profit if he performs the contract efficiently. In the process of incentive contracting, financial risk and control are shared by the client and contractor, according to a ratio which is established in the early stages of contract design. Once the targets and formula for earning fees or reward are known, the incentive contract becomes self managed to a certain extent (Stukhart 1984). However, as pointed out by Baker (1992, 2000), the principal’s (client) objectives are not always contractible performance measures and therefore a need for a delicate balance of the various types of incentives for success.

Bower *et al* (2002), in a study of incentive mechanisms for project success, define incentivisation as ‘a process by which a provider is motivated to achieve extra ‘value-added’ services over those specified originally and which are of material benefit to the user. These should be assessable against predefined criteria.’ This definition emphasises the need for a clear and precise objective of what is to be achieved and therefore the establishment of performance targets for the contractor. However, Bresnen and Marshall (2000a, 2000b) and other researchers, argue that implicit incentives were equally important for project success. Using six case studies from the UK construction industry and based on interviews and documentary sources, Bresnen and Marshall (2000a, 2000b) show that there are important limitations to the use of explicit incentives. Rose and Manley (2011), in a case study of using financial incentives as promoters of motivation and commitment on projects, concluded that financial incentives were less important to motivation and performance than relationship enhancement initiatives. Clearly, explicit incentives alone will not improve performance, rather appropriate combinations of explicit and implicit contracts will do.

Consistent with the predictions of self-interest based incentive theory, empirical studies of incentive contracting often show that incentive contracts encourage more effective work from contractors and suppliers (Jaraiedi *et al.* 1995, Arditi *et al.* 1997, Arditi and Yasamis 1998, Bubshait 2003, Meng and Gallagher 2012). Nevertheless, a large body of literature also suggests that due to the incompleteness of contracts in reality, incentives may be overused or underused, giving contractors opportunities to act in ways that may impair performance and efficiency (Baker 2002). As incentive contracts appeal to self-interest, parties to the contract might become more selfish. This has important implications for the design, implementation and monitoring of incentive contracts.

### **Actor-network theory perspective**

Drawing upon the Actor-Network Theory (ANT) (Latour, 2005); some authors suggest that incentives can be treated as actants (material and immaterial) and artifacts that act as an intermediary to stimulate social action. Even though the ANT perspectives on contractual relationships are growing in significance, it is not clear how artifacts as intermediaries and mediators affect and interact with the performance. Importantly, how are networks of action related to networks of actants (human and non-human, material and non-material)? Furthermore, according to the objective and subjective performance evaluation become a major problem for the actants and artifacts. Further research is required to understand whether and how actants and artifacts in incentive contracts and their specific properties motivate contractors to focus on certain activities and dimensions of performance. Recent reviews of the incentive contract literature indicate that incentives do not have disparity effects on task performance due to the complexity of task. However some research suggest that monetary incentives may reduce intrinsic motivation (effort) and performance on tasks viewed as complex and involving some level of innovation.

### **Monitoring and administering of incentive contracts**

Evidence from the wider literature also suggests that monitoring and administering incentive contracts is time consuming and expensive (Larbi 2001, Piñero and Garza 2003, Fernandez 2009, Hughes and Gruneberg 2009). In reality, clients (principals) are rarely in a position to monitor all the real and monitored outputs of the contractor perfectly at all times. Hence, the risk of the contractor is increased whether the gap between the real and monitored output is intentional or not. This might have an effect on contractor's profits or efforts. Similarly, the incentive criteria may not even be related to the critical procurement issues of cost, delivery schedule, or performance objectives, thus giving contractors either opportunities to receive undeserved fees or awards for effort, or getting underpaid for efforts.

While there is a broad agreement about the overall principles of incentive contracting as a trade-off between risk sharing and incentives, if used appropriately, there are nevertheless varying views on a number of its features such as balancing or sharing risks, types of incentives and performance measurement depending on the context of the contractual relationship. Contractors are paid based on their handling of risks, cost, delivery schedule, and general performance. Arguably incentives operate on different emotional mechanisms and the contracts communicate signals that appeal to these mechanisms in different ways.

## BALANCING RISKS IN INCENTIVE CONTRACTS

The importance of allocating risks in contracts is well established in the literature. Drawing upon the principal-agent framework, the incentive contract literature shows that when a client (principal) contracts out the work to the contractor (agent). The risks inherent in doing the work are transferred to the contractor. Thus while the client has no motive to minimise the risk, the contractor has strong motives to reduce the risk in order to make a profit. Other scholars however disagree arguing that the client bears the risk of not having direct control of how and when the work is done.

Incentive contracting is about tradeoffs between sharing risks and incentives. Much of the literature tends to suggest that risks should be carefully defined and allocated to the party that is in the best position to manage it is fairly well understood, but is often ignored (Chapman and Ward 1994, Arditi and Yasamis 1998).. For example, in a survey contractors and owners perception of incentive and disincentive provisions in a sample of Illinois DOT highway contracts that included I/D provisions, Arditi and Yasamis (1998) found that the contractors experienced higher frequency and magnitude of change orders were challenging.. Often in practice, the party with the strongest bargaining position gets to allocate the risk in the contract.. Well known scholars in the field like Baker (1994, 2000, 2002) believe that the relationship between risk and incentives is an important topic that is still not fully understood as incentive structures for balancing the risks can lead to both increased and decreased risk-taking among the parties to the contract. .

Among all the contractual risk issues and their corresponding incentive, financial (cost), technical or quality and delivery times have been argued extensively to be the most important in risk allocation and sharing in incentive contracting (Weitzman 1980, Chapman and Ward 1994, Aggarwal 2007, Marques and Berg 2011). Table 1 shows a summary literature reviewed and the selected incentive issues addressed (these issues are not coded or classifications but rather issues that were reviewed). Financial or Cost risk refers to uncertainty in final costs to the contractor and uncertainty in final financial commitment of the client. Most incentive contracts focus on cost as it is often the biggest element of risk in contracting. Technical or quality risk refers to quality issues and compliance with the technical specifications of the contract. Delivery risk relates to whether the deliverables of the contract will be met within the specified time.

Due to the complexity of risks and incentives in operation, often multiple incentives such as cost and performance incentives are incorporated into an incentive contract. For example, due to asymmetry of information, high incentive contracts can tempt contractors to take more risk and reduce performance in the long term. There is ample evidence that contractors respond to risks and incentives, and adjust their actions accordingly. Hence incentive contract are often designed to adjust the balance of risks between the client and contractor using a defined sharing ration (Weitzman 1980, Stukhart 1984). Often, the balance of risk is dependent on such features as uncertainty, risk aversion, and the contractor's ability to control costs (Weitzman 1980, Stukhart 1984) .

Table 1: Summary of literature reviewed

	Balancing risks	Cost incentive	Performance incentive	Alignment of goals	Delivery incentive
Fernandez, S. (2009).	✓	✓	✓		
Hague, D. J. (1985).	✓	✓	✓		✓
Hansen, S. J. and J. C. Weisman (1998).	✓	✓	✓	✓	✓
Hensher, D. A. and J. Stanley (2003)..	✓	✓	✓	✓	✓
Hosseinian, S. and D. Carmichael (2011).	✓	✓	✓		✓
Hughes, W. and S. Gruneberg (2009).	✓	✓	✓		✓
Ibbs, W. C. (1991).	✓	✓	✓		✓
Jaraiedi, M., R. Plummer, et al. (1995).	✓	✓	✓		✓
Kaarbøe, O. M. and T. E. Olsen (2008)	✓	✓	✓		✓
Meng, D. and G. Tian (2013).	✓	✓	✓		✓
Meng, X. and B. Gallagher (2012).	✓	✓	✓	✓	✓
Murdock, K. (2002)..	✓	✓	✓		
Richmond-Coggan, D. (2001).	✓	✓	✓		
Rose, T. and K. Manley (2011).	✓	✓	✓		✓
Rosenfeld, Y. and D. Geltner (1991).	✓	✓	✓		✓
Sommer, S. C. and C. H. Loch (2009).	✓	✓	✓	✓	
Sprinkle, G. B. (2000).	✓	✓	✓	✓	
Stenbeck, T. (2008).	✓	✓	✓	✓	
Stukhart, G. (1984).	✓	✓	✓	✓	
Abu-Hijleh, S. and C. Ibbs (1989).		✓	✓		
Aggarwal, R. M. (2007).	✓	✓	✓	✓	
Al-Subhi Al-Harbi, K. M. (1998).	✓		✓		
Ang, G., M. Groosman, et al. (2005).	✓	✓	✓		
Arditi, D. and F. Yasamis (1998).		✓	✓		
Arditi, D., C. Khisty, et al. (1997).	✓		✓		
Ashley, D. B. and B. W. Workman (1986).	✓	✓	✓	✓	
Bachmann, J. and A. Novoseltsev (2004)	✓	✓	✓		✓
Baker, G. (1992, 2000, 2002)..	✓		✓	✓	
Baker, G., R. Gibbon, et al. (1994).	✓		✓		
Berends, T. C. (2000).	✓	✓			
Bower, D., G. Ashby, et al. (2002).		✓	✓	✓	
Bresnen, M. and N. Marshall (2000).	✓	✓	✓	✓	
Bubshait, A. A. (2003).	✓	✓	✓	✓	
Chapman, C. B. and S. C. Ward (1994).	✓	✓			
Griffis, F. and F. Butler (1988).	✓	✓	✓	✓	✓
Gruneberg, S., W. Hughes, et al. (2007).	✓		✓	✓	
Hiller, J. R. and R. D. Tollison (1978).	✓	✓	✓	✓	✓
Jaafari, A. (1996).	✓	✓		✓	✓

## INCENTIVE CONTRACT TYPES IN CONSTRUCTION

Within the literature the two main types of incentive contracts are the Fixed-Price Incentive contract and Cost-Reimbursable Incentive Contracts. The various variations described below are adapted from (Weitzman 1980, Stukhart 1984, Burleson *et al.* 2007, American Society of Mechanical Engineers 2010)

**Fixed-Price Incentive Contracts:** a strong incentive is created to reduce project cost. However Contractors bearing all the risk must be compensated by a fee representing on average a high nominal profit rate. Thus most efficient where overall risk is low. Risk is shifted to the contractor. Variations of these contracts include (a) Firm-Target Fixed-Price Incentive Contracts (b) Successive Targets Fixed-Price Incentive Contracts (c) Fixed-Price Award-Fee Contracts

**Cost-Reimbursable Incentive Contracts:** The contractor has only committed to best effort on the contract, and the client. Thus the contractor assumes a relational share of the risk with an incentive-fee structure, and is rewarded with a greater share of fee, when the risk is mitigated or avoided

**Cost-Plus-Incentive-Fee Contracts (CPIF):** Relates fee to performance and provides contractor with incentives to control cost and schedule. It allows alignment of owner and contractor objectives. However, it is difficult to establish incentive goals that differentiate outstanding performance from good/ normal performance. The scope changes impact on incentives requires. Thus contractor will “push back” on item affecting their fee and very good negotiating skills required.

Incentive must relate to key project objective (never to both budget and schedule, for example)

**Cost-Plus-Award-Fee Contracts (Cost Reimbursement + % Fee):** Maximum contracting flexibility and can be fast tracked easily. Best for development/ changing scope as it is easier to insert proprietary needs. However, it required financial controls; highest owner staffing; many interfaces to manage; limited incentive by contractor to contain cost; owner assumes all risks. Thus rework is profitable for contractors. While this incentive contract encourages collaborative working, the owner can substantially influence contractor decisions; assumes more responsibility for results. It is often used where market place is saturated with work; when the scope is poorly defined and the contractor is known and trusted

Other types of incentive contracts are Subjective Risk-Sharing Contracts, Objective Risk-Sharing Contracts on Technical or Delivery Performance and Performance based contracting

## RELATIONSHIP BETWEEN INCENTIVE CONTRACTING AND STANDARD FORM CONTRACTS IN CONSTRUCTION

Standard form contracts are used widely in the construction sector for various reasons and purposes (Hughes and Greenwood, 2005). The implementation of incentive contracting in construction requires some kind of connection to standard (or non-standard) forms of contract. Contract is the vehicle that actually sets up the commercial relationship between the contracting parties. Various standard form contracts are used in different countries. It would clearly not be possible to enumerate all of them here. However, the paper authors are based in the UK and South Africa where similar standard form contracts seem to be used. These include JCT Forms, ICE Forms, NEC Family of Contracts, GC/Works Contracts, PC/Works Forms,

Association of Consultant Architects, Other Standard Forms of Contract, Non Standard Forms, Partnering Arrangements (see RICS Survey of Building Contracts in Use during 2010). In South Africa the JBCC standard form contracts is widely used in building projects similar to the use of JCT contracts in the UK. A common form of incentive contracting approaches in use in construction is target cost contracts. A target cost contract provides a mechanism where the financial risks of a project are shared between the employer and contractor in agreed proportions (Watermeyer, 2010). Target cost arrangements have been argued to help align the objectives of the parties, and thus create a partnering and collaborative working environment (Bresnen and Marshall, 2000).

From examination of the options offered in various standard form contracts, the NEC was found to have two options for setting up an incentive contract. These are Option C (Target Cost contract with activity schedule) and Option D (Target Cost contract with bill of quantities). In Option C, the Contractor tenders (or negotiates) a target price using an activity schedule. Each activity is priced as a lump sum and a Fee is also tendered as a percentage for subcontract work and for the Contractor's own direct work. The initial target price is the sum of the activity prices and the fee. During the course of the contract, the target price is adjusted to cater for compensation events that are set out in the contract. Payment is made on the basis of actual costs with an incentive mechanism for the Contractor to minimise costs. Savings and over-runs are shared between the parties. The sharing of risk in the target cost approach is likely to reduce the occurrence of disputes. In Option D, the target price is established by means of a bill of quantities rather than an activity schedule. During the course of the contract, the target price is adjusted to allow for changes of quantities as well as for compensation events. Thus, the Employer carries a rather greater risk in Option D than is the case with Option C.

## **DISCUSSION AND CONCLUSION**

The relationship between theory and practice has been discussed in construction management for generations. The divide between theory and practice in terms of the theoretical challenges of taking practice seriously needs to be addressed. Going forward, further research is needed to explore the relationship between incentive contracting theory and form of contract. A number of innovative procurement approaches have evolved in recent years and clients are constantly in need of new mechanisms for achieving best value for money (see UK Government Construction Strategy, 2011). The recent developments in client goals and the fact that incentive contracting is argued to enhance alignment of objectives between the parties in a contract (Bresnen and Marshall, 2000) suggest that more innovative ways of applying the theory of incentive contracting in construction need to be developed.

The review indicated that empirical and anecdotal evidence show that contractual incentives have widely varying effects on performance improvement. As discussed earlier, incentive contracts studies examining the effects of incentives on performance have reported mixed results with regard to their effectiveness. From the various theoretical perspectives, there are many activity variables that could interact with incentives to affect task performance.

Clearly within construction management research and practice, further research into incentive contracts has significant implications for numerous directions for future research in construction management. This would provide important insights into the effectiveness and efficiency of incentive contracts. Future research could examine

whether increasing the level of rewards induce risk taking behavior. Similarly, future research should investigate organization and person variables such as skills and task variables. The main barriers to relevance being the lack of overlap between the questions that academics ask and the problems and questions that practitioners face in incentive contracts. Clearly what is needed is bringing together multiple perspectives, knowledge bases, and methodologies to address the complex problems of incentive contracts.

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# ENFORCEABILITY OF EXEMPTION CLAUSES IN CONSTRUCTION CONTRACTS: A COMPARATIVE STUDY OF APPROACHES IN ENGLAND AND AUSTRALIA

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Exemption clauses are commonly provided in contracts by parties in the construction industry in an attempt to limit their liability for loss or exclude such liability altogether. The operation of exemption clauses in a legal context, however, has proved to have been fraught with great difficulties in both England and Australia. This paper seeks to address the question, "How does the enforcement of exemption clauses under Australian Law differ from the law of England?" A doctrinal legal research approach is used to establish the legal rules relating to the enforceability of exemption clauses in England and Australia. Once established, these rules are then compared and contrasted. The research found that, although the relevant law in both jurisdictions shared a common origin (the traditional English common law), there are now significant differences. These differences are primarily due to statutory regulation of exemption clauses introduced into England but not Australia, and the development and divergence of the Australian common law with respect to interpretation of exemption clauses. This paper provides a useful summary of the law pertaining to exemption clauses and, as such, will be of interest to construction and legal professionals and academics. The comparison of the law between England and Australia with respect to exemption clauses highlights an important debate as to whether freedom to contract should be regulated in commercial contracts.

Keywords: exemption clause, construction contract, contract law, unfair contract terms

## INTRODUCTION

As modern construction becomes more complicated, technical and sophisticated this has been reflected in contract documentation used in the construction industry. Parties involved in the construction process face potentially catastrophic losses and therefore often seek to exclude or limit liability for such losses. Werremeyer (2006) noted that construction contracts primarily involve the transfer of risks. Fewings (2013, p267) observed that there are "various techniques in dealing with risks" which include retaining risks, insuring against risks, spreading risks as part of a portfolio or moving away from the activity or "specialising in managing it." There are a number of ways parties may seek to exclude or limit financial losses in a construction contract. One of the most frequently used methods used to exclude or limit such losses in a contract is

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through the use of exemption clauses (ECs). Graw (2008: pp 275-276) defines an EC as a term of the contract inserted to exclude or limit liability, and explains that:

An excluding term (an exclusion clause) is one that completely excludes one party's liability ... A limiting term (a limiting clause) of much the same nature. However, it does not exclude liability entirely; it merely limits it to a particular fixed or determinable monetary amount.

For the reasons set out above ECs are part of the modern world of construction contracting and therefore understanding of ECs is important for academics and practitioners in construction management. Whilst the idea behind the EC is a relatively simple one of trying to exclude or limit liability, the operation of ECs in a legal context has been shown to be fraught with great difficulties.

Although English and Australian law share the same sources, the current approach of their respective courts shows a difference in their treatment of cases involving ECs. Whilst both countries started with the contemporaneous English common law as a basis, England has since passed the *Unfair Contracts Terms Act 1977* (UCTA), which dramatically altered how the courts deal with EC cases. Whilst Australia has enacted various legislation in the field of consumer protection law, there is nothing as far reaching as UCTA in Australia. This means that despite the historical and traditional links between the laws of England and Australia, UCTA does not apply in Australia and therefore decisions in the Australian courts use the common law as a yardstick in cases concerning ECs. The interpretation of ECs is often problematic and controversial in both countries.

This paper addresses the research question, "How does the enforcement of ECs under Australian Law differ from the law of England?" Using a doctrinal research approach, common law and legislation are considered in each jurisdiction to establish the current set of legal rules pertaining to ECs. As such, court decisions in several legal cases are considered. Although the facts of these cases are not always directly relevant to construction contracts, the legal principles emanating from the decisions are. Further, using a comparative legal research approach, the rules identified in each jurisdiction are compared and contrasted. The paper concludes by summarising the differences between English and Australian law with respect to ECs.

## **EXEMPTION CLAUSES IN ENGLAND CONSIDERED**

There is a dichotomy in the law of contract: on the one hand, there is the doctrine of "freedom of contract" (i.e. the ability to contract on whatever terms one likes) and, on the other hand, the injustice caused by onerous and oppressive contract conditions which may be imposed by contractual parties with dominant bargaining power. Advocates for the freedom of contract justify their approach on the notional basis that "if you don't like the contract terms, then don't enter into the contract". Support for this approach may be found in the words of Forbes J, in *Salvage Associate v CAP Financial Services* [1995] FSR 654, who stated:

Generally speaking where a party well able to look after itself enters into a commercial contract and with full knowledge of all the relevant circumstances willingly accepts the terms of the contract which provides for the apportionment of financial risks of that transaction, I think that it is very likely that those terms will be held to be fair and reasonable.

A case which upholds the attitude of the judiciary in a construction context can be found in Lord Pearson's speech in *Trollope & Colls Ltd v North West Metropolitan Hospital Board* (1973) 9 BLR 60, where Lord Pearson stated:

The basic principle [is] that the court does not make a contract for the parties. The court will not even improve the contract which the parties have made for themselves, however desirable the improvements might be. The court's function is to interpret and apply the contract which the parties have made for themselves. If the express terms are perfectly clear and free from ambiguity, there is no choice to be made between different possible meanings; the clear terms must be applied **even if the court thinks some other terms would have been more suitable**" [emphasis added].

This speech encapsulates the argument that the courts will not interfere where the words used are clear and unambiguous.

The counterpoint to this approach, however, is the view that the law ought to take cognisance of unequal bargaining power and oppressive behaviour. Accordingly, the courts throughout the years have tried to steer a middle path, attempting to uphold the parties' rights to make contracts on any terms they choose (as long as the contract is not tainted by illegality) whilst at the same time frowning upon extreme instances of what might be perceived as "sharp practice" or "unconscionability". As such, ECs have long been regarded as controversial and attracted the attention of the courts. For example, as long ago as 1877, the case of *Parker v SE Railway Co* (1877) 2CPD 616 considered the validity of an EC on the back of a left luggage ticket.

In the landmark case of *L'Estrange v Graucob* [1934] 2 KB 394, it was finally established that where a person signs an agreement which includes an EC then that person is bound by it whether or not the person bothered to read the agreement or not. However, the extent of *L'Estrange* was limited by a decision in *Curtis v Chemical Cleaning Company* [1951] 1KB 805 where it was decided that an EC in a signed document is ineffective if the other party has made a misrepresentation. Where a document containing an EC is unsigned, however, the traditional stance of the common law has been to generally require that reasonable and sufficient notice of the EC be given in order that the EC be valid (*Olley v Marlborough Court* [1949] 1 KB 532; *Thompson v LMS Railway* [1930] 1 KB 41; *Thornton v Shoe Lane Parking Ltd* [1971] 2 QB 163).

For a number of years it was argued that an EC could not exclude a fundamental breach of contract (see, for example, *Karsales (Harrow) Ltd v Wallis* [1956] 1 WLR 936). This view, however, was rejected in *UGS Finance v National Mortgage Bank of Greece* [1964] 1 Lloyds's Rep 446 (henceforth "UGS") on the grounds that such a rule of law interferes with the parties' "freedom of contract" rights. The decision in *UGS* was re-affirmed in the *Suisse Atlantique* [1967] 1 AC 361 and later in *Photo Productions Ltd v Securicor Transport* [1980] AC 827. The latter two cases confirmed the principle that liability for a fundamental breach of contract can be excluded by an EC. However, this principle is affected by a technical rule known as *contra preferentem* (against the preferred) discussed below, and UCTA discussed later.

Where ambiguity in the wording of ECs has rendered their meaning uncertain, the courts have applied the *contra preferentem* rule, thereby interpreting the EC against the interests of the party seeking to rely upon the EC (*Baldry v Marshall* [1925] 1 KB 260; *Houghton v Trafalgar Insurance Co* [1953] 2 All ER 1409; *White v Warwick* [1953] 1 WLR 1285). It should not be thought that *contra preferentem* represents English Law from a by-gone age. As recently as July 2012, in *Markerstudy v Endsleigh* [2009] EWHC 281 (henceforth "*Markerstudy*"), the court had to decide on the meaning and extent of the following passage:

Neither party shall be liable to the other for any indirect or consequential loss (including but not limited to loss of good will, loss of business, loss of anticipated profits or savings and all other pure economic loss) arising out of or in connection with this agreement.

As Robinson (2010) commented:

It was common ground this clause excluded “indirect and consequential loss” and that, by itself, this was of limited effect as it did not prevent recovery of “*losses which flow naturally from a breach without other intervening cause and independently of special circumstances*”. The contentious issue was other heads of loss in the parenthesis. Were they:

- freestanding, so that both direct and indirect loss of goodwill, business, profit and economic loss are excluded. This would be a potent exclusion and would severely hamper Markerstudy’s ability to recover; or
- qualified by the words “indirect or consequential” - i.e. loss of goodwill, business, profit and economic loss is to not be excluded if it flows naturally from the breaches

The judge decided that the latter view was correct and, as a consequence, the EC offered much less protection than Endsleigh had anticipated.

The decision in *Markerstudy* also reflects the traditional view of the English common law that consequential losses may be distinguished from direct losses according to the two limbs of damages in the test of remoteness laid down by court in the landmark case of *Hadley v Baxendale* (1854) 9 Exch 341. In other words, direct losses are to be equated with losses flowing naturally from the breach (the “first limb”), and consequential losses are to be equated to losses which were within the reasonable contemplation of the parties as a probable result of the breach at the time they made the contract (the “second limb”).

### **The Unfair Contracts Terms Act 1977**

In an attempt to regulate the potential for a contractual party to impose an unduly harsh or unfair EC on the other party, the UK Parliament passed the *Unfair Contracts Terms Act 1977* (UCTA). Adriaanse (2010, p263) observed that, "Despite its name, the *Unfair Contracts Terms Act 1977* (“UCTA”) deals with exclusion clauses, and not with terms that are unfair".

UCTA (s 2(1)) provides that any term or notice excluding or restricting liability for death or personal injury is void. UCTA (s 2(2)) further provides that in the case of other loss or damage, exclusions or restrictions of liability are subject to a requirement of "reasonableness". Crucially "reasonableness" is not defined. However, the Act provides the following "guidelines" (in Schedule 2 to the Act) in order to assess reasonableness:

- (a) the strength of the bargaining positions of the parties relative to each other, taking into account among other things) alternative means by which the customer’s requirements could have been met;
- (b) whether the customer received an inducement to agree to the term, or in accepting it had an opportunity of entering into a similar contract with other persons, but without having a similar term;
- (c) whether the customer knew or ought reasonably to have known of the existence and the extent of the term (having regard, among other things, to any custom of the trade and any previous course of dealing between the parties);
- (d) where the term excludes or restricts any relevant liability if some condition was not complied with, whether it was reasonable at the time of the contract to expect that compliance with that condition would be practicable;
- (e) whether the goods were manufactured, processed or adapted to the special order of the customer.

Despite the guidelines set out above, sometimes the concept of “reasonableness” can be difficult for the courts to deal with. This is demonstrated below in two recent cases involving ECs, namely *The Trustees of Ampleforth Abbey Trust v Turner & Townsend Project Management Ltd* [2012] EWHC 2137 (TCC) (henceforth “*TTPM*”) and *Allen Fabrications Ltd v ASD Ltd* (2012) EWHC 2213 (TCC) (henceforth “*Allen*”).

### ***TTPM* and *Allen* considered**

In *TTPM*, the project managers (TTPM) failed to arrange for the formal execution of a construction contract for works known as “H5”, which was the provision of bedrooms and other facilities for students at a private boarding school. TTPM had issued a series of letters of intent to the contractor working at the site but crucially had not warned their client of the inherent risks of using letters of intent. The works were completed late and the College (Employer) sought to recover liquidated damages under the contract. Due to the fact that no formal contract had been executed, and no mention of liquidated damages had been made in any of the letters of intent, the College was unable to recover any liquidated damages and therefore sued TTPM alleging professional negligence. TTPM denied negligence and pointed out a condition in their terms of engagement limiting their liability to the amount of their fees (which was £111,321). The College's claim was far higher than the amount paid in fees. TTPM argued that the wording of the EC was clear and, as the parties had equal bargaining power, the EC ought to be considered to be “reasonable”.

The judge agreed with TTPM that the wording of the EC was clear, yet he still found it to be unreasonable. TTPM's terms required them to maintain £10 million of professional indemnity insurance (effectively paid for by the College via TTPM's fees), but the EC limited liability to £111,321. In effect this meant that the College was paying for £10 million worth of insurance, which was more or less worthless because liability had been capped at such a low amount. Furthermore, the parties had worked together on two previous projects without this onerous EC being incorporated, yet TTPM had not specially drawn the College's attention to it when it was used in the terms of engagement for the H5 works. For the reasons stated above, the EC in *TTPM* was deemed to be unreasonable and unenforceable.

In *Allen* the works comprised the construction of a two storey workshop. The Client was a boat building company, Bembridge. The main contractors were PB Structures who were responsible for constructing a platform for entry and removal of boats from the workshop. PB Structures sub-contracted construction of the platform frame to Allen. The platform required a steel grating to be placed over the steel frame to take the weight of the boat, trolley and labourers. Allen subcontracted the supply of the gratings to ASD.

In September 2006 an employee of Bembridge was standing on the platform pushing a boat into the workshop when the grating gave way. The employee fell 3.4 metres and the employee was severely injured which left him incapacitated. Bembridge did not contest the employee's claim and paid out £7 million in compensation. Bembridge sought contribution from various parties including PB Structures which produced a “domino effect”, i.e. PB Structures sued Allen who, in turn, sued ASD alleging that the latter, as suppliers of the grating, failed to supply the correct number of fixings and /or failed to advise Allen on the correct method of fixing.

Counsel for ASD argued that it had no contractual obligations to Allen other than supply and that they (ASD) sought to rely on their standard terms and conditions which contained the following:

We are not liable for any other loss or damage (including indirect or consequential loss, loss of profits or loss of use) arising from the contract or the supply of goods or their use even if we are negligent.

Our total liability to you (from one single cause) for damage to property caused by our negligence is limited to one million pounds.

For all other liabilities not referred to elsewhere in these conditions our liability is limited in damages to the price of the goods.

Allen sought to prove that the ECs above were "onerous" and as such that they were required to be specifically brought to Allen's attention. The inference was that ASD's ECs were "unreasonable" and therefore ought to be struck down by UCTA. The judge rejected this argument making the point that, having conducted business together over 250 times, Allen must have been sufficiently aware of ASD's terms. The judge also noted that Allen's standard terms contained similar wording to ASD's and, therefore, could not be construed as being unreasonable. Therefore ASD's contribution was limited in this case to the purchase price of the goods i.e. £705. The judge also noted that Allen was adequately protected by insurance.

The two recent cases discussed above show that despite UCTA's guidelines, the courts still have problematic issues to deal with when deciding "reasonableness".

## **EXEMPTION CLAUSES IN AUSTRALIA CONSIDERED**

To consider the use of contractual ECs in Australia, it is necessary to categorise contracts into two types:

- Contracts for the supply of goods or services to a consumer which are covered by the Australian Consumer Law (*Competition and Consumer Act 2010* – Schedule 2); and
- All other commercial contracts.

### **Contracts for the supply of goods and services to a consumer**

The *Australian Consumer Law* ("ACL") aims to protect consumers who have entered into contracts by implying certain "guarantees" into contracts for the supply of goods and services such as, amongst others: guarantees relating to title (s 51), undisturbed possession (s 52), undisclosed securities (s 53), acceptable quality (s 54), fitness for purpose (ss 55 & 61), and due care and skill (s 60).

The ACL (s 64) renders void any contractual term that purports to exclude, restrict or modify any of the guarantees implied into such contracts with consumers. However, where the contract is for goods or services not of a kind ordinarily acquired for personal, domestic or household use or consumption, the supplier is allowed to limit its liability as prescribed in the ACL (s 64A (1) and (2)). Such limitation, however, is subject to it being fair or reasonable for the person who supplied the goods or services to rely on the limiting term of the contract (s 64A(3)). Notably, the test to assess reasonableness set down by the ACL (s 64A(4)) is almost identical to that used by UCTA, as discussed above, in England.

### **Commercial Contracts**

In order to establish the enforceability of ECs in contracts other than those with a consumer covered in the ACL, it is necessary to consider Australian common law. The Australian common law adopted many of the English common law fundamental principles with respect to ECs. For example,

- ECs must be contained within documents which are contractual (*Causser v Browne* [1952] VLR 1; *D J Hill & Co Pty Ltd v Walter H Wright Pty Ltd* [1971] VR 749; *Le Mans Grand Prix Circuits Pty Ltd v Iliadis* [1998] 4 VR 661);
- Reasonable steps must be taken to bring the EC, and its contents, to the notice of those against whom the clause may be used before or at the time the contract is entered into (*Oceanic Sun Line Special Co Inc v Fay* (1988) 165 CLR 197); and,
- Generally, persons are bound by ECs in contractual documents which they have signed (*Equuscorp Pty Ltd v Glengallan Investments Pty Ltd* [2004] 218 CLR 471; *Toll (FGCT) Pty Ltd v Alphapharm Pty Ltd* (2004) 219 CLR 165).

Despite these common principles, the fundamental difference between Australian and English law is that there is no general requirement for an EC to satisfy a statutory test of reasonableness in Australia as there is under UCTA in England. As such, courts in Australia will generally seek to uphold any clearly drafted ECs which parties, regardless of bargaining power, have freely agreed in their contract. In other words, Australian courts do not have the obligation, or discretion, to strike an EC out of a contract solely on the basis that it appears unfair to the party against whom it is being used. Having said this, the Australian courts view ECs with caution and, therefore, have been all too willing to limit their application by:

- placing a heavy burden on the party attempting to rely on the clause to show that the exclusion term is part of the contract;
- construing any ambiguity in the clause against the party relying on the clause (the *contra proferentum* rule); and,
- interpreting the clause strictly according to the precise meaning of the wording.

The current common law principle with respect to the construction of ECs was laid down by the High Court of Australia in *Darlington Futures Ltd v Delco Australia Pty Ltd* (1986) 161 CLR 500 at 510-511 (henceforth “*Darlington*”), as follows:

the interpretation of an exclusion clause is to be determined by construing the clause **according to its natural and ordinary meaning**, read in the light of the contract as a whole, thereby giving due weight to the context in which the clause appears including the nature and object of the contract, and, where appropriate, construing the clause *contra proferentem* in case of ambiguity. [emphasis added]

In *Darlington*, Delco instructed a commodity broker to engage in commodity futures dealings on its behalf. The broker engaged in dealings described a ‘day trading’ purporting to act on behalf of Delco, and exposed Delco unduly suffering huge losses. Delco had, in fact, not authorized day trading under the contract and sued for \$279,715. The broker attempted to rely on two exclusion clauses in the contract:

*Clause 6* – which absolved the broker of responsibility for any loss arising in any way out of trading activity undertaken on behalf of [Delco] whether pursuant to the agreement or not.

*Clause 7* – which limited the liability of the broker in respect of any claim arising out of or in connection with the relationship established by the Agreement or any conduct under it or any orders or instructions given to \$100.

The court held that read in context, the words of clause 6 plainly (according to their natural and ordinary meaning) refer to trading activity undertaken by the broker for Delco with Delco's authority, whether pursuant to the Agreement or not. Consequently, the court found that clause 6 should not apply in these circumstances because it was not consistent with the intention of the parties for unauthorized trading to be considered as being ‘undertaken on behalf’ of Delco. However the court considered that it was consistent with the intention of the parties for unauthorized trading to be considered as being ‘in connection with the relationship’ and therefore within the scope of clause 7. Therefore, the broker’s liability was limited to \$100 in respect of each of the unauthorised trades.

Despite the Australian courts cautious approach to interpretation of ECs, two recent decisions (*Owners Strata Plan 62930 v Kell & Rigby Pty Ltd* [2009] NSWSC 1342; *Lane Cove Council v Michael Davies & Associates Pty Ltd & Ors* [2012] NSWSC 727) have held that the words of a clause in a retainer agreement (for engineer and architect firms respectively) which limited liability “whether under the law of contract, tort *or otherwise*” [emphasis added] were wide enough in their ordinary meaning to limit liability for a claim under statute – specifically for misleading or deceptive conduct under the TPA (now the ACL). In both cases, the court found that the clause did not amount to a contracting out of the TPA (which is forbidden under the legislation), but simply reflected the parties intentions to impose temporal and monetary limits on the damages that may be awarded under statutory provisions.

The Australian courts have never adopted an approach that forbids contractual clauses which exclude liability for fundamental breach of contract. In this respect, the courts have always upheld the parties’ right to freedom of contract. The Australian approach, much like the one eventually reached by the English courts (as discussed above), is to decide whether the words of the exclusion clause read in their context and circumstances, and given their precise meaning, are wide enough to exclude liability for the fundamental breach that has occurred (*City of Sydney Council v West* (1965) 114 CLR 481; *Nissho Iwai Australia Ltd v Malaysian International Shipping Corp. Berhad* (1989) 167 CLR 219).

Traditionally, with respect to clauses excluding liability for consequential loss, the Australian common law has followed the English approach (as discussed above) that consequential losses equate to those falling within the second limb of the test for remoteness in *Hadley v Baxendale* (1854) 9 Exch 341. However, in its 2008 decision in *Environmental Systems Pty Ltd v Peerless Holdings Pty Ltd* [2008] VSCA 26 (henceforth “*Peerless*”), the Victorian Court of Appeal found the English position to be “flawed” (*Peerless* at [87]). Instead, in defining consequential loss, Nettle JA (*Peerless* at [87]) preferred a distinction

between ‘normal loss’, which is loss that every plaintiff in a like situation will suffer, and ‘consequential losses’, which are anything beyond the normal measure, such as profits lost or expenses incurred through breach.

The *Peerless* decision is highly significant in that it has the effect of expanding the definition of consequential loss in the context of ECs. As Nettle JA explained, under this definition, “some ‘consequential loss’ may well fall within the first rule in *Hadley v Baxendale* as loss arising ‘naturally’, ie. according to the usual course of things,

from the breach of contract.” The *Peerless* decision has subsequently been followed by the New South Wales Court of Appeal and the South Australian Supreme Court in *Allianz Australia Insurance Ltd v Waterbrook at Yowie Bay Pty Ltd* [2009] NSWCA 224 and *Alstom Ltd v Yokogawa Australia Pty Ltd and Anor (No 7)* [2012] SASC 49 (henceforth “*Alstom*”) respectively.

In *Alstom*, Bleby J explained:

To limit the meaning of indirect or consequential losses and like expressions, in whatever context they may appear, to losses arising only under the second limb of *Hadley v Baxendale* is, in my view, unduly restrictive and fails to do justice to the language used. The word “consequential”, according to the Shorter Oxford English Dictionary means “following, especially as an effect, immediate or eventual or as a logical inference”. That means that, unless qualified by its context, it would normally extend, subject to rules relating to remoteness, to all damages suffered as a consequence of a breach of contract.

Thus, at least in Victoria, New South Wales and South Australia, ECs which exclude liability for consequential loss are likely to have a wider coverage than a similar term in English law.

## THE CONSTRUCTION OF LIMITATION VERSUS EXCLUSION CLAUSES

The English approach to limitation clauses was stated by Lord Wilberforce in *Ailsa Craig Fishing Co. Ltd v Malvern Fishing Co. Ltd* [1983] 1 WLR 964 at 966 as follows:

Clauses of limitation are not to be regarded with the same hostility as clauses of exclusion; this is because they must be related to other contractual terms, in particular to the risks which the defending party may be exposed, the remuneration which he receives, and possibly also the opportunity of the other party to insure.

In the same case, Lord Fraser stated:

Such [limiting] conditions will of course be read contra proferentum and must be clearly expressed, but there is no reason why they should be judged by the specially exacting standards which are applied to exclusion and indemnity clauses.

This position was affirmed by the House of Lords in *George Mitchell (Chesterhall) Ltd v Finney Lock Seeds Ltd* [1983] 2 All ER 737.

Such an approach has not been adopted by the Australian courts. In Australia limitation clauses are construed by the courts in exactly the same way as exclusion clauses (see, for example, *Electricity Generation Corporation t/as Verve Energy v Woodside Energy Ltd* [2013] WASCA 36) according to the principle set out in *Darlington* (as discussed above). The rationale behind the court’s reasoning for such equal treatment is that “a limitation clause may be so severe in its operation as to make its effect virtually indistinguishable from that of an exclusion clause.” (*Darlington* at 511).

Koffman and Macdonald (2007: pp197-198), however, have observed that some support for a move towards the Australian position with respect to limitation clauses might be found in some English decisions. They state:

In *HIH Casualty and General Insurance Ltd v Chase Manhattan Bank* [2003] 1 All ER (Comm) 349 Lord Hoffmann emphasized that construction is a matter of looking for the parties’ intention. He referred to Lord Fraser’s statement in *Ailsa Craig Fishing Co. Ltd v Malvern Fishing Co. Ltd* (1983) as to the distinction to be made between limitation and exclusion clauses and doubted that Lord Fraser had been intending to make a ‘mechanistic’

rule (at [63]). Also, in *BHP Petroleum v British Steel* [2000] 2 All ER (Comm) 133 at [43] Evans LJ favoured the single line that:

‘The more extreme the consequences are, in terms of excluding or modifying the liability that would otherwise arise, then the more stringent the court’s approach should be in requiring that clause should be clearly and unambiguously expressed.’

## CONCLUSION

The traditional English common law position with respect to ECs has generally been one which upholds the contractual parties’ rights to freedom of contract; in other words, as long as an EC is well drafted and unambiguous, under the common law it is likely to be valid. On the other hand, where there is ambiguity in the wording of an EC, the traditional English common law position has been to construe the clause *contra proferentem* (i.e. against the interests of the party seeking to benefit from the EC). This traditional English common law position was adopted by the Australian courts.

The English law with respect to the enforceability of ECs, however, has since been regulated by legislation in the form of UCTA. Under UCTA, in order for an EC to be effective in England, it must be deemed to be reasonable in accordance with the reasonableness test laid down in the legislation. This gives the English courts the power to interfere with the parties’ right to freedom of contract in circumstances where the court believes the EC is unreasonably onerous or harsh to one of the contractual parties. Consequently, UCTA provides the scope for parties to mount challenges to ECs in court even if they are clearly drafted. However, whilst UCTA provides an avenue for the courts to rectify any perceived commercial injustices with respect to the operation of ECs, the concept of reasonableness as set out UCTA guidelines can often be difficult for the courts to deal with.

With the exception of contracts for the supply of goods and services to consumers, there is no statutory regulation on the enforceability of ECs in Australia. As such, with respect to ECs, the Australian law continues to uphold freedom of contract in commercial contracts, even in circumstances where operation of the EC appears to be unreasonably onerous or harsh on one of the contractual parties. This being said, the Australian courts do approach the interpretation of ECs cautiously. In addition to the traditional application of the *contra proferentum* rule, since the *Darlington* decision in 1986, Australian common law has consistently interpreted the wording of ECs strictly according to its natural and ordinary meaning in the light of the contract as a whole.

Furthermore, the approach of the Australian common law has diverged from the traditional English common law with respect to the construction of limitation clauses as opposed to exclusion clauses, and the definition of consequential loss in the context of ECs. The English approach appears to judge limitation clauses to less exacting standards than exclusion clauses, whereas the Australian approach does not differentiate between the two. The Victorian, New South Wales and South Australian courts have all recently widened the scope of ECs for consequential loss, such that a far broader category of damages may be categorised as consequential loss than under the traditional English common law position.

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# **RULES OF TENDERING AND THE INFLUENCE OF THE PRIVILEGE CLAUSE IN SOUTH AFRICA**

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The tendering process typically engages a number of parties, each of whom invests considerable time and money in the competition for a construction contract. Most of the rules of the competition are set out in the tender document. But the process also involves implied obligation and duties of fairness which do not appear in the tender documents and are not easily defined. Therefore this paper tend to address some legal and practical aspects of the tender process, the nature of the contractual obligations, potential remedies for aggrieved tenders, and the influence of the privilege clause on tender documents. Because of the expectation that government tender processes are conducted fairly and in accordance with high standards of probity and integrity the paper examine the legal aspects of government tender processes with a view to provide pointers on how to minimise adverse legal consequences of a poorly conducted tender process and conditions to tender.

Keywords: tender process, construction contract, obligation, duty, fairness.

## **INTRODUCTION**

Rwelamila and Meyer (1996) have revealed that South Africa had adopted a ready-made construction framework, including the hybrids of traditional procurement systems during the years when South Africa was a British colony. Although the South African procurement system is based on the British model, the context and the application of this model were unsystematic for the then apartheid South Africa; this was due to the different set-up and institutional arrangements between South Africa and Britain.

However, Mathonsi and Thwala (2012) indicated that the political uncertainties that had taken place during the early 1980s and late 1990s led to some changes within the South African construction industry. This was due to the South African construction industry shifting its focus from a predominantly first-world oriented construction environment to a developing-world construction environment that focuses on the basic needs of the population and its economic circumstances. Among other things, this shift was directed towards the development of new construction policies aimed at promoting stability; fostering economic growth and economic competitiveness; crating new sustainable employment; as well as addressing the historic imbalances as new industry capacity is being generated for development (Department of Public Works (DPW), May 1999).

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Post-1994, the newly formed South African Government of National Unity and all stakeholders of the construction industry headed by the Department of Public Works, initiated and co-ordinated the development of the Construction Industry Development Board (CIDB) which was mandated among other things to improve a standardised application of best practice in construction procurement within the framework of government procurement policy (Construction Procurement Library, CIDB, 2005). Therefore, this study aims to investigate the privilege clauses and the duty of fairness inserted and applied in tendering procedures in a South African context.

Procurement is a major part of supply chain management and specifically on tendering process in South African national government. Moeti et al. (2007:122). This is used to acquire goods and services by national, provincial government and also represent a substantial source of income to private sector.

According to Rashid, Taib and Ahmad (2006), there are today several types of project procurement systems being widely used in the construction industry. They range from the traditional system to the many variations of "fast-tracking" systems such as turnkey, design and build, build-operate-transfer (BOT), management contracting, cost-plus contracting etc. The introduction of many variations of project procurement system was induced by the quest for more efficient and speedier project delivery system and better project performance. They are innovations to the traditional delivery method aimed at meeting the changing demand of clients or customers. The different procurement systems present have brought changes not only to the process and procedure of project delivery but also the aspects of management and organization.

The following prescripts should be adhered to by all national and provincial government departments and tenderers namely Constitution of the Republic of South Africa. Act No. 108 of 1996; Preference Procurement Policy Framework Act (PPFA), Act, No. 5 of 2000; Public Finance Management Regulations Framework. The PFMA in general provides a clear regulatory framework for the tendering.

In terms of Sections 217 (1) of the Constitution (1996), when an organ of state in the national, provincial or local sphere of government, or any other institution identified in national legislation, contracts for goods or services, it must do so in accordance with a system which is fair, equitable, transparent, competitive and cost-effective.

PFMA was promulgated in 1999 and is mainly focused on the provision of sound financial practices to promote effective service delivery to people of South Africa through effective, efficient and economical use of existing resources (Luyinda et al., 2008:30).

Section 38(1) (a) (iii) of the PFMA stipulates that the accounting officer of a department must ensure that the department has and maintains an appropriate procurement and provisioning system.

The policy strategy is provided against the background of the provisions of the Constitution and subsequent enabling legislation and the promulgation of new BEE legislation and amendments to the PPFA as contemplated by government.

According to Visser and Erasmus (2007), this act gives effect to section 217(3) of the Constitution, by providing a framework for the implementation of the procurement policy framework. The Act requires any organ of state to determine its preferential procurement policy and implement this within the legislated framework of South Africa.

Furthermore Visser and Erasmus (2007) also alluded that the objective of act may include contracting with persons or categories of persons, previously disadvantaged by unfair discrimination, or implementing the programmes of the Reconstruction and Development Programme (RDP).

Singleton (2005) alluded to the fact that after much has been written about the law of tendering over the past decade or so, the decision by the Supreme Court of Canada in the case of Ron Engineering gave birth to the "two contract" model into the law of tendering. Under this model, the tendering process consists of the formation of two separate contracts: Contract A and Contract B. Contract A, also known as the bid contract, governs the manner in which the tendering process is to be conducted. Contract B is the substantive construction contract to perform the work that has been bid. This example is used as South Africa follow the same rule in tendering by first calling for tenders which can be regarded as contract A and then appoint the compliant tenderer which this can be regarded as contract B.

Requests for Tender are a common pre-contractual step. However, for the purpose of contract formation, a Request for Tender does not constitute an offer. Instead, it is an invitation to treat or a mere request to negotiate or make an offer.

It is the instructions to tenders and the tender form which establish the specific terms and conditions of Contract A. One of the terms of Contract A will be an obligation that the bidder is contractually bound to enter into the construction contract, Contract B, if the owner accepts its tender. Contract A comes to an end when an owner either 1) enters into the construction contract with one of the bidders; 2) rejects all of the bids; or 3) when the irrevocability period of the tenders (if applicable) expires.

The primary source of the express terms of the bid contract is the Instructions to Tenderers. Typically, this document will contain the fundamental terms of the tender call, including the irrevocability of the tender, the time of the tender close, the owner's discretion to accept or reject bids (including privilege or discretion clauses) and procedural requirements relating to the tender form and bid security. Other express terms and conditions can be found in other documents comprising the tender package, including any Tender Addenda, drawings, specifications, engineer's reports and the Tender Form. The bid contract may also incorporate, by specific reference in the tender package, standard industry rules.

Thus according to Singleton (2005), indicated that in evaluating and accepting or rejecting a tender, the owner is required to comply with both the express terms of the bid contract as well as the implied overarching duty of procedural fairness and good faith. In nearly all cases, the Instructions to Tenders will include a "privilege clause" which provides the tendering authority with broad discretion in relation to the acceptance or rejection of tenders. Although the privilege clause can take many forms, it usually reserves to the owner discretion to accept or reject the lowest, or any, tender.

Therefore, Derek and Brindle (1995), in their construction law report alluded about the expressed terms and conditions of the bid contract are contained in the tender documents, including

- Instructions to renderers
- Tender form
- Form of construction contract to be awarded;

- Drawings, specifications, consultants' reports (geotechnical, environmental, etc);
- Other information required to be provided with the tender.

The instructions to renderers generally incorporate a form of "privilege clause" which provides that the owner is not required to accept the lowest or any tender. Further, in order to provide the owner with some flexibility in overlooking non-essential irregularities in the tender submittals, the instructions to tenderes typically provide that the owner may waive technical irregularities, omissions, etc. in the tender form. The case law has yet to fully develop on whether this latter type of clause may be resorted to in curing defects that otherwise would invalidate a tender. Furthermore Derek, et al., (1995), argued that a bid contract will, in most instances, be held to contain an implied term that the owner will only accept a compliant tender and will invariably contain and implied term that the owner must act fairly and in good faith in the tendering process.

## **METHODOLOGY**

After literature review, a pilot survey was conducted on a capture audience during an annual general meeting of the Free State Chapter of the Association of South African Quantity Surveyors, on the 17th April 2013 at Anta Boga of which 23 quantity surveyors were in attendance questionnaires were distributed and 18 (78%) were completed and returned.

Section A consisted of questions regarding the profile, qualifications, professional registration and years of experience. The aim of this section was to determine the qualifications and experience of the respondents particularly in respect of privilege clauses inserted by clients in tender documents. In attendance where 16 (88%) quantity surveyors of which 9(50%) of them were directors in private companies with experience of more than 10 years. 1(6%) was a project manager in private company and 1(6%) was a construction mentor in a higher education institute. 8(43%) of the respondents hold a B.Sc(Hons) and 4(22%) had a masters degree and only 2(11%) had a PhD. 12(67%) were male and 6(33%) female who are active role players in the construction industry in the Free State Province of South Africa. This was just a pilot study and the results will not be viewed conclusive but will provide a directive to the construction industry of the Free State Province.

Section B consists of questions regarding the mitigating challenges of the privilege clause inserted into tender documents by clients during procurement. The opinion of the respondents was collected using the likert scale of 1 to 5, where 1 is strongly disagree, 2 disagree, 3 neither agree nor disagree, 4 agree and 5 strongly agree

Table 1: Mitigating challenges of the privilege clause

	Response (%)				
	1 Strongly disagree 5 Strongly agree				
	1	2	3	4	5
The duty of good faith obligates clients to treat all bidders fairly and equally (without the application of hidden preferences or undisclosed bid evaluation criteria).	6	0	0	22	72
In evaluating and accepting or rejecting a tender, the owner is required to comply with both the express terms of the bid contract as well as implied duty of procedural fairness and good faith.	6	0	0	17	78
Where the privilege clause forms a term of bid contract, the owner will generally not be required to award the contract to the lowest bidder.	6	6	17	6	33
The privilege clause in the bid enables the client to take a more “nuanced” view of cost, relying on factors other than simply the tender price.	0	0	22	39	39
If the privilege clause is used the client is entitled to consider experience and capacity	0	11	22	17	44
The privilege clauses and discretion clauses will not displace the overarching duty of procedural good faith.	0	0	17	28	50
The discretion given to the client by a privilege clause must be exercised “fairly and objectively.”	0	0	0	33	67
Where the client applies a “secret preference” in evaluating a tender, it will likely be found to have breached the terms of the bid contract.	0	0	22	28	44
Do owners always understand the expressed terms of the bid contract	Yes	22	No	78	
Do you always adhere to the duty of procedural fairness and good faith when evaluating bid.	Yes	94	No	6	
Tender is valid or compliant only if it meets all the requirements of the tender call, as set out in the tender document.	0	0	0	17	83
Tender offer that contains a fatal error cannot be accepted, because it is not compliant.	6	0	6	28	56
Tender which although valid on its face, contains a latent or hidden error (such as in the calculations or economics leading to tender price) is nevertheless valid and capable of acceptance.	22	6	11	33	22
The validity of tenders that contains hidden errors or technical irregularities would not operate to undermine the integrity of the tendering process.	17	17	11	11	33
The owner can elect not to award the construction contract if all tenders offers exceed its budget, with the properly worded privilege clause.	0	0	0	39	61
Non compliant tender offers can be accepted if there are no compliant tender offers received.	39	22	17	17	0
Should all tender offers exceed the client budget, the client can negotiate with the preferred bidder to decrease the offer submitted.	33	17	17	22	11
Have you ever read through the PPPFMA and understand it properly	Yes	39	No	61	

From table 1 above it was clear that (72%) of the responded strongly agree that the duty of good faith obligates clients to treat all bidders fairly and equally. (78%) strongly agree that during evaluating, accepting or rejecting a tender, the owner is required to comply with both the expressed and implied terms of the bid contract. Whereas only (33%) of the respondents strongly agree that where the privilege clause

forms a term of a bid contract, the owner will generally not be required to award the contract to the lowest bidder. (39%) of the respondents strongly agree that where the privilege clause is used in the tender document it in fact enables the client to take a more "nuanced" view of cost, relying on factors other than simply the tender price. Whereas (44%) of the respondents strongly agree that when the privilege clause is used the client is entitled to consider experience and capacity.

(50%) of the respondents strongly agrees that the privilege clauses and discretion clauses will not displace the overarching duty of procedural good faith. (67%) of the respondents strongly agree that the discretion given to the client by a privilege clause must be exercised "fairly and objectively, (44%) also strongly concur with the sentiments that where the client applies a "secret preference" in evaluating a tender, it will likely be found to have breached the terms of the bid contract. (78%) of the respondents indicated that they believe that clients do not always understand the expressed terms of the bid contract. Whereas (94%) of the respondents always adhere to the duty of procedural fairness and good faith when evaluating bid. (83%) indicated that they strongly agree with the fact that tender are valid or compliant only if they meet all the requirements of the tender call, as set out in the tender document and (56%) indicated that they strongly agree with the statement that tender offer that contains a fatal error cannot be accepted, because it is not compliant. (22%) strongly disagree that tender which although valid on its face, contains a latent or hidden error (such as in the calculations or economics leading to tender price) is nevertheless valid and capable of acceptance, whereas (33%) agree with the statement that the validity of tenders that contains hidden errors or technical irregularities would not operate to undermine the integrity of the tendering process. (61%) of the respondents strongly agree with the statement that the owner can elect not to award the construction contract if all tenders offers exceed its budget, with the properly worded privilege clause. (39%) of the respondents strongly disagree with the statement that non compliant tender offers can be accepted if there are no compliant tender offers received and (33%) of the respondents also strongly disagree with the statement that should all tender offers exceed the client budget, the client can negotiate with the preferred bidder to decrease the offer submitted. Also very interesting to find out was the fact that 61% of the respondent indicated that they have never read through the PPPFMA and understand it properly only (39%) said they have indeed read through.

## CONCLUSIONS

The procurement process is an essential tool for the construction industry. However, it remains a complex area of contract law and the subject of much litigation (Singleton, 2005). To help clients avoid costly claims, the following must be kept in mind:

1. During tender evaluation, whether accepting or rejecting a tender, die client is required to comply with both the express terms of the tender contract as well as the implied duty of procedural fairness and good faith.
2. Where a privilege clause is included in the instruction to Tenderers, the client will not be required to award the construction contract to the lowest tender. The client will be able to take a look more on factors such as the experience and capability of the contractor when assessing the relative strength of the tenders.
3. The existence of a privilege clause in the tender package will not displace the overarching duty of procedural good faith.

4. Even when there is a broadly worded privilege clause in the tender package, an owner may not award the construction contract to a tenderer whose bid is non-compliant.
5. The standard to be applied is one of substantial compliance rather than strict compliance.
6. Clients can rely on properly worded privilege clause to reject compliant tenders.

The findings of this research clearly show both parties must enter into tendering contract with a duty of good faith in mind. Furthermore in evaluating the tenders the client is expected to apply the sense of fairness. Very important the discretion given to the client by the privilege clause must be exercised "fairly and objectively".

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# TARGET COST CONTRACTS: ADOPTING INNOVATIVE INCENTIVE MECHANISMS TO IMPROVE THE PROJECT DELIVERY PROCESS

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Target Cost Contracts are widely recognised as cost-led procurement models which incentivise client and contractor to work collaboratively and develop mutual gains. Their use on recent high profile projects and inclusion in the recently published UK Government Construction Strategy recognises Target Cost Contracts as a “cost-led procurement model.” They have been identified as a model capable of producing the “15-20%” cost savings required for public sector construction projects by 2015, and act as key drivers for their use. This research aims to facilitate innovation in future Target Cost Contracts by expanding the current incentives offered to include a wider variance of stakeholders and performance metrics. A cross-sectional study utilising semi-structured interviews to test the initial findings generated by the literature review was employed to validate the use of such innovative incentives. Incentivising alternative performance metrics is required to generate greater motivation amongst project stakeholders, although there was insufficient evidence to suggest that incentive frameworks could achieve this. Incentive frameworks to include the design team and alternative performance metrics have been defined for testing in future research which could be pilot tested in practice.

Keywords: target cost contract, incentivisation, NEC3, performance metrics, key performance indicator

## INTRODUCTION

Target Cost Contracts (TCCs) were introduced as a cost management tool in order to reduce the cost of construction projects (Pennanen et al., 2011), promote collaboration in the whole supply chain, and are unique in that they motivate both client and contractor to reduce costs (Perry and Barnes, 2000; Hughes et al., 2012). TCC are an incentive-based procurement strategy which will award savings or penalise cost overruns according to a pre-agreed target cost and share ratio (Masterman, 2002). Incentivisation is used in construction contracts to motivate the contractor to achieve excellent performance, rather than the minimum contractual standards (Meng and Gallagher, 2012). The catalyst for this research has been the recently published UK Government Construction Strategy which recognised TCC as a “cost-led procurement model” (Cabinet Office, 2012, p.52) that could produce the “15-20%” cost savings required for public sector construction projects by 2015 (Cabinet Office, 2012, p.6).

TCCs have been successfully used on a number of recent high profile projects, such as; the London 2012 Olympic and Paralympics Games infrastructure, Heathrow Airport Terminal 5 Project and the Crossrail Procurement Strategy. The authors' aim

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in this research is to promote innovation within the use of NEC3 Option C and D contracts. The criticism evident in the published literature is that TCCs tend to incentivise cost, incentivise the client and contractor only and are sometimes perceived as profit making tools for contractors. The authors wish to implement the principles of innovation and project integration, by establishing incentivisation frameworks that, if adopted, could address some of the weaknesses identified in the literature.

## LITERATURE REVIEW

### Incentivisation in Construction Contracts

The Construction Industry is often criticised for its poor performance [Latham (1994); Egan (1998); National Audit Office (2000)]. The traditional fixed-price lump-sum contract is often a major factor in poor performance, as its use often engenders limited trust, lack of incentives, misalignment of objectives and adversarial relationships between the whole project team [National Audit Office, (2000); Rose and Manley, (2010)]. There is often inequitable risk allocation and lack of incentives to improve performance, which often leads to delays, cost overruns and a claims culture (Chan et al., 2010). There is limited opportunity for early integration of the supply chain and early contractor involvement under traditional forms of procurement (Latham, 1994), which often fuels poor project integration. Added to this is the fact that all project participants have conflicting objectives, which often leads to adversarial relationships (CIRIA, 2001).

Incentives and dis-incentives aim to reward or penalise the contractor based on his performance during the project (Bubshait, 2003). Chan et al. (2011b) found that incentivisation in construction contracts promotes deeper collaboration between client and the contractor, thus driving the contractor to innovate, save cost, work efficiently and solve problems as the project proceeds. Bubshait (2003) found that 64% of clients surveyed agreed that incentive provisions should be used at tender stage, while 60% of contractors believed that they should be included at construction stage. Meng and Gallagher (2012) also concluded that when time, cost or quality incentives are used, performances related to these measures are enhanced when compared to non-incentivised projects.

This view is further acknowledged by Bayliss et al. (2004), who found that the number of claims decreased, the percentage of valuations certified increased and the time taken to resolve claims reduced when incentivisation was introduced part way through a live project. Hughes et al. (2012) advance this theory by suggesting that the use of incentives helps to make partnered projects successful. Incentivisation improves trust, honesty, communication, teamwork and motivation to achieve mutual objectives [Bayliss et al., 2004; Rose and Manley, 2010]. Sir John Egan (2008, p.4) suggested when reviewing the progress of the Rethinking Construction report, that:

*“I have to say that I would introduce, as early as possible, in every possible project, a gain share between client and the industry, with a target based upon an agreed set of parameters, plus or minus I would say 15%.”*

Egan (2008) appears to reinforce the opinion that incentivisation should be introduced in all construction projects in order to improve performance. There is a clear impetus in the construction industry to move from adversarial arms length procurement systems, to more collaborative systems that are based on trust and co-operation (Espling and Olsson, 2004). CIRIA (2001) suggest that disincentivisation often leads

to the development of adversarial relationships, and challenged the use of reactive disincentivisation schemes and support the implementation of incentivisation schemes that are more proactive and collaborative.

The published literature indicates that incentivisation should be included in all future construction projects. There is a strong argument to share risk and reward through collaborative incentivisation where the motivation is proactive performance improvements from which all parties can gain.

### **Incentivisation in Target Cost Contracts**

Masterman (2002, 106.) provides a useful definition of TCCs:-

*“An incentive-based procurement strategy which will reward the contractor for any savings made against the ... target cost and will penalise him when this sum is exceeded as a result of his own mismanagement or negligence according to a pre-agreed share ratio.”*

TCC provide a higher level of cooperation, which reduces the opportunity for conflict and disputes to occur (Eriksson et al., 2009). Shorter construction programme is a perceived benefit due to the opportunity for early contractor involvement during design and early integration of the supply chain (Eriksson et al., 2009; Chan et al., 2011). The incorporation of the collective expertise of the contractor and other key members of the supply chain during the design phase promotes innovation which provides the potential for substantial cost savings (Chan et al, 2011). Faloon et al (2005) concluded that early contractor involvement and early integration of the supply chain provides a systematic cost reduction model. The collaborative integration of the supply chain ensures that accurate estimates are produced which minimise the use of inaccurate construction programmes and cost estimates (Chan et al, 2011).

In contrast Hughes et al. (2012) maintain that TCC are only beneficial for the client, as the contractor absorbs the additional cost to increase future workload. They suggest that there could be disadvantages including free-rider problems, self-interest and teams that are not easy to motivate. TCC are often criticised for the additional time required to complete the projects (Chan et al., 2011) and the additional time and cost required for administration (Badenfelt, 2008). Chan et al (2011) criticise the purely cost based incentives offered under a TCC as there are little incentives for quality, time and other performance metrics. It is apparent from the published literature that TCCs are mainly incentivised by the Pain Share / Gain Share (PS/GS). The more cost savings the contractor establishes, the larger the gain share. This develops a need for the contractor to work more efficiently and collaboratively in order to develop cost savings, thus producing a gain for both client and contractor.

It is broadly accepted in the contemporary published literature that incentive goals should cover all performance areas [Rose and Manley, 2010; Chan et al, 2011; Meng and Gallagher, 2012; Hughes et al., 2012]. Rose and Manley (2010, p.258) specifically criticise the current incentivisation offered under TCC as, “limiting goals to financial performance alone fails to encapsulate all incentive opportunities.” Rose and Manley (2010) concluded from their research that when multiple incentive goals were offered under a contract, this increased the incentive intensity and motivational power and delivered successful projects.

There is a concern in the published literature that multiple incentives that drive performance areas such as time, cost, quality, health and safety and other performance metrics would be more effective. There is also criticism that TCCs only incentivise the

client and contractor (Rose and Manley, 2010). To deliver a gain under a TCC it requires collaboration between the client, contractor, consultants, sub-contractors, design team, supply chain and manufacturers. How do TCCs motivate other stakeholders outside the contract if they do not receive any shares of the gain?

Generally the published literature indicates that TCCs tend to focus on cost as the incentive measure, and further suggests that multiple incentives that include further performance metrics and key members of the supply chain would fully incentivise the contractor. The use of such a system combined into the PS/GS mechanism therefore warrants further investigation.

## RESEARCH APPROACH

The aim of this research was to develop incentivisation frameworks that are transferable across construction sectors. It is proposed that these incentivisation frameworks could be used as part of the NEC3 Option C or D standard form of contract. Primary data was required to validate the use of such frameworks. The chosen methodological approach was a cross-sectional study. The research was concerned with understanding how incentivisation frameworks could be utilised in the future, including any barriers or limitations for their use. The chosen methodological strategy was well suited to the research as understanding the experience and opinion of key contractual parties is essential to the use of incentivisation frameworks in the future. The nature of cross-sectional studies is to collect primary data from a purposefully selected range of respondents.

The decision to utilise interviews was encouraged by the initial communications with potential respondents. Interviews would allow the authors to gather the opinions of respondents whilst maintaining their confidentiality. The qualitative approach gave the authors more flexibility to pose further questions or explain incentive frameworks. This approach developed a closer relationship with respondents, thus encouraging expansive responses. Table 1 overleaf illustrates the chosen interview sample.

Semi-structured interviews were preferred as the authors wished the respondents to answer the questions in as much depth as possible. The authors felt that allowing the respondents to answer the questions as freely and openly as possible would develop a close relationship with the interviewer. A sample of interviewees was selected to represent all roles within a project. A series of ten interview questions were developed. To aid analysis and synthesis of the primary data, the authors opted to pose questions within identified themes. The authors felt that grouping questions in themes would allow responses to be analysed more effectively, and encourage respondents in their responses. The interview themes were Profile, Benefits, Limitations, Pain Share Gain Share and Further Incentives.

*Table 1: Profile of Interview Respondents*

Respondent	Sample	Abbreviation
A	Innovation Expert	IE
B	Project Manager	PM
C	Procurement Specialist	PC
D	Contractor	CON
E	Construction Lawyer	CL

The aim of the research was to develop incentivisation frameworks to incentivise alternative performance metrics. The authors consider performance metrics to include time, cost, quality, safety and sustainability; areas that the client would have based his award decision on. The authors developed incentivisation frameworks that were tested in the series of interviews. Each performance metric is linked to the overall PS/GS for the project. The performance metrics are weighted by the client, in relation to the procurement strategy and overall objective of the project. The client then sets Key Performance Indicators (KPIs) against each performance metric. The framework was developed from findings of the literature review and the authors own experience of managing TCCs. Table 2 below illustrates an example of a project with £50,000 of gain where the contractor did not complete on time due to operational inefficiency, and was therefore penalised 40% of his gain share. Note - for the purposes of this conference paper Table 2 provides a simplified extract of the actual framework developed which serves to demonstrate the underlying principles involved.

*Table 2: Example incentive framework*

Performance Metric	Target Cost Percentage	Example Key Performance Indicator	Completion Percentage	Contractor Share (50%)	Client Share (50%)
Time	40%	Programme	0%	£-	£20,000:00
Cost	20%	Target Cost	20%	£5,000:00	£5,000:00
Quality	20%	Zero defects	20%	£5,000:00	£5,000:00
Health and Safety	10%	Zero accidents	10%	£2,500:00	£2,500:00
Sustainability	10%	BREEAM Excellence	10%	£2,500:00	£2,500:00
Overall Gain				£15,000:00	£35,000:00

The interviews were divided into two main thematic categories. The first category asked interviewees questions reflecting on their current and previous experience of target cost contracts. Following this general discussion the authors then introduced the interviewees to their incentive framework for their appraisal of its feasibility for utilisation on TCCs.

## DISCUSSION OF RESULTS

### Interviewees Profile

All five interviewees had extensive experience working on NEC3 TCCs and are currently actively working on TCCs. The five interviewees possessed 75 years of collective experience. This is extremely important as all five respondents work for organisations that are widely recognised throughout the construction industry, thus ensuring that responses are reflective of contemporary industry practice and beliefs.

### Benefits

The Innovation Expert (IE) suggested that the main benefits are that it provides some incentive and focus for the process for the client, contractor and possibly the design team. The Project Manager (PM) believed that the openness about risk through the use of Compensation Events was a major benefit. Compensation events are events which, if they occur and do not arise from the Contractor's fault, entitle the Contractor to be

compensated for any effect the event may have on the prices (NEC3, 2005). The way that the contract manages risk in an open environment, with an open discussion on the allocation of risk, which allows risks to be mitigated and managed effectively, is also a major benefit for the PM. The Procurement Specialist (PS) agreed with the other interviewees, although also suggested that the greater degree of certainty, the collaborative teamwork approach and the ability to reinvest the gain of a project on future projects were major benefits. This ability to manage the gain and provide a degree of certainty on budget is a major advantage to a public sector body. This advantage is demonstrated by the PS:

*“I certainly on major projects wouldn’t look at using anything else now that we have been using target cost.”*

For the Contractor (CON) the main benefits are the ability to work in a partnered collaborative approach, the ability to identify and manage the pain gain and the ability to commit to a project while the work packages are not yet fully developed. The Construction Lawyer (CL) did not cite any of the previous benefits, and believed that the main benefit is the incentive for the contractor to undertake value engineering. The CL suggested that the contractor using his abilities to seek savings and enjoy the pain gain is the major benefit of TCC.

Several of the interviewees stated that the major attraction for the client is the degree of certainty achieved and the ability to share some risk, as the PM described this as a “common sense approach.” The ability for the client to see compensation events priced openly and the focus on providing up-to-date information is a major benefit. The PM considers that this allows the client at any point in the project to have an idea of the overall financial commitment, which might not be achieved under alternative contracts. The CL suggested the main benefit is the potential ability for the client to lower his final project cost.

The IE suggested that the main motivation for the contractor is that it provides a focus and a target, and the ability to introduce continuous improvement into the process. The IE discussed the motivation for the contractor to improve from contract to contract, thus enhancing innovation. There was a need for the contractor to be claims conscious, and have an understanding of the way to deal with the contract. There was a consensus that it forces the client to work as a more informed client, which makes it a “very clearly defined process.” The CON and the PS were consistent as the CON suggested that early contractor involvement enhances the open collaborative way of working, while the PS suggested that it breeds openness about issues. The PS also indicated that such an open approach could not be achieved under alternative contracts, therefore encouraging an open forum where everybody can accept and discuss risks.

### **Limitations**

All interviewees agreed that the main limitations of TCCs are the lack of full cost certainty and they are open to abuse if not approached in the right mind set. The CL firmly believed that the only benefit for the contractor is money. When asked by the interviewer if it is a purely profit making tool, the CL stated:

*“Purely. Yes. There is no other reason for it ... it doesn’t help the contractor. It gives no incentive. It’s purely based upon money.”*

The CL further developed this argument by suggesting that the contractor can “artificially inflate the target cost” which in essence is only going to benefit the

contractor through the gain share proportion. The IE also expressed this concern, and asserted that TCCs are open to abuse from all parties if not managed correctly. The IE also suggested that TCCs are only really well suited to long term relationships as it can be easily abused on one off projects. Three of the interviewees highlighted the difficulty of establishing an equitable TC. The CON summarised this as:

*“Quite heavily resourced approach I think target cost, because all of the work you have to do behind the scenes.”*

The majority of interviewees believed that the interplay between fee and the PS/GS weightings can disincentivise the contractor, and agreed that the share arrangement affect contractors’ motivation. In addition to these limitations, there was a general consensus that the understanding of the parties to the contract is a limitation. They cite the need for an investment in time to understand TCCs as a barrier to its use.

All respondents agreed that TCCs provide cost only incentives. The IE felt that a way of overcoming this concentration on cost is to “develop some proper measure for softer targets like quality issues.” The IE felt that including some KPIs in TCCs would incentivise the contractor, although was also wary of utilising too many “artificial KPIs.” In contrast the PM proposed that TCCs do incentivise time and quality as doing things as quickly as possible and getting things to the right quality the first time affects the actual cost. The PM recommended that TCCs could do more to specifically incentivise contractors. The PS also stated:

*“Yes it is limited to cost. It would be difficult to see how you could bring other incentives in that would mean as much as money does at the end of the day. Both for the client and back on the contractor side I think.”*

All respondents throughout their interviews referred to the misalignment of objectives between client, contractor and design team as they are motivated for different things. The IE suggested that a way of overcoming this would be to include the design team on a 40:40:20 or 45:45:10 PS/GS basis, and also suggested “innovation should come from the design team and without that sort of incentive for them they will just become disengaged from the process.” The PS strongly agrees with this statement by suggesting that this would allow the design team to become more commercially aware, drive the collaborative effort and would make designers “think a bit harder about their design and the cost plan.” In contrast to other respondents, the PM had some experience where the design team and consultants were under TCC, which were beneficial in terms of the whole scheme cost. The CL noted that such a system could be used, although was concerned about the complexity required to implement it. Contractually linking the system was also an issue, although the PM suggested overcoming this issue by having the individual TCCs linked to one PS/GS pot.

### **Pain Share Gain Share**

The majority of interviewees agreed that 50:50 is the correct PS/GS weightings to use, while the CL states that a minimum 60:40 or ideally 70:30 in favour of the contractor should be utilised. The IE, PS and CON stated that if it is weighted in favour of the client or contractor this can affect the incentive power as it does not seem that the parties are working equally. The PS evaluates this argument by suggesting:

*“I think the fifty fifty was right and that’s what it was about. We are in this together so we are going to work through it together, and therefore will benefit or fall either way by that working together.”*

The PM generally agreed with the even split, although did suggest that under competitively procured TCC the share should be in favour of the contractor in order for a realistic TC to be developed. The CL argues that the PS/GS should always be in favour of the contractor by advising clients that “if you are happy with your target cost, deal with this as a bonus.” While the PS disagreed with this:

*“We really need the contractor to be driving the target cost to be as accurate as we can get it.”*

All respondents had experience of PS/GS where there was one hundred percent of pain to contractors. All respondents disagreed with such a system. The PM strongly suggests that if the client adopts the approach to pass all the pain to the contractor, he should follow a variant of a lump sum contract. The PS and CON also raised some concerns regarding the use of PS/GS frameworks by suggesting how far down the supply chain does the PS/GS go; possibly an area for future research.

### **Incentive Frameworks**

The IE supported the use of such frameworks and believed that the frameworks could be used in practice. The IE believed that the performance metrics should be aligned to the tendering process and used under collaborative long term relationships. Therefore if a TCC is competitively procured the contractor should be favoured in the PS/GS weightings to motivate the contractor to develop a favourable target cost. The PS also agreed with the IE by confirming that they would “not be too difficult to administer.” Although the PM did not agree with this and suggested:

*“I am unconvinced as to whether or not the time it takes understanding it before you bid, the provisions you make when you bid and the time you spend administering it when you're on the project actually pay their way.”*

The CON was unconvinced as to whether the frameworks should be used as he believed that Clause X20 caters for bonuses for KPIs. Clause X20 is an optional clause which allows the use of KPIs and incentive payments with NEC3 contracts. They differ to the authors'proposed incentive frameworks as Clause X20 is not linked to the PS/GS framework as is being suggested by the authors. None of the interviewees had ever seen clause X20 used. The CON was not convinced that the target cost should be adjusted if a certain performance metric is not achieved. This perhaps is evidence of the drive for a contractor to make profit under a TCC as previously suggested by the CL. The CL was in favour of such frameworks that assess the contractor's performance, although did not believe that there should be a monetary link. In contrast the IE and PS felt that the frameworks should be used. A major point that all interviewees questioned was how such frameworks would be measured fairly.

The PS was strongly in favour of such frameworks, although was also concerned as to whether such frameworks would “skew the contractor in different ways.” In response to this the CON stated that they see “things like that give a good incentive,” as it “breeds a proactive collaborative way of working.” The PM indicate that “incentivisation of timely performance is a key matter,” and incentivising the project team to make decisions quicker would save time, save money and allow that money to be used elsewhere on the project. The IE strongly supported the use of such frameworks as long as they were “fair, equitable and transparent.” He felt that the use of alternative incentive mechanism would incentivise the contractor to develop a more sensible target cost. The CL strongly supported the use of alternative incentive mechanisms, and believed that it is a “wasted opportunity” if they are not used. The

PS provided a useful summary of how she considers alternative incentive mechanisms:

*"So yes I think it's a good idea. I think it will be interesting to look at further and see how it works, but you have got to be careful that it is not driving the contractor to just behave in a different way."*

All respondents felt that alternative incentive mechanism could have a beneficial impact on TCCs, although they were also concerned how they would work in practice. It could be suggested if a contractor at tender stage predicts that he will deliver a project within gain, with zero defects, to the proposed completion date, with zero harm and with BREEAM Excellent rating, why should he not be penalised if he does not achieve a certain performance target? Conversely why should he not be rewarded for achieving a certain performance target? In the instance of a quality price tender, a contractor would have been awarded the contract based on the Target Cost value and the quality elements. It would only be reasonable and transparent to all parties if the contractor fulfils what he anticipated.

## CONCLUSIONS

TCCs are largely criticised in the published literature as they tend to focus on cost as the incentive measure and only provide an incentive to the client and contractor. To generate greater motivational power the authors proposed incentive frameworks could be modified for time, cost and quality-led projects. These were discussed in the series of five semi-structured interviews. The interviewees believed that such frameworks could work, although were sceptical about the industry's ability to bear the cost of the complexity and time required to understand, perform and measure the metrics. However there was a strong suggestion from the interview data that there was a requirement to align the objectives of the project team. The interviewees noted that designers need to become more commercially aware and highlighted the importance for information to be provided on a timely basis. It was also noted that this could potentially drive innovation which in turn could generate greater gains. The flexibility of the incentive frameworks would allow designers to be included in the share arrangement, with the overall motivation for collaboration and integration of the supply chain.

The aim of this research was to identify how effective further incentives would be under TCCs, and develop incentivisation frameworks to motivate parties to achieve alternative performance metrics. In essence incentive frameworks have been developed which motivate parties to achieve better performances in alternative performance metrics. However the research is based on limited interview data and the performance frameworks developed by the research have not yet been tested in practice. Further investigation is required to understand how the incentive frameworks and including the design team in the PS/GS affect the overall motivational power of incentivised performance metrics, and in turn the overall project outcome.

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# THE APPLICATION OF WHOLE LIFE COSTING IN PFI/PPP PROJECTS

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The concept of private finance initiative (PFI), later known as public-private partnership (PPP), was introduced into the UK in the early 1990s. Under the PFI/PPP scheme, a special purpose vehicle (SPV) from the private sector is generally responsible to design, build, finance and operate a public project for 20-30 years. For this reason, an emphasis is placed on the use of whole life approaches, such as whole life costing (WLC) or life cycle costing (LCC). However, few studies to date have investigated the application of WLC/LCC in PFI/PPP projects. Therefore, there is a knowledge gap in this particular field. To bridge the gap, an empirical investigation was made in the UK. The aim of this study was to explore PFI/PPP practice in terms of WLC/LCC. This study adopted a combination of a literature review, two case studies and a questionnaire survey. Qualitative data collected from the case studies and quantitative data collected from the questionnaire survey are analysed in this paper. The analysis of empirical data shows a wide embrace of WLC/LCC in PFI/PPP projects due to full control over lifetime expenditure and long-term value for money. Although WLC/LCC has been widely applied in PFI/PPP projects today, there are still some factors that affect its successful application. In order to overcome the barriers, efforts are needed from both public clients and private companies. The success of WLC/LCC in PFI/PPP practice depends on client driven optimisation, good awareness of WLC/LCC, encouragement of WLC/LCC through competitive bidding, integration of all key stakeholders into WLC/LCC, early involvement of construction and facilities management (FM) teams in design, well-established procedures and methodologies, reliability and accuracy of data, and regular monitoring the implementation of WLC/LCC.

Keywords: barrier, critical success factor, effectiveness, private finance initiative, whole life costing.

## INTRODUCTION

Traditionally, construction investment and procurement decision were based on initial capital costs, and there has been a shift from the emphasis on initial capital costs to the consideration of whole life costs (Mootanah 2005). According to the procurement guide on WLC released by the Office of Government Commerce (OGC) in 2003, the shift reflects the importance of long-term value for money. The terms WLC and LCC are often used interchangeably (Building Services Research and Information Association 2013). Many people and organisations, such as Gluch and Baumann (2004) and OGC (2003), treat them as synonyms. In the strict sense, WLC should be distinguished from LCC. For example, the British Standards Institute (BSI) defines

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life cycle costs as costs of an asset or its parts throughout its life cycle and whole life costs as all significant and relevant initial and future costs and benefits of an asset throughout its life cycle (BSI 2008). Unlike the LCC methodology focusing on costs only, the WLC methodology covers both costs and benefits during the lifetime of a project (see Figure 1). In addition, WLC includes other costs, such as non-construction cost. By comparison, WLC is wider than LCC and meanwhile LCC can be considered as part of WLC. This paper explores the application of long-term value methodologies in PFI/PPP practice. Similar to WLC, LCC represents long-term value. For this reason, both the literature on WLC and the literature on LCC are useful for

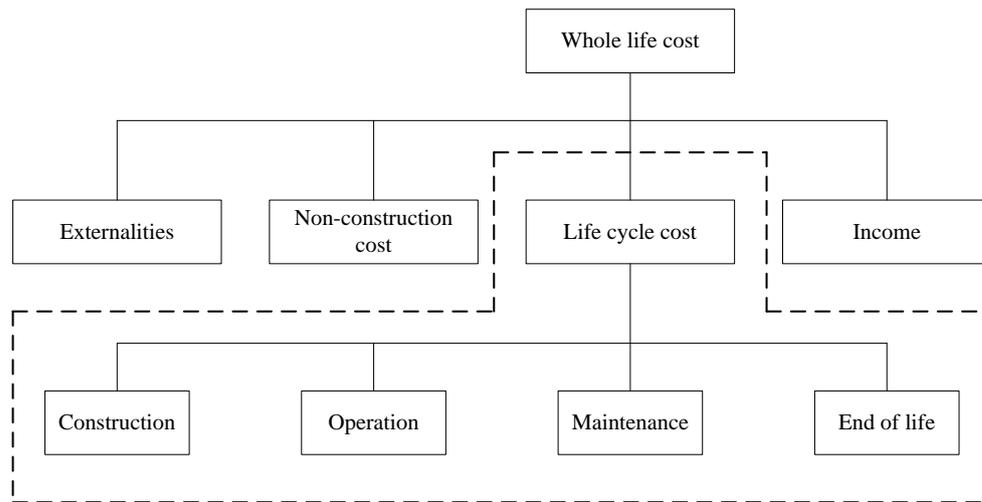


Figure 1 Relationship between WLC and LCC  
Source: BSI (2008)

this research.

The literature review provides evidence to demonstrate research efforts for WLC/LCC in construction (see Table 1). For example, Woodward (1997) explained the procedure of LCC and presented a case study for the application of LCC in a transport project. Nicolini et al. (2000) discussed the possibility of applying WLC in construction projects. Sterner (2000) and Cole and Sterner (2000) identified the gap between theory and practice of LCC. Nicolini et al. (2000), Sterner (2000) and Cole and Sterner (2000) found that WLC/LCC was little used in construction practice although their importance was well recognised. According to Nicolini et al. (2000), the little use of WLC is because (1) no strong client requirements; (2) insufficient availability of reliable data; (3) lack of monitoring targets; and (4) no well-established standard methodology. Similarly, Sterner (2000) identified “lack of relevant input data” and “limited experience in using LCC calculations” as two main constraints for the implementation of LCC. In order for WLC/LCC to be better applied in construction practice, other researchers and practitioners made further efforts. For example, El-Haram et al. (2002) developed a framework for collecting WLC data in building projects to address the problem of unreliable and inconsistent data. Wu et al. (2006) analysed the impact of reliability on the improvement of WLC performance.

*Table 1: Application of WLC/LCC in construction practice*

Author and date	Focus	Methodology	Finding
Woodward (1997)	Encouragement of using LCC	Case study	Application of LCC in a transport project
Nicolini et al. (2000)	Possibility of applying WLC in construction	Case study	Little use of WLC in construction
Cole and Sterner (2000)	Gap between theory and practice of LCC	Literature review	Key factors that limit the widespread adoption of LCC
Sterner (2000)	Using LCC in construction	Questionnaire survey	Main constraints for the implementation of LCC
El-Haram et al. (2002)	Collection of WLC data	Framework development	Addressing the problem of unreliable and inconsistent data through a data structure
Wu et al. (2006)	Reliability in WLC	Questionnaire survey	Improving WLC through reliability analysis

Since the concept of PFI was introduced into the UK in the early 1990s, 717 projects have been procured by using this method with the total capital costs of £54.7 billion, in which 648 projects are operational (HM Treasury 2012). PFI is a form of PPP utilised by the UK government, in which a SPV from the private sector generally designs, builds, finances and operates a public project for a period of 20-30 years (Meng and McKeivitt 2011). In addition to government budget constraints, another main reason behind the introduction of PFI is the inefficiency and ineffectiveness of project management in the public sector. The lack of efficiency and effectiveness in public projects has been criticised by a number of industry reform reports in the UK, such as Latham (1994) and Egan (1998). Introducing PFI/PPP becomes an important way of addressing this major problem (Li et al. 2005). On the other hand, PFI/PPP contracts require the private SPV to take responsibilities for the performance of a public project over a long-term. Adopting WLC/LCC methodologies improves the long-term efficiency and effectiveness (Nisar 2007). Compared to non-PFI/PPP projects, this explains why some researchers and practitioners, such as Baldwin (2003), believed that more opportunities are provided for the implementation of WLC/LCC in PFI/PPP projects.

Although in theory PFI/PPP schemes can provide more opportunities to implement WLC/LCC, few studies to date have reported the use of WLC/LCC in PFI/PPP projects. Swaffield and McDonald (2008) was one of the few studies. Swaffield and McDonald (2008) found that the use of LCC in PFI projects was often inconsistent and unstable. This meant that in some cases LCC was taken into consideration and in other cases it was ignored and replaced by the lowest capital investment, especially during busy times or when working with tight budgets. Therefore, there is a lack of empirical support for the effective use of WLC/LCC under PFI/PPP schemes. In order to have a better understanding, an empirical investigation was made in the UK through a combination of two case studies and a questionnaire survey. The research questions in this empirical study concerned (1) whether WLC/LCC is generally applied in PFI/PPP projects; (2) what is the real effect of applying WLC/LCC in PFI/PPP practice; (3) whether there are still any barriers to the use of WLC/LCC in PFI/PPP projects; and (4) what are the critical success factors (CSFs) for the implementation of WLC/LCC in PFI/PPP practice.

## RESEARCH METHODS

This study adopted a combination of qualitative and quantitative methodologies. It started with a comprehensive review of the literature on WLC/LCC and PFI/PPP. The literature review provided a background for the existing knowledge about WLC/LCC and PFI/PPP. It also provided a justification for the research topic. Subsequent to the literature review, two case studies were conducted to collect qualitative data from two hospital projects using PFI/PPP: one was in England and the other was in Scotland. The case studies were based on the interviews with senior managers/engineers in different parties involved in the two projects. The interviews were semi-structured. Some interviews took place face to face while others were through telephone, depending on the interviewees' availability and convenience. The information collected from different parties helped to generate an overall picture of WLC/LCC application in each project.

The case studies provided initial evidence for the application of WLC/LCC in two hospital projects using PFI/PPP. Although the case study methodology is good at collecting in-depth information, it lacks generalisability (Gray 2004). For this reason, the two case studies were followed by a questionnaire survey to collect quantitative data. This is because a questionnaire survey gets access to a larger population (Cargan 2007). The questionnaire survey in this research provided further evidence for the application of WLC/LCC in various projects under PFI/PPP schemes, such as hospitals, schools, courts, sport centres, social housing projects, and highways or motorways. The link between the case studies and the questionnaire survey represented a research strategy from particulars to generals. By comparison, the case studies were more in depth while the questionnaire survey was more in breadth.

As mentioned above, WLC is a wider concept that covers LCC. For this reason, the term WLC was used in this research when collecting empirical data through the questionnaire survey and case studies. The questionnaire survey targeted PFI/PPP projects. The questionnaire was divided into five sections: (1) project information; (2) application of WLC and its effectiveness; (3) benefits and barriers; (4) CSFs for the implementation of WLC; and (5) additional comments. In Section 2, the application of WLC was a Yes/No question. On the other hand, the question about the effectiveness of WLC application was answered in terms a five-point scale from "Very ineffective" to "Very effective". In order to collect in-depth information, the questions in Sections 3 and 4 were open-ended. This meant that a respondent had enough flexibility to express his/her opinions rather than only ticked boxes. The draft questionnaire was piloted with a group of five PFI/PPP experts whose comments contributed to its refinement. The questionnaire was finalised after the pilot study.

The final questionnaire was sent to 200 potential respondents via emails. The potential respondents were selected through industry contacts and social networks or using the information about PFI/PPP projects provided by the HM Treasury. They represented public clients or investors, designers, construction contractors and FM service providers from the private side. Forty completed questionnaires were returned with a response rate of 20%. The questionnaire responses were collected from different regions of the UK: England, Scotland, Wales and Northern Ireland. Approximately 80% of the questionnaire responses came from hospitals and schools, two main industry sectors using the PFI/PPP procurement method. Over 70% of the surveyed projects were during operation. The questionnaire responses provided a good sample of 717 PFI/PPP projects procured in the UK.

## ANALYSIS OF CASE STUDIES

In this research, two case studies were conducted to explore the application of WLC in PFI/PPP practice. Both of them are hospital projects running in the UK.

### Case One

Case One refers to the design, finance, construction and operation of a hospital project under the PFI/PPP scheme. It is one of the largest hospital projects in the UK, including over 800 new beds, over 20 new centres and over 20 new wards. It is responsible for meeting the healthcare need of more than 800,000 people. The concession period of this project is 25 years. WLC was undertaken at different phases of the project, such as preferred bidder, best and final offer, financial close, construction, and operation. The integration of designer, construction contractor and FM service provider was critical to the success of WLC. This project used higher quality, more expensive finishes to reduce maintenance costs in the long-term. The additional costs of providing basement service distribution tunnels and extra access lifts were paid for by the enhanced efficiencies in the movement of materials and wastes. Toilets were prefabricated in a factory to a higher quality than they would have been onsite. Prefabrication was also cheaper compared to onsite production. On the whole, this project demonstrated an optimal combination of WLC and quality to meet end users' requirements, in which the former indicated economic sustainability while the latter represented project quality and social sustainability.

### Case Two

Case Two relates to the redevelopment of nearly half of an existing hospital. It is an extension project that adds a new diagnostics centre and an outpatient centre. The client's needs and end users' requirements were well reflected throughout the design. It was the bidders' interest to estimate whole life costs and evaluate long-term commercial risks. However, the problems for the use of WLC were a shortage of relevant data and a lack of contractual incentives for WLC. Despite the problems, value for money was a main pursuit of the client. In order to win the project, the successful bidder had to demonstrate value for money. In this project, the construction team was involved early to work with the design team. For example, the mechanical and electrical (M&E) contractor and the concrete frame contractor were brought into early design meetings and their inputs contributed to the improvement of façade and buildability. Early contractor involvement enabled the successful bidder to reduce long-term costs and increase value for money. In this project, early stakeholder involvement as well as local community engagement played a critical role in ensuring the success of WLC. Good working relationships among the designer, construction contractor and FM service provider were also critical to the success of WLC.

## ANALYSIS OF QUESTIONNAIRE RESULTS

Forty questionnaire responses are analysed quantitatively in this section. Based on the two case studies, the analysis of questionnaire results provides more empirical evidence for the application of WLC in PFI/PPP practice.

### Application and effectiveness of WLC

Among 40 surveyed projects, 95% used WLC. Only 5% did not use WLC. Obviously, it demonstrates a warm embrace of WLC in today's PFI/PPP practice. WLC was only absent in a school project and a motorway project. Among 38 surveyed projects using WLC, 45% responded to "Very effective" for the use of WLC, 32% responded to

“Effective”, and 23% responded to “Neither effective nor ineffective”. On the other hand, there were no responses to “Ineffective” and “Very ineffective”. In terms of the use of WLC and the effectiveness of WLC, the findings in this study show a great contrast between PFI/PPP projects and non-PFI/PPP projects. Compared to non-PFI/PPP projects reported by previous studies, the analysis of questionnaire results in this study demonstrates the more common and effective use of WLC in PFI/PPP projects. It gives empirical support to some researchers and practitioners, such as Baldwin (2003), who believed that PFI/PPP schemes can provide more opportunities to implement WLC. The findings bring a more promising future for the application of WLC in construction. As for the project phases in which WLC was applied, the responses were quite diverse. In spite of that, WLC techniques were applied in more than 60% of surveyed projects during early phases, such as preferred bidder. This is consistent with Zheng et al. (2008) that considered WLC forecasts central to the PFI/PPP bidding process.

### **Benefits and barriers**

An open-ended question was included in the questionnaire to identify the benefits from applying WLC in PFI/PPP projects. The purpose of including such a question was to compare the benefits of WLC between PFI/PPP projects and non-PFI/PPP projects in construction. The analysis of questionnaire responses provides a list of the top five benefits: (1) increased long-term value and economic sustainability; (2) reduced costs of construction, operation and maintenance; (3) reduced needs for maintenance; (4) optimised selection of materials, equipment and components; and (5) better understanding of risks and increased certainty and transparency. By comparison, there are no big differences between PFI/PPP projects and non-PFI/PPP projects in terms of benefits of WLC. The only difference between them is perhaps that WLC in a PFI/PPP project enable both the public client and the private SPV to pursue best practice. On the other hand, the benefits of WLC may be more significant in PFI/PPP practice than in non-PFI/PPP practice. In addition to the benefits, the barriers to the implementation of WLC are also identified from the analysis of questionnaire responses, mainly including poor awareness of benefits, data problems, and lack of contractual incentives. In addition to the questionnaire survey, data problems and lack of contractual incentives are also identified from the analysis of case studies. The identification of barriers illustrates that the introduction of PFI/PPP does not imply the automatic disappearance of potential problems. Although PFI/PPP can provide more opportunities to implement WLC, efforts cannot be compromised in order to overcome the barriers.

### **CSFs for the use of WLC**

CSFs were defined by Cooke-Davies (2002) as inputs to a management system that lead directly or indirectly to the success of a project or a business. Müller and Turner (2007) further considered CSFs as elements that can be influenced to increase the likelihood of project or business success. In this study, the questionnaire provided an open-ended question to identify CSFs for the use of WLC in PFI/PPP practice. The CSFs identified from the analysis of questionnaire responses mainly include: (1) contractual obligation and client driven optimisation; (2) good awareness and understanding of WLC; (3) encouragement of WLC through competitive bidding; (4) integration of all key stakeholders into WLC; (5) early involvement of construction and FM teams in the design process; (6) well-established procedures and

methodologies; (7) reliability and accuracy of data; and (8) regular monitoring the implementation of WLC.

As mentioned above, few studies to date have reported the use of WLC in PFI/PPP practice. On the other hand, existing studies has rarely identified the CSFs for the use of WLC. Although Park (2009) identified a list of CSFs for whole life performance assessment, they are related to scope, time, cost, quality, health, safety and contract administration rather than WLC. Li et al. (2005) is another study on CSFs for PFI/PPP projects. The three most important factors identified by Li et al. (2005) are: a strong and good private consortium, appropriate risk allocation, and available financial market. Obviously, the CSFs identified by Li et al. (2005) have much more relevance to the generic management system of PFI/PPP than the use of WLC under PFI/PPP in specific. For this reason, the identification of CSFs in this research fills in the knowledge gap within existing studies. It provides a useful framework for the pursuit of WLC in PFI/PPP practice. The success of WLC is more likely to be achieved if particular attention is paid to these key factors.

## **FURTHER DISCUSSION**

Both the analysis of case studies and the analysis of questionnaire results identify the key role of integrating all the stakeholders into WLC. In a PFI/PPP project, it means that both the public client and the private SPV need to make enough efforts for the application of WLC. For example, the public client needs to drive WLC while the private SPV needs to provide the optimal WLC model. It also means that the designer, construction contractor and FM service provider from the private side should work collaboratively together. In order to collaborate with each other, they must develop good working relationships. This explains why Smyth and Edkins (2007) highlighted the importance of relationship management in PFI/PPP projects. The analysis of qualitative and quantitative data reveals that early involvement of construction and FM teams in the design process is critical to the success of WLC. This is because it provides an important opportunity to integrate the whole team for collaborative working during the project. This is also because it enables different teams to share knowledge and experience in order to increase long-term value for money.

According to the questionnaire respondents and the interviewees involved in the case studies, WLC well reflects economic sustainability. This is similar to De Lemos et al. (2003) that considered WLC as a sustainable competitive advantage of PFI/PPP projects. Sustainable development has three pillars: economic, environmental and social. In addition to economic sustainability, WLC also contributes to sustainability in other two aspects. This is a common understanding among the industrial experts involved in the questionnaire survey and case studies. It is because WLC can be used to evaluate or appraise the technologies and solutions for environmental and social sustainability. This understanding can also be found from existing studies, e.g. Gluch and Baumann (2004) and Steen (2005) believed that WLC is helpful in assessing environmental costs and benefits over the long-term and making environmental decision. The contribution of WLC to sustainability in different aspects reveals more roles of WLC and further highlights the importance of WLC application in PFI/PPP practice. However, it is important to realise that WLC-efficient alternatives are not always the most environmentally and socially sustainable ones (Perera et al. 2009). When a WLC-efficient alternative is not the most sustainable in terms of environmental and social attributes, there is a need for the balance between economic, environmental and social benefits.

## CONCLUSIONS

This study looks at WLC from the PFI/PPP perspective. The analysis of qualitative data collected from the case studies and quantitative data collected from the questionnaire survey provides empirical evidence for the application of WLC in PFI/PPP practice. The main findings include:

- There is an increasing embrace of WLC in PFI/PPP practice to reduce long-term costs and increase long-term value for money;
- Compared to non-PFI/PPP projects, PFI/PPP projects are more likely to commonly and effectively apply the WLC methodology;
- The introduction of PFI/PPP does not help to overcome the barriers to WLC automatically, and therefore both public clients and private companies need to make enough efforts for the implementation of WLC;
- PFI/PPP provides a good platform for designers, construction contractors and FM service providers to collaborate with each other, which is a key to the success of WLC;
- WLC should be implemented as early as possible in order to generate greater benefits; and
- Close attention should be paid to some important issues, such as client driven optimisation and contractual incentives, in order to ensure the successful application of WLC.

The study on WLC application in PFI/PPP practice is ongoing. Further research can be outlined to identify how to apply WLC optimally in PFI/PPP practice. Further research is also recommended to establish incentive mechanisms for good performance and disincentive mechanisms for poor performance in terms of WLC. The only purpose of further research is to find out more space for the successful application of WLC in PFI/PPP practice.

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# A CASE STUDY OF CHANGING PROCUREMENT PRACTICES ON DELIVERY OF HIGHWAYS PROJECTS

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Despite many changes to industry best practice since the publication of the Latham and Egan report, the construction industry has been heavily criticised for inefficient procurement strategies. The publication of NEC 3 (the latest version of the New Engineering Contract) in 2005 instigated improved collaboration, flexibility, risk sharing and enhanced management practices, particularly in relation to public sector procurement projects. This study analyses the organisational benefits of changes to the procurement strategy, based on NEC 3 and including framework contracts and key performance indicators, to the Engineering Consultancy which delivers highways and transportation projects for Hampshire County Council. Quantitative data from 51 projects completed prior to 2008 when the new procurement framework was introduced was compared to data from 23 projects completed post 2008 to establish key areas of improvement. A case study approach was adopted comprising interviews with project managers, quantity surveyors and supervising engineers, together with further detailed data analysis from three typical projects. The results of the investigation demonstrate better predictability for projects delivered under the new procurement strategy as they were more likely to be delivered on time and to cost, and less likely to overrun on tender value. Other benefits identified include closer working relationships with contractors and faster agreement for compensation events, time extensions and valuations. This study supports the premise that such changes in procurement practices can lead to improvements in the efficiency and delivery of highways construction projects and overall methods of working.

Keywords: framework agreement, highway, NEC3, procurement, public sector.

## INTRODUCTION

This research stemmed from the introduction of framework agreements adopted by Hampshire County Council (HCC) within the Engineering Consultancy, an in-house consultancy responsible for the majority of highways and transportation Civil Engineering projects. The rationale for the adoption of framework agreements was to bring the Consultancy in line with industry best practice and the recommendations proposed within the Egan and Latham report.

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Egan (1998:7) was critical of the traditional form of construction procurement, particularly for Local Government, where contracts were usually awarded to the lowest priced tender rather than best value due to a need for accountability, which he viewed as one of the greatest barriers to improvement. In a Chartered Institute of Building (CIOB) Report (2010) it was highlighted that having a lowest bid mentality delivers high risk, poor quality projects, that result in unplanned increases in cost and time. Other critics of the lowest bid over value approach include Byatt (2001), Naoum (2003), Black et al. (2000).

Two new Framework Contracts were introduced by HCC in 2008 using the New Engineering Contract 3rd Edition (NEC 3) as the standard form of contract in line with industry changes. These were Improvement Works Framework 1 (IWF1) for small scale works up to £500,000 and Improvement Works Framework 2 (IWF2) for more complex project ranging from £50,000 to £3,900,000. The anticipated benefits included: increasing predictability of construction durations and emphasising a zero defects culture, moving towards a procurement system based around quality and value rather than cost and improving the relationship between the client and contractors. The longer term aspiration was to bring about increases in operational efficiency and better value for money for all stakeholders. This supports Egan's recommendations (1998:7).

Framework agreements are attractive as they are simple to use, requiring only one negotiation for a series of projects, which should deliver value for money and save time. There is commercial advantage for Contractors in the framework as they will be able to bid for a higher proportion of contracts available, in the knowledge they are only in competition with a handful of other contractors. The main benefit to the Client is that by working with a small group of contractors it is easier to build closer working relationships, learn from mistakes and ensure continuous improvement. However, Mosey (2009) warned that there is a need to remain more flexible than with single projects, as much of the detailed planning will only take place as each project is identified and initiated. Frameworks provide the prospect of future projects so any potential opportunistic behaviour is outweighed by fear of long-term reputational damage, although some critics do refute this (Campbell and Harris 2005).

Prior to 2008 the Consultancy procured the majority of construction services using the Institution of Civil Engineers Conditions of Contract 7th Edition as the standard form of contract. This involved sending invitations to tender to contractors from the Approved List of Contractors, with the contract awarded to the Contractor with the lowest priced tender.

This paper will start by identifying ongoing problems within the construction industry and key recommendations made within the Egan and Latham report. It will then present the research methods adopted to assess improvements in performance within the Engineering Consultancy following the introduction of IWF2 and end with a discussion of the findings, including perceptions of key staff in relation to working practices and relationships.

## **CONSTRUCTION: A CHANGING INDUSTRY**

UK construction accounts for over 7% of GDP or £110bn per annum of expenditure, of which 40% is accounted for by the public sector, which makes a sizeable contribution to the overall economy (Cabinet Office 2011:3). Despite this, the construction industry has traditionally been regarded as inefficient, with a reputation

for completing projects late and over budget. It is therefore unsurprising that over the last 60 years, especially in periods of austerity and recession, construction has come under scrutiny from numerous Government reports and initiatives to deliver better value for money and thus contribute to economic growth (National Audit Office (NAO) 2005). In a review of these reports, Murray and Langford (2003) reveal that they share similar underlying explanations for the poor performance of the industry as a whole. Common themes include: fragmentation between the design and construction teams, coordination and management of subcontractors, procurement with lowest priced tendering, adversarial relationships between client and contractors, and poor contractor performance and client dissatisfaction with late and over budget delivery.

The Latham (1994) report was published following a tough recession in the late 1980's and early 1990's and with extensive consultation from within the industry. Increased competition, resulted in contractors tendering very low prices to win work, with the intention of making up shortfalls and losses through additional claims (Murray and Langford 2003) which led to an industry characterised by conflict and disputes, adversarial relationships and dissatisfied clients. Sir Michael Latham made a number of recommendations including standardised contracts, evaluation of tenders on quality as well as price criteria, and the Government committing itself to being a best practice client. The most controversial recommendation was the adoption of partnering, which was not met by universal approval by main contractors who felt that their role as principal agent under traditional contracts was threatened (Green 2011).

Although generally well received, the industry was slow to react to Latham's recommendations and in 1998 a new report 'Rethinking Construction' was published. With a background in motor manufacture and a reputation of turning around struggling businesses, Sir John Egan was brought in to shake up the industry and modernise construction, as a means to create 'economic, social, and environmental value through innovation, collaboration and integrated working' (McGeorge 2013). Egan proposed several ways to speed up this change utilising his manufacturing background; including lean construction, total quality management, business process reengineering, key performance indicators, benchmarking, concurrent construction and supply chain management. He identified 7 targets for improvement; capital cost, construction time, predictability, defects, accidents, productivity and turnover, and profits. These targets have been iconified in the 5-4-7 model (Green 2011:143) which also itemises the 5 drivers for change; focus on the customer, committed leadership, product team integration, quality driven agenda and commitment to people. Critics of the initial report demanded the inclusion of an eighth target relating to client satisfaction, and also pointed to the potential conflicting views within the client organisation as clients were seen as unitary entities (Green 2011). Others directed their comments to the fact that whilst partnership is positive and useful, contract management may be more effective at delivering results (Hughes and Maeda 2002). In order to prove the value of his approach Egan established demonstration projects, called the Movement for Innovation (M4I), which provided an industry benchmark. In the follow up report *Accelerating Change* (2002), Egan again stressed the importance of integrated teams to deliver greater process efficiency, drive out outmoded adversarial culture and end lowest price tendering as the main procurement tool.

Considering industry transformation, a change was clearly long overdue for the Engineering Consultancy, however the introduction of a brand new, untested form of contract on projects worth millions of pounds carries a significant element of risk. This is why local authorities often choose to wait and see how such contracts perform

in the private sector, particularly with regard to litigation, before deciding whether to adopt new methods.

## **RESEARCH AIM**

The overall aim of the research was to carry out a preliminary investigation to contrast data pre and post introduction of the new standardised framework agreement and to assess the efficacy and success of the change. Success is defined as greater predictability in terms of time, overall cost and variance from tender value, as well as ensuring designs and projects were right first time.

To achieve the aim, the key objectives pursued were:

- To compare existing operational monitoring data on all projects completed before and after the introduction of the new framework agreement and assess potential performance improvements
- To undertake an in-depth case study of 3 projects completed under the new framework agreement to understand why variations to the contract occurred within 4 defined compensation event categories
- To interview key staff from the case study projects and explore reasons for compensation events, perceptions of the new framework agreement, and observations regarding changes in working practices, including relationships with clients and contractors.

## **RESEARCH METHODS**

A multiple perspective approach was adopted using methodological triangulation of project data to provide a clear and valid view and explore more deeply the impact and success of the procurement changes on project delivery and working practices (Patton 2002). Qualitative case study research was conducted to explore outcomes of the new framework and ensure as wide an understanding of the situation as possible (Babbie 2001) in order to complement the quantitative data generated. Case studies were selected as an appropriate method as they allow investigation in greater depth drawing out the complexity of relationships and behaviour through numerous sources of information (Denscombe 2003:32).

Initially the population was all schemes (N=74) undertaken by the Engineering Consultancy (2006 - 2011) comprising of data on 51 projects completed between 2006-2009 (pre-IWF) and 23 projects completed after the introduction of the new procurement strategy in 2008 (IWF2) and the start of this research in 2011.

After an introductory assessment, 5 schemes (2 pre-IWF and 3 IWF2) were excluded on the grounds that they were atypical schemes. These 5 schemes delivered in excess of 100% of the tender value due to exceptional circumstances and change, which created a disproportionate skewing of results. Whilst this data clearly merits further investigation to assess the surrounding circumstances, it is outside the remit of this study. This reduced the total number of schemes analysed to 69.

Existing data from pre-IWF and IWF2 projects were analysed and compared using basic performance data on tender and final cost values, cost variations, and programme durations.

In terms of data limitations, it should be pointed out that the pre-IWF projects contain figures for schemes completed at all values whereas IWF2 contracts are only for more complex projects costing £50,000 to £3,900,000. Whilst it could be argued that the

information is not fully comparable, the inclusion of the numerous lower cost schemes under IWF1 would have involved a great deal more data collection and this would have been impractical from a cost and time perspective, as this was deemed a preliminary investigation.

Secondly, case studies from 3 typical IWF2 projects were undertaken to try to ascertain why cost and duration variations might exist and to establish if lessons could be learned to inform future projects. The 3 schemes selected were chosen as they encompassed different types of project, in terms of size, type and complexity, characteristic of the range delivered by the Consultancy in the highways and transportation sector.

The selected schemes were:

- M27 Junction 5 Improvement Scheme (Phase 1). This was a scheme to improve traffic flows and reduce congestion around a busy motorway junction. Completed in July 2010 the contract was tendered on a cost only basis and was awarded to the contractor with the lowest priced tender.
- Winchester High Street Improvement Scheme. This was a major maintenance and refurbishment scheme with bespoke features in a sensitive historic area. Completed in October 2010 the contract was an NEC 3 Option D contract, target cost with bill of quantities and was tendered on a 70% price/30% quality basis and included an Early Contractor Involvement element to provide advice on materials, products and build-ability.
- Winchester Park and Ride Scheme. This was a scheme to provide a car park to the south of Winchester City Centre. Completed in April 2010 the contract was an NEC 3 Option B priced contract with bill of quantities and was tendered on a 70% price/30% quality basis.

Each case study provided a basic description of the scheme, quantitative data relating to the costs and duration of each project and more extensive cost data relating to 4 categories of compensation events which were:

- Unforeseen circumstances which could not have been reasonably foreseen or predicted (e.g. unusual ground or weather conditions)
- Design issues resulting in change (e.g. due to poor or incorrect information in the design that could not be implemented during the construction phase)
- Quantity surveyor issues (e.g. failing to include all items within the Bill of Quantities)
- Additional work (e.g. extra items requested by the Client)

All variations were agreed by the Supervising Engineer and Contractor, in accordance with the NEC Conditions of Contract.

Numeric data was underpinned by personal face to face semi-structured interviews with key practitioners within the project team including Project Managers, Quantity Surveyors and Supervising Engineers. This allowed empirical investigation in a real life setting using multiple sources of evidence which Robson (2002:59) suggests can be helpful to 'find out what is happening' and 'to seek new insights'.

The interviewer used open ended questions to allow respondents to reply freely and provide detailed information about their experiences of project delivery including usage of the IWF2 contracts for the case study projects. Respondents were not identified by name to ensure anonymity and each gave consent for their responses to

be used for any further research. Questions were tailored for each group specialism within the team. They included personal information about work experience, contractor selection, stakeholder involvement, duration and costs, compensation events, perception of the project and framework agreements, as well as potential improvements. This aided detection of project trends within the Engineering Consultancy and investigation of the rationale for cost variations and categorisation of the area of responsibility for each variation within each project.

## DATA ANALYSIS AND DISCUSSION

### *Comparison of pre IWF and IWF2 contracts*

Taking the data from the projects shown in Table 1, comparisons of pre-IWF and IWF2 schemes revealed overall success with the change to procurement strategy. On average 18% fewer projects were delivered late and 5% more projects were delivered to budget under the new framework agreement. In addition, 29% more projects were completed within 10% of their tender value, the Hampshire County Council target, under the new framework.

*Table 1: Comparison of projects completed before and after the introduction of the IWF2 Contract*

	Projects under pre IWF contract	Projects under IWF2 contract
Number of projects	49	20
Total tender value (£)	26,022,937	13,676,569
Final contract value (£)	30,155,079	15,551,354
Percentage of projects completed within 10% of tender value	51	80
Average cost variation per scheme (%)	13	8
Average project variation between scheduled time and actual time	42 days	17 days
Percentage of projects completed late*	58	40

\* Prolongation days deducted from the actual duration.

The results from this preliminary investigation reveal better time and cost predictability for the Engineering Consultancy, which suggests that the use of IWF2 as a new procurement tool has been successful in improving construction durations. This suggests that contractors are increasingly cognisant of the key performance indicator relating to time predictability, and are keen to meet deadlines to improve their position in the following performance period. This data also demonstrates better value for money for stakeholders including HCC, the Engineering Consultancy and tax payers, which is essential for public sector procurement (Byatt 2001, Raymond 2008, Griffith 2011). Overall findings are consistent with industry recommendations (Latham 1994, Egan 1998, NAO 2005, CIOB 2010) regarding standardisation, reducing construction time and costs and general predictability.

*Case study data*

Table 2 shows comparison figures for the case study projects. All three projects were considered to be a success in that they met the objectives of their original design briefs and were right first time.

*Table 2: Comparison of case study IWF2 projects*

	M27 J5 Improvement Scheme	Winchester High Street Improvement Scheme	Winchester Park and Ride Scheme
Tender value (£)	1,223,680	1,405,070	3,431,437
Final contract value (£)	1,853,980	1,513,554	3,766,030
Total cost variation (£) and percentage increase	630,299 (52%)	108,484 (8%)	334,593 (9%)
Actual duration, days late*	278 days (2 days late)	413 days (42 days early)	365 days (28 days early)
Right first time	Yes	Yes	Yes

\*Figures include agreed days prolongation

Egan (2002:3) discussed the importance of improvements in quality and efficiency within the industry and aspired to a 'zero defects culture'. These results imply that the Engineering Consultancy have a robust process in place to monitor and control defects to ensure design briefs are met and clients kept satisfied. Time variations were also well controlled, with both Winchester schemes being delivered early. This supports Egan (2002) who believed that construction times were a key target for improvement. The M27 improvement scheme was delivered 2 days late which could be considered a minor failing, but this equates to less than 1% of the overall total time taken.

In relation to cost increases, the Winchester High Street Improvement and the Winchester Park and Ride scheme completed within 10% of their tender value which is within the HCC target. Unfortunately the M27 improvement scheme completed 52% above tender value with additional costs relating to poor design of drainage and issues with traffic management and safety fencing, as well as extras added by the client during construction. This does not demonstrate an improvement in cost management on this project. Lessons identified include ensuring that contract documents are audited thoroughly before tender and getting the Supervising Engineer more involved during the design stage. It may also be relevant that this project had a relatively inexperienced project manager running the project. This could reflect on a failure of the procurement process, where more time should have been spent in the pre-project phase analysing documentation or it could be attributable to a break down in project management processes and controls.

The data relating to compensation events were inconclusive. It showed that the largest proportion of cost variations for two projects were due to design issues, Winchester Park and Ride Project (55%) and M27 Junction 5 Project (60%) with the next highest category being additional work. Overall it was difficult to identify clear trends or similarities between the three case study projects, suggesting that a larger sample size is needed.

*Case study interviews*

Project Team members were asked specific questions about duration, costs and variations in their projects to understand whether the 3 case studies were representative of those undertaken by the Consultancy. In addition they were questioned about the new contracts and general working practices. The aim was to establish whether there had been general improvements in ways of working since the introduction of IWF2, what further recommendations could be made for the delivery of future projects and to inform ongoing best practice in meeting industry standards. Comments were categorised in 4 key areas: relationships with contractors, design, necessary change and inclusion of quality elements in tendering.

Respondents felt that IWF2 contracts are an improvement as they provide and promote a closer working relationship with Contractors. This premise supports the multitude of literature on the benefits of partnering in reducing the adversarial culture within construction (Black et al. 2000, Bresnen and Marshall 2000, Naoum 2003). They were also positive about Key Performance Indicators (KPI's) which they felt offered good commercial incentives for Framework Contractors to perform better. This finding concurs with Thomas and Thomas (2005) who identified that benchmarking against past performance and other organisations, drives continuous improvement and demonstrates value for money. Several respondents also noted that Early Contractor Involvement (ECI) should be encouraged to promote further improvements. According to Mosey (2009) lack of ECI leads to greater likelihood of decisions being delayed or sidestepped, increases risk and results in poor communication between team members.

In relation to design, respondents felt that Framework Contracts do not necessarily result in a better quality product, as this is governed by the quality of the design work undertaken. Some Project Managers expressed concern that designs can be rushed to accommodate funding streams and increased time should be allocated to the design process. This illustrates a point made by Mosey (2009) that project funding can distract the client's attention away from the important task of agreeing and managing the pre-construction process. Other concerns included; enhanced training and more time to complete designs to adequate standards for Design Engineers, improved communication between Quantity Surveyors and Design Engineers, and greater involvement of Supervising Engineers during the design process to allow improved auditing of contract documents prior to tender. These comments about communication and involvement link back to the importance of ECI and also the fact that partnering is a long term commitment (Bresnen and Marshall 2000).

In terms of change, many of the project team felt that whilst it is not necessarily easier to agree Compensation Events, extensions of time and valuations, they are agreed more quickly due to the use of NEC 3. This supports the view of Eggleston (2006) who considered that NEC 3 provided a stimulus to good management with a greater emphasis on communication and cooperation.

Finally the respondents identified that increased use of quality elements within tenders and contracts yielded positive results which mirror recommendations by Egan (1998), Byatt (2001) and Wong et al. (2000) that best value tenders will include both quality criteria as well as price.

Overall the interviews provided a clear indication that the IWF2 contracts are a significant improvement over the previous procurement system, as they provide closer

working relationships with the Contractors, and much of this is attributed to the use of NEC 3 as the standard conditions of contract.

## CONCLUSIONS

The changes to procurement strategy through the introduction of the IWF2 framework agreement sought to reduce tender costs and defects and improve construction durations as well as overall client satisfaction. Based on these factors the changes can be seen to be effective and successful in terms of delivering better overall value to stakeholders, which is key to public sector projects. This links to a number of the targets for improvement highlighted by Egan (1998) in *Rethinking Construction*, namely, predictability in relation to time and cost, improvements in delivery time of projects, cost reductions and zero defects. Further analysis of the data may also find that such savings have increased productivity and profit, but that is outside the remit of this paper.

If we also consider the anecdotal evidence from project team members, it is apparent that the new framework agreement has been well received and has generally improved working relationships and allowed faster decision making. This is very much in the spirit of integrated collaborative partnering espoused by many as the panacea to the inefficiencies of the construction sector. Although, as Bresnen and Marshall (2000) are keen to point out, partnering does not represent a quick fix as mutual trust and cooperation are slow to develop and compliance may not result in genuine attitude change. It could be said that as this procurement revision encompasses culture change, an assessment after 2 years is insufficient to draw any strong conclusions about management practices and ways of working, and a further protracted longitudinal study would be more appropriate to investigate this in greater detail.

Whilst the majority of evidence has demonstrated a positive transformation, an area that the new framework does not appear to have tackled is ECI, particularly interaction with the design team, who may be rushed to produce inadequate or inappropriate designs and it is disappointing to note that the fragmentation between design and construction teams identified by Murray and Langford (2003) is still very much in evidence. However, this may also be an area that needs more time to bed in.

In conclusion, the industry recommendations made by Egan (1998) and Latham (1994), particularly in relation to standardised procurement best practice, have been demonstrated as being beneficial in contributing to improved efficiency and delivery of best value within the Engineering Consultancy.

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# PROJECT ALLIANCES: AN INVESTIGATION INTO THE LOGIC BEHIND THE RANGE OF A DUTCH PUBLIC SECTOR CLIENT'S INITIATIVES

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For fifteen years, the Dutch railway agency (ProRail) has implemented various alliance elements in its procurement strategies. Several project alliancing applications have been developed and applied in succession, ranging from a limited shared risk domain to a directly tendered full alliance model. The progress seems to be evolutionary rather than planned. The emergence of these alliance variants suggests implicit motivations and expectations. Changing the implicit reasoning to explicit logic could help in the evaluation and development of alliance approaches, from project-based evolutionary adaptations to a conscious planned strategy. This study considers a number of alliance projects. The variation amongst these projects is mapped against a number of criteria derived from the literature. Contracting plans, the tendering board's minutes, contracts and other policy documents were scanned and interviews were held with key players to reconstruct the motivations for the various alliance approaches. The initial results confirm that changes and choices made in terms of the particular alliance domain are mostly implicit and only sparsely explained by motivations. This paper will present a first overview of ProRail's alliancing variants, corresponding motivations and expectations, plus more explicit insights into the prevailing implicit reasoning. This study offers a first step in mapping the variation in alliance methods, evaluating their effects and moving the implicit evolutionary development of alliance methods towards more deliberate planned choices in future alliancing variations. The next step in the research project will be to verify the validity of the expectations and logic regarding alliancing.

Keywords: project alliancing, procurement, motivation, decision analysis.

## INTRODUCTION

Several new project delivery methods have been introduced in the construction industry over the past three decades. Before adopting a new procurement method, a client will explicitly consider the expected advantages and downsides. Once a method becomes more frequently used, the initial motives and arguments tend to become more implicit, and the method is amended and modified in an evolutionary way. Several variants of the original pure type (as in Weber's sociology) will emerge. A family of method variants grows organically. Since this spreads naturally from project

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to project, methods change in often unobserved ways and the considerations behind the changes go undocumented. Since altering the method implies adding new insights and arguments to the initial considerations, the underlying logic explaining the initial, pure type and the subsequent range of options becomes hidden, making it difficult to consciously and cautiously evaluate and improve the method. This trajectory from explicit to implicit reasoning may become an obstacle to evaluation and further development.

The Dutch state railway agency (ProRail) first applied the “project alliance” as a procurement and project delivery method in 1998. In the fifteen years since then, several projects have been procured in a way that can be labelled as a “project alliance” although the procurement approaches taken have differed somewhat from the original method. Since alliances are seen as a valuable method for the future, ProRail has recently started a study to evaluate the merits of the alliance method and to bring a more systematic approach to advancing the method. As such, ProRail should be able to move away from implicit organic development towards a more conscious and planned advancement of the alliance method.

This paper gives an account of the initial steps in this research project. The purpose is to present a quick overview of (a) ProRail’s project alliances over a fifteen-year period, (b) the key variations and (c) the traceable considerations, motivations and expectations. This quick-scan strategy is used to assess the conjecture that the reasoning and considerations are evolving implicitly, and to assess whether the implicit logic(s) can be traced back. A positive outcome on both these assessments would mean that there is a basis for a thorough reconstruction of the dominant logic behind the implicit reasoning. This will provide the necessary conditions for the next step in the research project, which is to verify the validity of the traceable considerations and logic regarding project alliancing.

Ibrahim et al. (2011) identify a current geographical research gap in the implementation of the concept of project alliances. As such, explicating the alliance practices of a major public sector client in the Netherlands will contribute to knowledge and to the debate on the reasoning used in implementing a project alliance. The insights into the dominant logic regarding project alliances reveal apparent dilemmas at a deeper level than the motivational level that research has so far considered. This study also identifies several variations of project alliances. Further, it sheds light on the dynamics in the evolutionary and planned development of procurement methods. These elements contribute to science as well as to practice.

The next section of the paper addresses the working definition of project alliance and the emergence of this method in a Dutch context. The following section explains the steps taken in developing the quick-scan overview, namely: (1) determine the criteria to select alliance projects from all the other ProRail projects, (2) determine the elements that vary amongst the alliance projects, (3) identify considerations given and (4) reconstruct the underlying logic. Once the research method has been explained, the results from the first two steps are presented in the 'first results' section. Reflections and conclusions then follow in the final two sections.

## **RESEARCH CONTEXT**

Project alliancing is a relatively young construction project delivery method. Searching on “alliance” in the Arcom database lists only 66 papers, and only four of these date from before 2000; The first paper was by Badger et al. (1995) and the

history reflects that collaborative forms of project delivery are increasingly being developed in order to move away from the customary adversarial behaviour of the traditional approach (e.g. Lahdenperä 2012). An offshore project in the North Sea, initiated by British Petroleum, is commonly considered to be the origin and first application of alliancing (e.g. Bakshi 1995; Halman and Braks 1999). Scheublin (2001), focussing mainly on the petrochemical sector, was the first to describe project alliances in the Netherlands. In the Dutch public infrastructure sector, the first project alliance was initiated in 1998 by the Dutch railway agency. Since then, project alliancing in Dutch infrastructural projects is much debated but there have been few implementations. Of the Dutch public sector agencies, ProRail has been the most frequent user of project alliancing forms. Since the initial project in 1998, ProRail's concept of project alliancing has seen both minor and major changes in successive projects; and several alliance variations have been implemented. However, only one of these project alliances has been reported in the international scientific literature (Laan et al. 2011).

Alliances and alliancing are not clearcut concepts. Several authors warn over possible confusion regarding the interpretation (Yeung et al. 2007; Chen et al. 2012). Yeung et al. (2007) observe that numerous definitions of alliancing are available in the literature. Moreover, Lahdenperä (2012) points out that concepts such as project alliancing are not stable and have developed over time in interactions with other project delivery methods, and will probably keep on developing in the future. Therefore, the scope of the project alliancing concept as used in this study needs to be explained to avoid misunderstandings. Alliances can be categorized as either project, programme or strategic (Wood and Duffield 2009; Chen et al. 2012), and this study deals only with the 'project alliance' form: 'a project alliance is generally formed for a single project, after which the team is usually disbanded' (Wood and Duffield 2009). From the range of available high-level descriptions of project alliancing, the description provided by the State of Victoria's Department of Finance and Treasury fits well with the ProRail context: "a method of procuring (and sometimes managing) major capital assets, where a state agency (the Owner) works collaboratively with private sector parties (Non-Owner Participants or NOPs)" (State of Victoria 2010). This description serves as an initial high-level definition of a project alliance for the purposes of this study.

## **RESEARCH APPROACH**

Our basic question is how to move from successive implicit evolutionary developments in the project alliance method to explicit design rules and planned advancement. The research approach adopted is to analyse a number of successive ProRail alliancing applications through applying the perspective of knowledge mapping and dominant logic. The overall study is divided into two phases. First, the chronology of the variations and corresponding motivations in the implemented alliancing applications are reconstructed and mapped. The second phase is to verify the validity of the expectations and logic regarding alliancing. Phase 1 aims to establish a factual basis on which one can verify the initial assumptions. This involves: (1) distinguishing the alliance projects from all the other ProRail projects, (2) determining the elements that vary within the selected projects, (3) investigating whether the motives for these variations are explicitly stated in the project documents, and (4) holding interviews to investigate the logic used in each instance. This study has only recently started, and therefore this paper homes in on the early results from the first three of the above steps.

### **Step 1 – Characteristics of alliance projects**

How can one identify and single out projects that can be regarded as project alliances? In order to identify alliance projects among the thousands of ProRail projects between 1998 and 2012, selection criteria are needed, and the literature provides some suggestions. Yeung et al. (2007) distinguish: 'soft (relationship-based) elements' and 'hard (contractual) elements'. Under hard elements they include the 'formal contract' and 'real gain-share/pain share'. In this initial phase of the study, the 'soft elements' (i.e. trust, long-term commitment and cooperation and communication) are disregarded because selecting past contracts based on these criteria would be arbitrary or require a subtle set of criteria for objective decision-making, which is not available. Furthermore, by their nature, these are the 'hoped-for' results of a project alliance and cannot be fully created by the contract alone (Bresnen and Marshall 2002). In terms of the hard contractual elements, the 'formal contract' is viewed as providing the evidence of the existence of an alliancing arrangement between companies in the form of a signed contract; and genuine sharing of pain and gain is the key criterion. A literature search indicates that there is no general consensus on the precise meaning of 'real gain-share/pain share', although a compensation model derived from Australian practice is considered typical (Love et al. 2011). Following these authors, this ProRail research considers a compensation element to reflect the project alliance form if the client and other participants have a contractual arrangement that somehow relates to over- or under- run of targeted outturn costs. This compensation element is chosen as the main determiner in identifying projects delivered through an alliance method.

### **Step 2 – Differentiation within the project alliance category**

How can the implicit evolutionary development of the project alliance method be observed and assessed? Alongside a time reference, this requires an ability to identify differences among the alliance projects. Here, some basic characteristics were chosen to differentiate in terms of context: project size, type of work, type of contract tendered (i.e. Design (D) - Design & Construct (D&C) - Design, Construct & Maintain (DC&M) - Project Alliance (PA)), type of partner (contractor consortium (CC) - engineering firm (EF)), when the alliance agreement was signed (i.e. number of months after awarding the tendered contract) and changes relative to the first implemented alliance agreement (minor - major - new contract).

Distinctions within the project alliance category are derived from the 'real gain-share/pain share' characteristic mentioned above. The majority of project alliance definitions emphasize 'collaboration' as a key to achieving high performance. This collaboration is primarily stimulated by aligning objectives (Love et al. 2011), and this is established through the gain and pain sharing arrangements. In contracts, pain and gain sharing can be directed towards specifically recognized shared project activities and/or risks, but it cannot include all activities and risks. Some domain boundaries must be set in the contract (such as the risk that the client makes major scope changes). Some activities typically remain with the client or with the NOP's.

Further, the existence of a shared domain suggests the needs for procedures or an organization to manage the domain. The State of Victoria's 'Practitioners Guide' and Mills et al. (2011) propose an Alliance Leadership Team (ALT) and an Alliance Management Team (AMT) to manage the shared domain (State of Victoria 2010). Where the shared domain is very small, this could be scaled back e.g. to procedures or an Alliance Manager (AM) only.

Based on the above, the pain and gain sharing element can be differentiated in terms of the following aspects:

- domain of shared activities (broad / narrow);
- domain of shared risk (broad / narrow);
- management arrangement (ALT, AMT, AM, no specific arrangement).

### **Steps 3 and 4 – Identification of explicit motivations and expectations**

Assuming that the project alliance method undergoes organic evolutionary development, what are the motives and expectations that drive this differentiation? Can the motivations and expectations be retrieved from ProRail documentation? To answer these questions, project-related documents including contracting plans, tendering board minutes, contracts and policy documents were reviewed. During the overall project, more documents will be studied and analysed in greater detail, and interviews will be conducted to deepen and crosscheck the data (Step 4).

In their overview of alliancing research, Chen et al. (2012) distinguish between 'motivations to use alliancing', 'alliancing benefits' and 'the applicability of alliancing'. Each of these contains various items that can be considered as potential motives for forming a project alliance in the context of our study. However this division into three categories adds little value at this early stage of this study. Motivation largely consists of the expected benefits. The first column in Table 2 presents a list of motivations derived from the general literature complemented with motivations found in the ProRail documentation.

By interviewing key players and investigating other, less formal, documents, such as PowerPoint presentations, the implicit reasoning will be reconstructed to explain the dominant logic behind the major choices that have been made.

## **INITIAL RESULTS**

Based on the pain/gain sharing criterion, the initial scan identified eight projects that could be interpreted as project alliances. Two of these projects encapsulated multiple project alliances, with project #3 containing three separate project alliances and #6 two. The eight projects were mapped in terms of the alliance characteristics developed in Step 2. Table 1 shows the results of these two steps.

Table 2 shows the results of Step 3. As in Table 1, the columns represent the eight selected projects, and this time the rows contain identified motives. Where a particular motive was identifiable in the project documents this is reflected by a (✓) at the row/column intersection. A conclusion from Table 2 is that motivations for an alliance initiative differ per project or are of an implicit nature (project #7). The bottom row shows 'not found' if no explicit motivations were found for choosing a different approach from that previously used. The table indicates that the reasons for change are rarely explicitly stated.

This initial overview also shows that specific procedures and organizational forms to manage the shared domain become more elaborate as the size of the shared domain increases. Over time, the frequency of alliancing applications in projects seems to grow while the size of the shared domain reduces. In terms of the dominant logics used by the client, one particularly interesting aspect seems to emerge from Step 3 concerning the 'real gain-share/pain share' criterion. In the literature, this aspect is considered essential to the concept of project alliancing on the basis that this mechanism will align interests and thus behaviour among project participants, which is assumed to enhance project performance. As such, attention is drawn to the

substantial variation in the shared domain, for which little explicit motivation has been found.

*Table 1: Results of Steps 1 and 2*

Project	#1:	#2:	#3:	#4:	#5:	#6:	#7:	#8:
Year of publication	1998	2005	2005	2006	2008	2009	2011	2012
Value (€ million)	>100	25-50	<25	>100	>100	>100	25-50	<25
Technical scope	civil works	civil works	instal- lation	civil works	civil and railinfra works	civil and railinfra works	civil works	civil works
Contract type	DC&M	D&C	D	D&C	D&C	PA	D&C	D&C
Type of party	CC	CC	EF	CC	CC	CC	CC	CC
Agreement on alliance contract	<4 months	<5 months	<9 months	<6 months	<4 months	-	-	-
Changes to reference contract	NA	minor	major	new contract	new contract	major	new contract	new contract
Activity domain	broad	broad	broad	narrow	-	broad	-	-
Risk domain	broad	broad	broad	narrow	narrow	broad	narrow	narrow
Man'ment arrangement	ALT & AMT	ALT & AMT	ALT & AMT	ALT	-	ALT & AMT	-	-

The risk and activity domains are classified as either narrow or broad. These are qualitative indicators that do not reveal the actual contents of the shared domain or the pain/gain clause(s). Recollection of past discussions, and other contingent evidence, indicate that two dominant and conflicting logics may have emerged over time. On the one hand, a formulation is found in the documents that explicitly proclaims the extension of the pain/gain sharing domain to its “reasonable maximum”. On the other hand, contingent evidence indicates an implicit preference to limit the shared domain to that “considered strictly necessary”. The latter is demonstrated in the move towards sharing only specific risks. The dominant logic underlying the first formulation seems to follow the logic of alliance goal alignment: the greater the shared domain, the fewer conflicts of interest may be expected. The latter's dominant logic seems to be driven by defence and risk avoidance. A reconstruction of this shifting logic suggests that the reasoning was as follows:

- Transfer risks to the party that can best manage them, but:
- If that party has only limited influence on a specific risk, then the client will not benefit much from transferring that risk;
- In such situations, perhaps the risk is more manageable when the client and the other party have a common interest in avoiding or managing that risk;

- A common interest is best stimulated by including pain/gain sharing arrangements.

The dynamic created between the “domain maximizers” and the “domain restrictors” perhaps holds clues to the evolutionary development of the alliance method.

Table 2: Results of Step 3

Explicit motivations for alliance initiative:	#1:	#2:	#3:	#4:	#5:	#6:	#7:	#8:
Cost reduction	✓	✓	✓	✓	-	-	-	-
Tight time constraint	✓	-	-	-	-	-	-	-
Flexibility in development	-	-	-	-	-	-	-	✓
High quality	-	-	-	-	-	-	-	-
Innovation required	-	-	-	-	-	-	-	-
Earlier commencement	-	-	-	-	-	✓	-	-
Economizing on resources	-	-	-	-	-	-	-	-
Source of learning	-	-	-	-	-	-	-	-
Enhancing reputation	-	-	-	-	-	-	-	-
Improving competitive advantage	-	-	-	-	-	-	-	-
Dispute avoidance	-	-	-	✓	-	-	-	-
Improving non-cost outcomes	-	-	-	-	-	-	-	-
Project complexity	-	-	-	-	-	✓	-	-
High risks	✓	-	-	-	✓	✓	-	-
Complex stakeholder issues	-	✓	✓	-	-	✓	-	-
Complex external threats	-	-	-	-	-	-	-	-
Other ...	-	-	-	✓ <sup>a</sup>	-	-	-	-
Explicit motivations for alliance change:	NA	Not found	✓ <sup>b</sup>	Not found	Not found	✓ <sup>c</sup>	Not found	Not found

a) Stimulate cooperation over seven specific problem areas, b) No added value for contractor as NOP, c) Direct PA tender requires reference changes; maximize alliance domain.

The purpose of this first quick scan was to assess whether it would be possible and worthwhile to study the implicit reasoning behind the evolutionary development of the alliance project delivery method. The initial results indicate an increase in the number of alliance projects taking place and variation in their key characteristics. Further, the reconstruction of the motives involved suggests implicit reasoning in the decision-making process and possible contradictory dominant logics. Changing the implicit reasoning to using an explicit logic would provide the necessary basis for evaluation purposes and enable the further development of project alliance variations. As such, the conclusion is that the mooted second research phase can be considered worthwhile.

## REFLECTION

The reported study is still in its initial stage. The concepts developed are not yet sufficiently precise and the data gathered are not on the scale and detail needed to satisfy the overall aims of the research project. Nevertheless, the findings provide some interesting initial results and insights.

The selection criteria used in Step 1 led to eight projects that - at least at first glance - can be considered to be project alliances. However, the choice of 'formal contract' and 'real gain-share/pain share' as the selection criteria appears somewhat crude and a bare minimum. The literature offers several other contractual criterion options in the form of informal or non-contractual aspects, e.g. trust, long term commitment (Yeung et al. 2007) or cultural differences between traditional and alliance projects (Reed and Loosemore 2012). However, the application of additional criteria would probably have led to the selection of fewer projects. Some of these criteria can, and probably should, be used in a later stage of the study as evaluation criteria. The "soft" (relationship-based) criteria in particular might be viewed differently by the shared domain "maximizers" and by the "restrictors".

The selection method employed did identify alliance projects, but excluded those projects in which a project alliance was considered but then rejected as the delivery method. These projects would be valuable in research aiming to uncover the dominant motivations and expectations. As such, the selection strategy rejected relevant data and data sources. A broader study of tendering board minutes and early stage project reports might be a first step in identifying such data.

Similarly, in Step 2, additional variation characteristics could have been considered. The limited number used in this study was sufficient for the purpose of confirming the initial assumption of there being variations among the alliance applications. The distinctions between activity and risk and between narrow and broad are crude categorizations. As the study progresses, these need to be elaborated and developed.

Step 3 identified a number of potential motivations for alliance projects. The study of formal documents showed that the choices made over the alliance method are either apparently "different per project" or "seldom explicitly motivated in the documents". This is indicative of the implicit nature of the reasoning in selecting a procurement method. Planned interviews will probably add more information and insight enabling one to reconstruct the reasoning behind the choices made for specific projects. However, this might not be as successful as one hopes due to selective memory and biased hindsight regarding many projects. Longitudinally observing project teams as they decide over a delivery method might reveal a clearer picture of the logic and reasoning used.

Further, the 'standard' motivations derived from the literature could be elaborated and sharpened. For instance, 'cost reduction' might be anticipated through several factors such as greater efficiency, fewer conflicts and better design optimization. Attributing documented project motivations to items on such an extended list would probably require less interpretation.

The dominant logics reconstructed in Step 4 are, at this stage, plausible rather than definite. They require confirmation of the implicit reasoning and potentially conflicting stances that drive the evolutionary process towards variation in alliance project delivery methods.

Although still in a preliminary stage, this study seems to confirm that ProRail is following a trajectory, as identified by authors such as Lahdenperä (2012), towards project delivery methods that are more collaborative. Although this trend is visible in terms of frequency of alliancing applications, remarkably the alliance collaborative domain seems to be narrowing.

## CONCLUSIONS

It was fifteen years ago that the Dutch railway agency (ProRail) first opted for the alliance project delivery method. Since then, at least seven other alliance-based projects have followed. Recently, a four-year study has started to evaluate the alliance delivery method as practiced by ProRail. The first steps of this four-year project are described in this paper: the approach, the initial data and the preliminary results. Based on a literature study, “pain and gain sharing” was identified as a way to distinguish project alliances from other procurement methods. An assessment of the eight so-identified project alliances and their characteristics shows that several variations of the concept have been applied. Alongside the basic characteristics such as size, date and contract type, particular attention was given to the alliance collaborative domain, and this was assessed in terms of activities, risks and management structure. A literature study identified potential motivations for using alliance project delivery. A review of documents related to the eight identified ProRail projects revealed that the motivations for changing the alliance approach with specific shared domains were seldom explicitly stated. A reconstruction of the reasoning seems to point towards there being two implicit dominant logics regarding the scale of the shared domain: one that reasons for “maximizing the shared domain to align the interests of the client and the contractors” and one that reasons for “restricting the shared domain to reduce the client’s risk”.

Already, the initial stage of this study has produced insights and contributions that are relevant for other scholars. The paper explains a strategy to distinguish alliance projects from other delivery types, introduces an initial rationale, based on a typology of the shared domain, for mapping variety among alliances, hints at opposing logics regarding the shared domain and provides an overview of potential motives for opting for an alliance form of contract. The paper also develops a prototype theory concerning the evolutionary development of the alliance method. Practitioners considering alliance project delivery could use these early results to reflect upon their motives and logics regarding the shared domain and pain/gain structures.

In terms of the objectives of the four-year research project, this initial step confirms it is possible and valuable to explicate the implicit evolutionary development of the current alliance method and to use the results to work towards more deliberate planned choices in determining future alliance forms.

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# **INNOVATIVE USE OF ECC (NEC3) FOR PROCUREMENT AND MANAGEMENT OF INFRASTRUCTURE PROJECTS WITH LIMITED FUNDING: BERVIE BRAES CASE STUDY**

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In this case study from Scotland, we demonstrate a successful use of the benefits of the NEC3 contract in a situation when only limited project funds are available. Following an action research (AR) methodology and aiming at maximising the value for the Client and the general public from the available funding, an innovative approach was devised and used during the procurement process of a £3 million infrastructure project for stabilisation of a high coastal slope with residential properties at risk from potential instability. Environmental protection, natural disaster risk management, as well as sustainability in the built environment featured highly on the Client/Consultant procurement/design agenda with public participation throughout the duration of the project. General, fixed, and variable items in the Activity Schedule, as well as an alternative Activity Schedule, enabled the Client to control and direct spending on the project based on the risk analysis and design management by the Designer. This approach offered flexibility to the construction Contractor in terms of selecting methods, materials and labour that will ensure positive balance between profit and costs. Practical problems stemming from the innovative approach encountered during the construction process are discussed in the light of contract management strategies and use of the same approach in the future. The management of health, safety, and environmental risks before, during, and after the construction, as well as the sustainability benefits from the innovative approach are also discussed.

Keywords: procurement, research method, risk management, sustainability, value management.

## **INTRODUCTION**

Public procurement has been utilized as an important tool for achieving economic, social and other objectives (Arrowsmith 2003), as it is possible to reduce project capital cost through selection of a most appropriate procurement method by an average of 5% (Gordon 1994). A number of problems with procurement have been

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reported recently where the projects had to be abandoned or suspended (Hansford 2013). Procurement method used and the type of client procuring the project had an effect on the project success, especially with traditionally procured contracts (Masterman 2002; Conlin et al 2012).

It is the responsibility of the client to use the funding, however limited, to provide services based on their procurement policy and management requirements. While the procurement policy requirements normally include economic goals (e.g. “more for less” or “lean” procurement), environment protection or “green” procurement, and social goals, the procurement management requirements normally include inter alia quality, timeliness, financial and technical risks cost (more than just the price), minimizing business, maximizing competition, and maintaining integrity (Cox and Townsend 2009). The relative importance of the objectives' and the trade-offs between the requirements, as well as the lack of skills and knowledge (Bowen et al 1997) make it difficult for the policy makers and public procurement practitioners to efficiently manage infrastructure project delivery.

Procurement selection process evolved from the early models (Building EDC 1983), through multi-attribute decision analysis (Chan et al 1994), analytical hierarchy process models (e.g. Al-Tabtabi 2002), fuzzy set theory models (Ng et al 2002), computer-based expert systems (Brandon et al 1988), screening process modelling (Alhazmi and McCaffer 2000), to computerised decision making tools based on case studies (Luu et al 2003, 2005), none of which have been widely adopted in practice (Chan 2005). Recent advances in procurement research include foci on team relationships and communication, detailing the role of the client, project success in relation to different components of the procurement approach, risk allocation, and the impact of environmental and sustainability issues on the procurement process (Morledge and Smith 2013).

One of the main options for procurement of engineering works in the public sector is the New Engineering Contract (NEC). Developed in the UK in 1993, it has become widely used internationally, especially since its 3rd edition, NEC3, was published in 2005 (NEC3, 2005). The main difference from the other standard forms of contract is the link that NEC3 provides between the standard contractual subjects and a project management scheme which relies on strict planning/programming, deadlines, and notices but also rapid decision-making. The main concepts underlying an NEC3 contract are the stimulus to good management through detailed programming requirements, flexibility, and the adoption of spirit of mutual trust and cooperation through successful management of project events by engaging contract parties in a problem-solving dialogue throughout the project (Shaw, undated). The proper use of the contractual mechanisms by the contract parties should mitigate the problems often associated with the traditional procurement routes (Conlin et al 2012) and decrease the risk which is often the prominent criterion that determines the selection of a procurement method (Love et al 1998). However, the challenge for the contract parties is twofold: a major investment in the management resources required to meet the contractual demands, and the need for swift and effective decision making.

Academic research in applied disciplines such as infrastructure engineering and management is aimed at contribution to the solution of practical problems while creating theoretical and conceptual knowledge. In the past, the research methods in these disciplines have predominantly been quantitative surveys (e.g. Luu et al 2003) or case studies (Luu et al 2005) or AI studies (Lewis et al 2011), leaving a gap in the

knowledge of research methodology (Azhar et al 2010). In this paper, action research (AR) methodology, demonstrated through application in a case study, is proposed as an answer to this knowledge gap and theoretical framework behind the subjective and, in many cases, intuitive judgement underlying the management of large, and especially projects with combined technical contextual complexity (Luu 2003).

The aim of this paper is to demonstrate the successful use of the benefits of a NEC3 contract for a project with limited funding through a case study following an AR approach. The objective is to improve the future procurement and construction management practice by implementing the approach and rationale presented in this paper on projects in similar circumstances.

## **METHODOLOGY**

Action research (AR) is an inductive approach to investigation, attempting to solve real-life problems and improve professional practice (O'Brien 2001), where the researchers are involved as co-practitioners in the research setting. It involves systematic observations and data collection which can be then used by the practitioner-researcher in reflection, decision-making, and the development of effective practical strategies (Lewin 1946, Parsons and Brown 2002). The aim of AR is to contribute both to the practical concerns of people in an immediate problematic situation and to simultaneously enhance learning and knowledge on the phenomenon under study. The commitment in AR is dual: studying a system while collaborating with system members to change the system in in what is jointly regarded as a desirable direction. Accomplishing this twin goal requires the active collaboration of researcher and client and, thus, it stresses the importance of co-learning as a primary aspect of the research process (Gilmore et al 1986).

The difference between AR and the general professional practice or consulting is the scientific approach where the researcher/co-practitioner studies the problem systematically, ensures the action is informed by theoretical considerations, refines the methodological tools to suit the problem situation, while collecting, analysing, and presenting data on an on-going, cyclical basis.

AR methodology has been employed in various engineering environments (e.g. Mejia et al 2006, Azhar 2010) and is quoted as the most practicable methodology for creating environments that foster coordination and collaboration among engineering groups (Mejia et al 2006,). Different research tools, generally common to the qualitative research (case studies, journals/diaries, document collection and analysis, participant observation recordings, questionnaire surveys, and interviews) can be used for AR as the project is conducted. As these methods coincide with the prerequisites and perceived benefits from the use of NEC3 family of contracts and some procurement methods (e.g. Luu et al 2005), it was considered that the AR would be an appropriate methodology to study the application of NEC3, as long as the principles considering the ethical considerations in the conduct of AR (Winter 1996) were observed.

AR methodology was used in this project, despite the perceived lack of impartiality of the AR team (O'Brien 2001) that may lead to bias in the research. To minimise personal bias in the reflective conclusions, the action research methodology was supplemented by case study research to provide descriptions of the phenomena/problems encountered and carry out an in-depth investigation. It is considered that the combination of these two research methods contributes towards

improved collaborative engineering and improved decision-making (Luu et al 2005) which are basic concepts of NEC3 (NEC3, 2005). The experiences presented in the following case study follow the structure of the AR model, describing an identify–plan–act–observe/reflect cycle (Figure1) after a brief introduction to the case study where the context and background are presented.

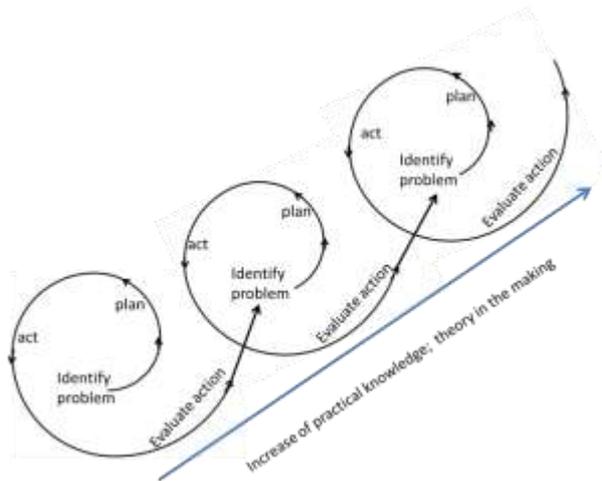


Figure 1. Action Research cycle and application for improving the practical knowledge. (Adapted from O'Brien 2001).

## CASE STUDY

### Background:

Bervie Braes is an infrastructure project for stabilisation of a 700 m long, 30 m high coastal slope overlooking Stonehaven harbour with the residential properties at the toe of the slope at risk from potential instability. The slope had a history of instability with a number of landslips and soil mass wasting events documented in the last 80 years resulting in the closure of the trunk road bisecting the slope for the past five years due to safety concerns. The closed road and the slope footpaths are still used by residents and tourists for recreational purposes. The slope is owned by a trust that transferred their rights and responsibilities to the local authority (Aberdeenshire Council, the Client) as the owners of the former trunk road. Following a landslide in 2008, the Client appointed a Consultant (Jacobs UK Ltd) who, through forensic analysis, intrusive, and non-intrusive ground investigations developed a number of specimen design options for stabilisation. Client and Consultant (C+C) also developed an Emergency Action Plan for management of the risk of future instability of the slope. The general public, as users of the slope, was involved in the investigation process through Public Consultation Meetings and voted for the most acceptable specimen design solution. Based on the voted solution, the Consultant was commissioned to deliver detailed design, procure the stabilisation works, and manage the construction works.

Acknowledging the main constraints and challenges to the project delivery: limited funding, environmental protection of the slope, and the social goals such as minimising the risk for the residents at the toe while maintaining the recreational value of the slope, the Consultant assembled a multi-disciplinary team, obtained planning permission for the proposed works, and delivered the detailed design within three months from the date of the commission.

The tender, based on ECC Option A, was abandoned after the tender returns indicated estimated values above the available budget and the Client, due to the regulations for public bodies, could not negotiate on the offers.

**Problem identification:**

Reflecting on the design and procurement process as well as on the ramifications of abandoning the project, the C+C team identified the procurement of stabilisation works within the limited budget, while providing value to the Client and slope users as a problem. Workshops involving C+C team concluded that, due to the risk for the residents and potential liability issues for the Client, abandoning the project is not a viable option. Jointly (Winter 1996), the C+C team decided to adopt an AR approach and investigate new ways of procuring and constructing the stabilisation works. Areas for potential action implementation were identified in the design and procurement process and funding mechanism.

**Planning:**

Driven by the need for minimising total costs and providing value for the Client, the Consultant envisaged changes in detailed design which, while minimising the import of material for construction (mainly steel) and wastage, would require a change in contract documentation (performance specification) and closer supervision. The consultant considered that these changes would provide net savings of up to 20% of the overall budget. Changes to the funding mechanism and overall budget could not be identified, and the Client accepted the possibility of partial completion of the envisaged works. Based on this, the Consultant mapped the stability risks for a number of sections of the slope and agreed with the Client that the drainage works and the re-vegetation of the slope are of the highest priority and will have to be carried out in full to minimise the risk of surficial stability and erosion of the slope, as well as increase the environmental and sustainability benefits for the slope users.

The Consultant prepared a detailed procurement plan and programme based on the experiences from the original tender process, i.e. previous learning cycle. The C+C team agreed on action to implement the potential savings identified at planning stage, and change the procurement to fit with the overall budget available and minimise the residual risks. Additional step towards minimising the residual risks of slope instability was taken with the installation of a remote ground-water monitoring system (cost: 0.5% of the total budget) which would be used in the interim period between the tender and re-tender for the safety of the residents but available to all contract parties (Winter 1996) during construction for the safety of the construction workers and residents alike.

**Action:**

To take into account the risk-based stability approach and procure the largest amount of stabilisation works for the available funding, the Activity Schedule was divided into General Items (GI), Fixed Works items (FWI), and Variable Work items (VWI). The GI covered the preliminaries and Contractor's site supervision. The FWI covered the stabilisation in the slope sections where either the slope stability was inadequate and/or the risk to the residential properties was high (the 'must have' stabilisation works). The FWI also included the drainage and revegetation works for the whole slope identified as essential with long-term benefits to the stability of the slope. The VWI covered the stabilisation of the other slope sections listed in the order of

decreasing risk, i.e. the sections at highest risk of slope instability and/or risk to residential properties would be stabilised first.

Apart from minor changes in the Works Information, the other changes in the procurement documentation included the added flexibility to the contract through the use of any savings identified during the construction works for procurement of additional works from the VWI list. This, together with the explicit statement of the overall budget, was seen as a motivation for the contract parties to provide value engineering in order to increase the amount of work commissioned and was emphasized on the tender clarification meetings and interviews which, in turn, were implemented with the aim of creating a process that maximizes the opportunities for involvement of all participants (Winter 1996).

Performance, rather than detail, specification was adopted for a number of FWI and VWI in order to motivate the Contractor to provide competitive tender and ensure a suitable profit margin while demonstrating value engineering to the Client which would satisfy Client's procurement policy and management goals.

The tender assessment process was also modified to allow emphasis on the quality of work offered within the budgetary constraints. The tenderers were asked to provide separate Quality and Financial submissions, allowing the C+C team to assess and score the Quality submission first. The Financial submission was assessed only for the tenders that passed the predetermined quality threshold (Chan et al 1994). The contract was awarded to the tenderer who passed the quality threshold, offered to complete the FWI and the greatest percentage of the VWI within the tender value.

### **Reflection:**

The new tender attracted more attention with 9, including non-UK, contractors expressing an interest. The pre-qualification process placed an emphasis on the experience of the contractors with the works of similar technical difficulty and contractual terms which eliminated 30% of the interested contractors. 50% of the contractors invited to tender, did not pass the quality threshold set to ensure the proposed construction methodology and management comply with the financial and environmental restrictions. The tender was jointly assessed by the C+C team and awarded to the contractor who provided the best value within the contractual constraints.

The action undertaken - modifications in the procurement process - resulted in commissioning of stabilisation works in the most unstable areas of the slope (approximately 45% of the total slope area), as well as works for other areas of the slope with lower risk which amounted to structural stabilisation of more than 60% of the slope area, and preventive measures (new/improved drainage and re-vegetation) installed for the entire slope. This compares with the option of abandoning the project due to budgetary and contractual constraints if the action had not been implemented. Apart from the action taken, the critical decision that ensured the success of the re-tender was the Client's acceptance of the risk of limited works scope of due to limited funding and adoption of AR approach in the re-design and procurement.

The re-design recorded savings of 505 tCO<sub>2</sub> through reducing waste, re-use of materials, reducing transportation costs, optimization of material usage, phasing of operations, providing environmental and social value, and performance specification. The overall recorded savings for the project throughout the design and procurement

phases were approximately £2.8 million, achieved through design optimisation and value engineering, which compares to the £2.4 million construction cost.

The C+C team showed that there is a desire and motivation to innovate and see new solutions developed to accommodate budgetary constraints in infrastructure contract procurement which is often quoted as a constraint to the procurement (e.g. Conlin et al 2012). This project showed how the investigation into the potential of innovations in both procurement and slope stabilisation resulted in a set of experiences structured in such a way that lessons learned were an opportunity to improve further similar experiences and to improve the knowledge on NEC3 application. The obstacles which were encountered during the original tender, such as time constraints due to statutory obligations of the Client or the delivery of the detailed design by the Consultant, were dealt with in a more timely and rational manner during the re-tender due to the experience from the original tendering process.

Collaborative working, identified as one of the main concepts of NEC3, was achieved during the AR cycle through interviews, workshops and questionnaires but also through regular summary and progress reports in recordable format which is another of the cornerstone concepts of NEC3. The involvement of experienced professionals who can make engineering judgements (Masterman, 2002; Hansford 2013) and keeping detailed records of the changes allowed for rapid decision-making and timely estimation of the financial and time effects on the project for the PM. The re-tender, including the re-design and planning for risk between the tenders, was delivered for 30% of the cost of the original tender. This cost was spread over eight months due to the early action to re-tender and the environmental constraints preventing the start of the works.

Critical to the success of future projects adopting this approach would be the understanding of the client's culture and philosophy and critical (self)assessment of the capabilities and contractual responsibilities of all parties to the contract (Bowen et al 1997). It is important that the client recognises their own strengths and limitations, identify skills gaps and more importantly implement an improvement programme (strategy) before considering the adoption of alternative procurement methods.

## **DISCUSSION**

The applied action resulted in an outcome that satisfied Client's procurement policy and management goals (Bowen et al 1997, Thai 2001), and the C+C team considered that the application of NEC3 with the approach adopted in this study can help deliver successful projects in the right circumstances (Conlin et al 2012).

However, the action resulted in a number of practical challenges for the construction phase which were considered in further AR cycles and are summarised below:

### *Providing appropriate supervision:*

the technical requirements of the re-designed solution required closer supervision by the Supervisor who, through planning and flexible resourcing, had to provide value for the Client but also the necessary coverage of the concurrent operations on the 2 ha large site.

### *Motivating the Contractor:*

being explicit about the nature of the research process from the beginning (Winter 1996) through a number of meetings and workshops, the C+C team detailed the design rationale and the contract philosophy that any savings to the project identified during construction will have to be recorded, and additional works from the VWI

procured to the value of the identified savings during construction. The value of savings identified during construction was 3% of the total project budget and these were translated into additional stabilisation works from the VWI, covering additional 5% of the slope area.

*Planning and programming:*

The working programme agreed at the start of the process and updated on a monthly basis, together with the regular progress reports and open communication through meetings and workshops between Consultant, Client, and the tenderers were important reasons for success of the re-tendering process. The biggest challenge, however, was to motivate the Contractor to involve sufficient resources in planning of the site operations to match the flexible nature of the contract without breaking the spirit of trust and cooperation. The lack of understanding of the importance of construction programme and the absence of punitive mechanisms under NEC3 contributed to extended time needed for completion.

*Implementation of the NEC3 requirements in an AR framework:*

The AR team treated the Early Warning notifications as problem identification sheets and achieved efficient problem solving with involvement of all parties in the decision making process. This resulted in 48 Compensation Events during construction, with 30% of them resolved within a month after being identified, 50% after 3 months, and 20% within 6 months.

The perceived benefits of the approach that may help future application include: Delivering more for less: limited budget projects could adopt this approach in conjunction with risk-based design to deliver better value for client and public while encouraging competition and ensuring profit for the Contractor.

*Reflective process:*

Through recording and reflection on the actions the project participants are able to learn from experience in a practical and methodical way. The benefits of NEC3, combined with AR approach allow the AR team to identify key issues at each stage of the project by using working methodologies leading to improvements of the project through collaboration and support of engineering activities.

*Sustainability:*

Identification and recording of potential savings throughout the project should be used for motivation of all contract parties on the account of additional works that will be procured for the value of savings identified. "Green" certification that can improve the track record of the parties can be used as a motivation strategy.

*Development of collaborative engineering and improvement of praxis:*

AR approach aims to generate knowledge about social systems as well as attempting to change these (Hart and Bond, 1995). This approach could be a vehicle to enable practitioners and researchers to collaborate in their efforts to improve the real world of practice, including contract procurement and construction management.

The emphasis of the future application of this approach would be on ensuring the service providers have a relevant proven track record in embracing the NEC3 culture and providing value for the Client. Increasing the speed of information (Tseng et al 2003) would enable collaboration and interaction among the contract parties during the pre-construction and construction phases of the project regardless of their locations and incorporation of information and tools in accordance with the project activity (Mejia et al 2006) or contract conditions. However, all parties would have to

invest in adequate programming/planning resources to cope with the potential expansion of scope and degree of concurrency of construction operations, which is already a prerequisite for successful application of NEC3.

## CONCLUSIONS

This study demonstrated that limited budget contracts can be procured using NEC3 contract incorporating Activity Schedule dividing the works into ‘fixed’ and ‘variable’ based on risk-based design approach also advocated in the literature (Morledge and Smith 2013). Our research showed that to implement this approach, all parties to the contract have to be motivated and engaged in identifying opportunities for value engineering and/or sustainability benefits. The success of this approach will depend on the level of investment in adequate programming/planning resources and tools by the contract parties (Addis and Talbot 2001) which do not have to be additional to the ones required under NEC3 (diaries, notices, communications) for recording the actions, reflection on them, and identifying new problems and challenges for action during the project phases.

Similarities between the basic concepts of AR and NEC3, make AR suitable methodological framework for improving the practical implementation of NEC3. Based on reflective experiences from this study, it is our opinion that collaborative working can be achieved through open communication and early assessment of the capabilities and contractual responsibilities (including risks; Cox and Townsend 2009) of all parties to the contract. This helped help not only in identifying motivational drives but also stimulated the management of the modified Activity Schedule.

We used AR approach in this study to create a process that maximizes the opportunities for involvement of all participants through questionnaires, meetings, interviews, workshops, notices, formal and informal communication. Most importantly, we used the records from the AR process to enable learning from experience and improvement of the professional practice which can be seen as a single stage of a case-based procurement approach (Luu et al 2005).

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# **PUBLIC PRIVATE PARTNERSHIPS: THE PROVISION OF HEALTHCARE INFRASTRUCTURE IN AUSTRALIA**

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The emergence of Public-Private Sector Partnerships (PPPs) provides a means for developing infrastructure without directly impacting upon the budgetary constraints of Government. Social infrastructure projects (schools, hospitals, prisons et al) are characterised as generally being smaller in scale than economic infrastructure projects (motorways, bridges, tunnels et al). However, by their very nature, social infrastructure projects also tend to be complex, particularly in terms of on-going involvement with the community. Thus, private sector bidders for social infrastructure PPPs are often presented with a situation where operational complexity, including government policy toward the sharing of revenue, is one of the key differences in whether PPPs are as attractive for social infrastructure compared with economic infrastructure. This research centres on how consortiums manage the many risk factors involved and the results are presented from a case study of a hospital PPP project. This paper presents the preliminary findings of the case study research and in particular focuses on the process for selecting the PPP consortium and the research methodology.

Keywords: Australia, healthcare, procurement, public-private partnership, social infrastructure.

## **INTRODUCTION**

Public private partnerships (PPPs) are long-term arrangements between public and private sector organisations for the provision of infrastructure involving allocation of project functions to optimise risk management and maximise value for money (Akintoye et al., 2003; Commonwealth of Australia, 2002). Contemporary PPP models emerged in the UK in the 1980s as a result of the requirement for improved infrastructure and the public sector's inability to meet demand within the confines of conventional financing methods (Watson, 2003; Commonwealth of Australia, 2002).

The first PPPs were for economic infrastructure such as major road projects, which provide an income stream either from user charges, or shadow tolls paid by the government for each vehicle, to the private sector operator (English and Guthrie, 2003; Tillman, 1997). This new method of infrastructure provision soon emerged in Australia where early PPPs included the Sydney Harbour Tunnel and Melbourne's Citylink Expressway, which are both toll roads (Grimsey and Lewis, 2002; DOTARS, 2002). PPPs in Australia are now rationalised by 'value for money' and this has led to

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the emergence of social infrastructure PPPs such as hospitals, schools and housing (NSW Government, 2000; Commonwealth of Australia, 2002).

In 2002, the New South Wales (NSW) Government identified over \$4 billion worth of emerging privately financed projects (PFPs) for the next four years, and in excess of \$13 billion of major project proposals worth over \$100 million, to be implemented over the next decade, including many social infrastructure projects (NSW Government, 2002; Allen et al., 2004). This projected growth presents a range of research opportunities, particularly for social infrastructure projects.

This paper focuses on risk management issues in a social infrastructure PPP project, i.e. the Newcastle Mater Hospital redevelopment, which has stimulated public debate stemming from considerable apprehension within the employee and community stakeholder groups, as the first health sector PPP proposal in the Hunter region. This paper presents preliminary findings of the case study project and focuses on the establishment and rationale for the PPP and discusses the research methodology used.

## **HEALTH SECTOR PUBLIC PRIVATE PARTNERSHIPS**

Public Private Partnerships (PPPs) are broadly defined as partnerships or financial arrangements between the public (Government) and private sectors for the purposes of implementing projects that have traditionally fallen within the remit of the public sector (McCann-FitzGerald, 2000; Akintoye et al, 2003; Walker and Hampson, 2003; Blake 2004; Jefferies and McGeorge, 2009). PPPs involve the sharing of responsibilities and the Australian Procurement and Construction Council (APCC) (2002) identifies government procurement through a PPP as involving the private sector delivering certain services for government and creating, financing, operating and sometimes owning any necessary new asset.

In the early years of Australian health sector PPPs, the contracts were predominantly adapted from the Build-Own-Operate-Transfer (BOOT) arrangement, whereby new hospitals were constructed and operated privately (Dowdeswell and Heasman, 2004). This strategy presented limited success and Australian governments have subsequently declared a commitment to provide the core services in social infrastructure, such as clinical services in hospitals, meaning that the roles filled by the private sector are generally support services (English and Guthrie, 2003; NSW Treasury, 2002). Tasks commonly transferred to the private sector in PPP developed hospitals include maintenance, catering, porter services, laundry, waste and other non-core services (De Lemos et al, 2003).

The Australian health sector is relatively inexperienced in PPPs, however, the contemporary approach has been developed based on international experience such as the Private Finance Initiative (PFI) in the UK (English and Guthrie, 2003). Australian state governments that have implemented health sector PPPs have had limited success, with certain projects being declared 'failures' by some factions. Three Australian healthcare projects that have been completed in the last 10 years are: Port Macquarie Base Hospital in NSW; Latrobe Regional Hospital in Victoria; and Berwick Community Hospital in Victoria.

Theoretical case analysis has been completed for these three healthcare projects. The main issues are summarised below and based upon the findings of Allen (2001); English (2004); Fitzgerald (2004); Abelson (2005); Hodge and Greve (2005); Chung (2008); NSW Treasury (2009); and Victorian Government (2010):

- early PPP's seem to have Governments focusing heavily on:

- transferring risk to the private consortiums
- undertaking development with what offers the lowest costs
- lack of due diligence by the public/private sectors which has seen the Government lose significant funds in having to buy incurred failures and debt
- for the transfer of risk, Governments seem to be paying excessive rates for services (however, the Government will bear the ‘ultimate’ risk if default or inadequate performance occurs and health services still need to be delivered)
- BOO type projects seem to:
  - have failed due to the private sector assuming/expecting to deliver services provided previously by the public sector more efficiently
  - be an affect of government policy of the time to transfer risk to meet ‘value for money’ benchmarks (for which they have not)
- the issuing by the Government of 99 year leases to the private sector even though the concession agreements may be only for 20-25 years seem to not be in the public's best interest
- the ‘build’ component of PPP procurement has been completed effectively on time and on budget
- risk transfer and assumptions needs to be better evaluated and analysed by both public / private parties
- accounting practices and the application of discount rates, providing consistency etc. for determining the Governments contract obligations need to be more rigorous and not be reliant on comparisons with the ‘PSC’
- management of applying best practice, disclosure and conflicts of interest
- Partnerships Victoria policy 2005 implemented in 2005 and providing additional guidelines known as the Standard Commercial Principles which outlined and identify risks and who maybe best able to manage them
- PPP BOOT-type arrangements seem to be more effective in the delivery of health services (subject to risk transfer) specifically with the Government delivering clinical services.

PPPs are increasingly becoming the preferred option for Government's to deliver a range of services in social infrastructure, particularly healthcare (Jefferies et al, 2007). According to Jefferies and McGeorge (2008), current government policy limiting risk allocation and the sharing of business operation is a restricting factor for private sector stakeholders in the development of a successful revenue stream. They also indicate that Social infrastructure PPPs have relatively higher bid costs compared to economic PPPs with only a marginal increase in business opportunity. The key to a successful project is the identification and allocation of risks to the best party to manage such risks during the tender stage (Jefferies and McGeorge, 2008; 2009). Therefore, with the partnership between the public and private sectors there must be a revised approach to the allocation of risks.

## RESEARCH METHOD

### A single case study approach

A qualitative single case study strategy was proposed in order to “*investigate a contemporary phenomenon within its real-life context*” (Yin, 2003, p13). The single-case rationale lies in the unique opportunity presented by the case study project and the limited number of healthcare PPP projects in Australia and in particular in the

State jurisdiction of New South Wales. The method initially consisted of a literature review that identified current theory regarding risk management of PPPs. Case study data collection then went on to firstly analyse project documentation which was used to establish project background information and establish the parameters for the interview component of the research. A semi-structured face-to-face interview format was then used and data analysed using a content analysis approach.

Yin (2003) describes two types of case studies, being exploratory and descriptive. “*An exploratory case study will be utilised to satisfy the objectives of the study*”. This was achieved through the interview process conducted with senior project personnel. A qualitative approach has been used as the main focus of the research to explore the ‘nature of inquiry into a human process’, i.e. the development of the risk management process at the tender/bid stage of a PPP project. Subsequently, the case study method adopted, supported by Yin’s (2003) research design, inspires researchers to produce an investigation of the utmost quality by following a set of four principles. The first principle is the need to examine a ‘case’ within its ‘real-life’ context; the second principle provides a platform for an appropriate methodology within the context of the research; the third principle concentrates on data compilation and analysis; and the final principle is that the researcher must explain the findings and establish conclusions that will lead to further the analysis of the topic.

A case study is an experimental investigation that studies a contemporary phenomenon within its real-life context (Waal, 2007). Yin (2003) highlights single cases as being used to confirm or challenge a theory, or in order to represent a unique or extreme proposition. As PPPs are a relatively new and unique phenomenon the multiple case study approach is somewhat irrelevant in this instance given the limited extent of social infrastructure PPPs such as hospitals.

### **Case study participants**

The selected project for the case study is the Mater Hospital, which is a current social infrastructure PPP project. The participating organisation, Lend Lease, was selected as they were the representative of the client (NSW Government) on the case study project (Mater hospital) and were instrumental in terms of developing the PPP risk and contractual documentation. Lend Lease staff interviewed as part of the case study project had significant experience with PPPs both on a national and global basis. These experiences range in varying capacities from representing both private and public sectors in providing initial expressions of interests to leading full tender preparation and evaluation of major PPP projects.

### **Data collection and analysis**

Case study data collection involved analysing project documentation, such as contract summary documents, to establish background information and establish the parameters for the interview component of the research. A semi-structured face-to-face interview format was then used and data analysed using a content analysis approach. The intention of the interview process was to focus on risk factors identified by key senior management involved in developing both the project’s risk profile and contract. To ensure this data was accurate and reliable, all participants must have played a leading role (e.g. Project Manager, Contract Manager et al) and have previous experience with PPPs and large-scale construction projects. The participant organisation then selected individuals to complete the interview process that aimed at capturing their perspectives on risk management approaches used in the project.

## THE CASE STUDY PROJECT: THE MATER HOSPITAL REDEVELOPMENT

### Project background

The New South Wales (NSW) Government in conjunction with the Department of Health developed an Action Plan for NSW Health incorporating key principles in to improve the state's health services. As described in Lend Lease (2002), the implementation of these principles by Hunter Area Health via the Hunter Strategy – an area wide strategic resource plan that promotes the effective management of the area's finances, people, information technology and physical assets, as well as the effective use of the resources of the private sector. Part of the Hunter Strategy is the Newcastle Strategy (Mater Hospital re-development forms 1 of 4 projects) and involves major new upgrade works initiatives by the NSW Government. These projects were to be originally procured under conventional arrangements from the Department of Health's Capital Works budgets.

Prior to the PPP proposal, the Mater was a functioning hospital. However, the buildings were out-dated and inappropriate for tertiary cancer services, emergency medicine and mental health. Many of the buildings were obsolete and it was the preferred option to redevelop the Mater as an integral part of the Newcastle Strategy.. There have been numerous studies over the past twenty years that have clearly established that many of the Mater's buildings are beyond, or are reaching the end of, their economical life (Lend Lease 2002, p18). Current ownership of the facility is held by the Little Company of Mary Health Care (as an affiliated health organisation) and the hospital continues to provide services to the community in the Catholic tradition. The Calvary Mater Newcastle has an agreement with the Hunter New England Health Service to provide a number and range of health services to agreed quality standards (NSW Health, 2004, p.7). These arrangements are completed under a Labour Services Agreement whereby public sector funding and public sector health employees (who remain public sector employees of the Hunter New England Area Health Service) are used for clinical purposes. Jointly, these 2 entities provide health care services at the Mater (Hunter New England Health Services, 2009, p2).

### The PPP process

From the initial concepts envisaged under the Hunter Strategy, a more detailed analysis was completed under the Newcastle Strategy and revealed a greater scope of works was required due to *“substantial upgrades and demand for additional services....which far exceeded the available public funding”* (Lend Lease, 2002). Due to the financial constraints with the existing deficiency in the NSW Health budget, the NSW State Government considered alternatives besides delivering a staged Mater Hospital redevelopment using the conventional Capital Works budget. In June 2003, the NSW Government entered into an agreement with the then owners of the Hospital site (NSW Health, 2005, p.3) for *“an Agreement for Lease and Initial Project Agreement for the Redevelopment of the Mater Hospital.”* This agreement established the parameters by which a redevelopment could be considered using private funding.

While no certainty on a procurement method had been decided, NSW Health had formulated through workshops facilitated in June 2010 by Lend Lease (the Government's procurement partner) a list of *“generic risks likely to be found in the design and construction of health facilities”* which were later defined within the Project Definition Plan. The process began in April 2002, when a preliminary risk

review was conducted and focused on *“the initial processes rather than later delivery risks and the risk review focused on the elements with higher level risk profiles”* (Hunter Health, 2002, Section 8, p.2) relative to development, management and delivery of the Mater Project. This process of risk identification was continued through an intensive stakeholder engagement process, with six (6) key risk area headings identified:

- Quality of service/Quality of hospital product
  - Timely delivery/Costs within budget
  - Disruption to hospital activities during delivery
  - Urban development
  - Equality and availability of opportunity
  - Information and consultation
- (Hunter Health 2002, p.3)

Following evaluation of the significant risks by the NSW Government it was considered in August 2003 that the hospital would be procured using a PPP. NSW Health (2004, p.3) has stated that the *“Project will be undertaken within the framework of the NSW Health’s ‘Working with Government Policy and Guidelines for Privately Financed Projects’ ”*. NSW Health, in establishing a commercial framework for the project, wanted to maximise the private sector’s role by transferring risks and allowing the consortiums to produce *“innovative design, engineering, operating and commercial solutions”* (NSW Health, 2004, p.3). The ideology of NSW Health appointing a procurement partner would assist in realigning its asset management objectives and still allow delivery of the aims of the Newcastle Strategy.

### **The proposed redevelopment**

The agreement between the NSW Government and the proposed private sector consortium involves over a project term of 28 years the financing, design, construction and commissioning of: new hospital buildings; refurbishment of the old Mater Hospital; transfer of local mental health services onto the site; and maintenance of buildings, car-parks and grounds, utility supply; and management services (operational services et al). In addition, the consortium will provide a range of ‘non-clinical services’ (security, catering, cleaning, general services et al) while managing public sector health employees (who remain public sector employees of the Hunter New England Area Health Service) under a Labour Service Agreement.

*The proposed revenue streams from the Government to the private sector are on a monthly performance based payment structure which begins when the hospital is operational. The payments relate to the finance (initial project capital investment); design, construction, & commissioning; and the maintenance and operation of the hospital including the management of the health sector employees. As stated by Lend Lease (2002, p.35), the “monthly service payment (subject to abatement for non-performance) is made up of volume adjustments (catering, clinical waste), energy payments, and additional payments (groceries, security guards)”*. The Mater Hospital is the first hospital in New South Wales to be built, maintained and operated by the private sector under a PPP, and is the largest provider of radiation oncology services in NSW (Infrastructure Partnerships Australia, 2009). The redevelopment will provide a 176 bed hospital, new mental health facility, and new radiotherapy facilities.

### PPP expression of interest/detailed proposals process

In October 2003, “*a Call for Expressions of Interest*” (NSW Health, 2005, p.3) by the NSW Department of Health occurred with 6 consortiums responding at the close in November 2003. An Evaluation Committee assessed the proposals on:

- design and construction experience;
  - facilities management experience;
  - structures, risk management and financial experience;
  - financial experience and financial strategies; and
  - by applying a ‘percentage weighting criteria’ to distinguish proposals.
- (NSW Health, 2005, pp3-4)

Three respondents were short-listed to present ‘Detailed Proposals’ with one withdrawing prior to the ‘Request for Detailed Proposals’. The ‘Request for Detailed Proposals’ was issued in August 2004 and in December 2004 two private sector consortiums had lodged bids. Assessment of the ‘Detailed Proposals’ by the Evaluation Committee was broadly based on financial, commercial, technical and services issues, legal and costs parameters (NSW Health, 2005, p.4) which were greater defined by the following criteria:

- design;
- construction and commissioning;
- service delivery; commercial;
- financial; and
- probity compliance.

(NSW Health, 2005).

Again a percentage weighting criteria was used to distinguish the proposals. However after evaluation of payment and risks, it was concluded that neither proposal had effectively established value for money to the Government. It was considered that negotiations should continue to improve the deficiencies within the proposals that had been provided to date, and the preferred bidder needed to satisfy several criteria with a specific focus on:

- Costs below those of the public sector comparator;
- Compliance with the project’s design requirements, as ‘represented’ by the ‘reference project’ and the project’s technical specifications;
- Compliance with the project’s services requirements, in its services and technical specifications; and
- An ‘acceptable’ risk position, documented in a draft Project Deed.

(NSW Health, 2005, p.6)

NSW Health and Novacare’s (one of the private sector consortia) preferred individual position was reviewed in relation to certain risks and whether that risk was considered high, medium or low to the Government. The re-evaluation of the proposals occurred in June 2005 under the same weighting criteria and in December 2005 it was publicly announced that contracts had been executed between the Government and the Novacare Consortium. NSW Treasury calculated that the Novacare proposal would provide a ‘net present cost’ saving to the Government of approximately 2% when compared to a traditional public delivered procurement model over the contractual PPP term. Novacare’s bid price of approximately \$378.8 million was exclusive of certain risks. Through negotiations with NSW Treasury, a \$1.7 million estimate of

those excluded risks was added to the price to allow a comparison with the Public Sector Comparator. As shown in Table 1, it compares Novacare’s contractual price (risk adjusted) against the ‘Public Sector Comparator’.

*Table 1: Value for money comparison between public sector and private sector project delivery*

Delivery method	Public sector comparator (PSC) (hypothetical, risk-adjusted estimate of the cost of the most efficient likely method of public sector delivery)			Private sector delivery (as Contracted)
	PSC best case (95% probability that PSC cost would be higher than this)	PSC likely case (mean of PSC cost estimates)	PSC worst case (95% probability that PSC cost would be lower than this)	
Estimated net present value of the project cost (over 28 years) to the NSW Health	\$384.1 m	\$388.7 m	\$393.7 m	\$380.5 m
Estimated saving through private sector delivery	0.9%	2.1%	3.4%	

As identified within the interview process with Lend Lease (Government’s Procurement Partner) the final contractual negotiations between the Government and the private sector consortium saw “*minimal changes to the risk profile*” to what the Government had previously established. As stated “*The Government’s preferred position ultimately was to allocate the risk to the party who would be best to manage that risk, and determine what proportion of cost was associated to accepting that risk by either party.*”

### **PPP Contracting Parties**

The Novacare Consortium is made up of the following parties: Westpac (Consortium Leader and Financier); Medirest (Soft Facilities Management); Honeywell (Hard Facilities Management); and Abigroup (Design and Construction Contractor). The contractual rights and obligations are specified within the PPP Project Deed. Project securities are based on the negotiated acceptances of risks on the design, construction, commissioning, provision of hospital operational services and finance of the PPP Mater project. Additionally, the Project Deed stipulates the requirements to manage, under the Labour Services Agreement, the clinical staff, the leases and cross leases, novation, certification and other project stipulated agreements.

### **CONCLUSIONS**

The objective of the Mater Hospital Case Study was to establish how ‘current industry practice’ is utilised by PPP consortiums in the assessment and evaluation of risks during the tender phase of a project. This paper presents the preliminary findings of the broader case study project and focuses on the PPP selection process. The NSW Government assessed procurement alternatives for delivering the new hospital (i.e. traditional public sector delivery or a PPP). Upon determining the procurement method as PPP, a scope was determined and this established a project term of 28 years for the finance, design, construction and commissioning of new hospital buildings, refurbishment of some existing buildings and transferring of mental health services to

the site. Clinical services were to remain the responsibility of NSW Health while non-clinical (building maintenance, grounds, security, cleaning et al) services were to be completed by the private sector. Payments from the NSW Government for services were based on performance benchmarks. Significant assessment was completed for design risk, construction risks, interface risks and hospital disruption, financial risks et al in order to determine the best 'value for money' proposal against risk transfer (using the Public Sector Comparator benchmarking model). Following a rigorous tender period, the private sector consortium bids were evaluated on financial, commercial, technical and services issues, and legal and cost parameters. Final contractual negotiations between the Government and the private sector consortium saw minimal changes to the risk profile to what the Government had previously established. Through the PPP process, NSW Treasury calculated that the Novacare proposal would provide a 'net present cost' saving to the Government of approximately 2% when compared to a traditional public sector delivered procurement model over the contractual PPP term. The next stage of the research is to analyse the data collected during the interview process that focused on identifying the project specific risk factors and how they were successfully managed.

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# **TIED SUPPLY CHAINS IN CONSTRUCTION PROJECTS: LESSONS FROM LONDON UNDERGROUND'S PUBLIC-PRIVATE-PARTNERSHIP**

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This paper addresses the lessons learnt by London Underground (LU), the public sector contracting authority, when a tied supply chain arrangement, namely where shareholders are also commercial beneficiaries from sub-contracted delivery, was utilised by a consortium to upgrade its system under an innovative Public-Private-Partnership (PPP) model. Research on tied supply chains and their application in PPP agreements is significantly under reported. The paper sets out insights from industry using secondary sources, which include parliamentary reports and reviews. The paper postulates that different models of tied supply chains might exist, from those that rely on some form of equity structure to those that rely only on the collective reputation of the supply network. Five lessons learnt from the contracting authority's perspective are highlighted on the use of tied supply chains in PPP contractual arrangements. Whilst tied supply chains can be effective, they are better utilised in PPP contractual arrangements where there is certainty with the scope of works and required resources. During the bid evaluation stage the contracting authority must evaluate whether prospective bidding consortiums have satisfactory governance arrangements at Board level and across its tied supply chain. Furthermore, the contracting authority must include governance safeguards within the contractual documents and strictly regulate the tied supply chain to prevent failure. This paper provides a new insight into tied supply chains and their governance with respect to Public-Private-Partnership models, and other forms of procurement.

Keywords: governance, procurement, public-private partnership, tied supply chain.

## **INTRODUCTION**

Public Private Partnerships (PPP) were introduced into the United Kingdom (UK) in the Conservatives' autumn 1992 statement, once privatisation of public sector assets had been exhausted (Gannon 2006). In the period 1992 to 2009, PPPs in the UK accounted for approximately £65bn worth of capital expenditure (HMT 2010a), represented 67% of all European PPPs by number (899 projects) and 53% by total value (Kappeler and Nemoz 2010). The UK's extensive use of PPPs has been primarily motivated on political-economic grounds (Gannon and Smith 2010). The most complex and controversial PPP undertaken globally was the partial privatisation of London Underground (LU).

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LU's £15bn PPP was shrouded in controversy, attracting significant opposition from The House of Commons Transport Select Committee, Greater London Authority's (GLA) Mayor Livingstone, leading academics and industry think tanks (Gannon 2006, 2010). The then Labour government, who initiated LU's PPP funding policy in March 1998, steered the project through multiple project reviews and two judicial reviews, eventually signing two contracts with the Metronet consortium and one with the Tube Lines consortium (Gannon, 2010). Four years into the contract Metronet's performance had been heavily criticised by the GLA's Transport Committee (GLA 2007) and in July 2007 went into administration with assets reverting back to the public sector a year later. Metronet's inadequate governance structures and tied supply chain arrangements were reported by the NAO (2009) as the main cause of failure. The subsequent collapse of Metronet resulted in an estimated loss between £170m to £410m to the UK tax-payer; and £540m to consortium shareholders (NAO 2009).

Traditional buyer-supplier governance forms for projects, based on adversarial relationships that emerge from competitive tendering, are often deemed to be wasteful (Eriksson, 2010, Hartmann and Caerteling 2010). Development of a governance structure, supported through appropriate mechanisms, for dynamic and temporary construction supply chains has led to governments' trialling different approaches. One innovative approach for government sponsored public projects is the development of self-regulating networks of organisations governed through rules they fix to achieve common action which also determine responsibilities and commitments of the individual company (Dunn-Cavelty and Suter 2009). Tied supply chains are an example of a self-regulating network established by the private sector in response to the government's requirement to deliver major investment in the UK's infrastructure. Tied supply chains are defined as a network of shareholders who are also the main suppliers to a project (NAO 2004). In a PPP context, this can occur where the equity shareholders of the consortium are the main suppliers 'tied' into receiving and delivering works to the contracting authority. This structure introduces a hierarchy into the tied supply chain, those that are equity shareholders and those that are bound by commercial gain linked to their own and supply chain reputation. In practice tied supply chains have merits in delivering efficiencies, security of supply, price certainty and knowledge retention for a traditional PPP.

Christopher (1998:19) defines an integrated supply chain as a 'network of connected and interdependent organisations mutually and co-operatively working together to control, manage and improve the flow of materials and information'. Integration is the extent to which separate organisations work together, in a co-operative manner, to derive mutually acceptable outcomes (O'Leary-Kelly and Flores 2002). Within an integrated tied-supply chain the network consists of interdependent and interconnected organisations acting both as suppliers and buyers working towards a common outcome. The danger is that governance structures involve judge, jury and executioner arrangements within the same umbrella organisation. In this context, the Special Purpose Vehicle (SPV), set up to act as the overall co-ordinator of the supply chain in a PPP, and typically involving some form of equity sharing amongst key stakeholders that will also be delivering the work, acts in the form of a supply chain broker (Male 2005). Hence, there are potential conflicts of interest inherent within this model, in that the SPV acts as a surrogate client of the supply chain, who it in turn has both selected and won the contract on the basis of the networks' collective reputation. Additionally, it can also be argued that a tied supply chain occurs where a collaborative form of procurement arrangement sets up a network structure under a

Framework arrangement. Here, the collective reputation of the supply chain, when chosen by a ‘supply chain leader’ or ‘supply chain broker’ (Male 2003) and who determines those firms included or excluded from the network, creates potentially different models of tied supply chains. For example, one type of model could exist where there is some combination of equity structure and collective reputation; through to another model that relies only on the collective reputation of the supply network, and where the lead supply chain leader or broker wins work under repetitive bidding structures such as a Framework arrangement on behalf of the supply chain. The key issue is the nature of what constitutes the tied element, for example, collective reputation for commercial gain, equity relationships alone, or a hybrid, together with the duration of that relationship – short, medium or long term. It can be argued that Prime Contracting creates a form of reputation-based medium-term tied supply chain, whereas PPP creates a reputation and equity based long-term tied supply chain relationship where return on investment, commercial gain and reputational risk are important drivers.

Literature relating to tied supply chains and their application within a PPP context is significantly under reported. This paper addresses this gap through a combination of industry insight and the empirical investigation of the experiences of LU, the contracting authority, across an innovative tied supply chain structure implemented by the Metronet consortium. The paper closes with final observations and concluding remarks, also postulating an embryonic model for understanding tied supply chains.

## **LONDON UNDERGROUND’S PUBLIC-PRIVATE-PARTNERSHIP**

### **Background**

Two infrastructure contracts (BCV and SSL Infracos) were awarded to the Metronet consortium in April 2003 and one contract (JNP Infraco) awarded to the Tube Lines consortium in December 2002. The contract term was 30 years with three periodic reviews every seven and half years overseen by the PPP Arbiter; and was expected to attract £15.7 bn of investment over thirty years to LU with £9.7 bn (2002 prices) in the first seven and half years (NAO 2004). The PPP contract between LU and the Infracos (Infrastructure Companies) was comprised of a performance (bonus/penalty) payment mechanism to incentivise contractor performance. LU was charged an Infrastructure Service Charge (ISC) in return for a service delivered by Infracos. The PPP Arbiter, established under the GLA Act 1999, had a role to give direction and guidance on the price of work and disputes arising between contracting parties during each of the three review periods (PPP Arbiter 2010).

### **Metronet’s Tied Supply Chain Model**

The Metronet’s legal, commercial, organisational and supply chain delivery structure was complex. First Metronet’s Rail Companies comprised of two holding companies Metronet BCV and SSL Holdings Limited, each in turn comprising leading construction and construction-related firms each with 20% equity shareholdings: Atkins, Balfour Beatty, EDF Energy and RWE Thames Water. Second, each holding company had three further subsidiaries: Metronet Rail BCV/SSL Finance Limited, Metronet BCV/SSL Rail and Metronet Rail BCV/SSL Intermediate Limited. Third, Metronet effectively operated as a tied supply chain, comprising of Balfour Beatty, Atkins, Bombardier, EDF Energy and RWE Thames Water; and with each firm having a 25% equity shareholding (Atkins 2006). Finally, the Trans4m Alliance comprised Balfour Beatty, Atkins, EDF Energy and RWE Thames Water each with equal shareholdings (Atkins 2006).

Metronet Rail BCV/SSL was the main company through which refurbishment works were undertaken. Contract supply was arranged on an asset group basis: Rolling stock and Signalling supply delivered by Bombardier Transportation using a lump sum supply contract, Track with Balfour Beatty Rail Projects using a Schedule of fixed rates and the Trans4m Alliance was setup to deliver Station and Civil refurbishments using a target cost supply contract (Atkins, 2006). It is evident from these arrangements Metronet had not only a very close interconnectedness between firms that are equity partners / shareholders but also had responsibilities for ongoing service provision during the delivery phase.

### **Operational Performance**

During the First Review Period Metronet's operational performance was reported by the GLA's Transport Committee as being mixed (GLA 2007); and it had during this period awarded itself 60% of the contract's capital expenditure (PPP Arbiter 2006). Whilst rolling stock was operating successfully under a tied supply arrangement, track replacement and station and civil works operated in a situation where the tied supply chain was not effective. The main reason was that the rolling stock and signalling contract had an output based specification and certainty with the scope of works. Track, on the other hand, had variable volumes of work, with stations and civil works having input based specifications, but were less certain in terms of scope since asset condition was open to considerable uncertainty.

## **LESSONS LEARNT**

Metronet's delivery response to LU's PPP contract outlined earlier utilised a tied supply chain, from which five lessons can be learnt. These will be discussed further below.

### **1. Strict governance arrangements are essential across all the tied supply chain.**

Metronet's governance and leadership was reported as being poor, leading to inappropriate risk management and financial control across its tied supply chain (NAO 2009). Governance was particularly poor in the Trans4m alliance, dominated by shareholders who were suppliers for station and civil works. Decision-making power lay with the suppliers, demonstrating conflicts of interest, rather than with the Board of Metronet Holdings, who also lacked the independence, and, continuity at senior executive levels (NAO 2009). Halldorsson et al, (2007) have argued that tied supply chains conform to network theory as the interacting companies 'adapt their processes and systems to each other' to achieve the goals. However, Metronet's governance arrangements prevented its Board from capturing the issues that arose within its own tied supply chain, as conflicts of interest surfaced with suppliers, and, in the delivery of a complex programme of works in the first review period. Furthermore, the Department for Transport's (DfT) governance arrangements were also criticised for their 'hands off' approach to LU's PPP arrangement HMT (2010b).

### **2. Ensure alignment of public and private objectives.**

The tied-supply chain governance model reflects a self-regulating network of organisations working towards a common, government-explicitly stated goal (Dunn-Cavelty and Suter 2009). However, Metronet's shareholders and its tied supply chain were not aligned with the objectives of LU and the PPP Arbiter. This lack of alignment in the supply chain was evident from deficiencies of reporting and the expected programme for upgrade of assets and performance specified within the

contract. The PPP Arbiter reported that the information from the Metronet consortium was not sufficiently detailed and had significant weaknesses. The main areas outlined by the Arbiter concerned delivery and cost information, and, explanations for variances related to claims (PPP Arbiter 2006). This deficiency of information further suggests difficulties in the review and management of the tied supply chain.

### **3. Necessity of benchmarking costs to assess future value for money.**

The tied supply chain was criticised for its failure to deliver to a market discipline expected by a PPP (NAO 2009). By limiting the supply of services to the tied supply chain members, this created an inward looking consortium focused on achieving its financial returns rather than the efficiencies anticipated through a PPP mechanism. This, in turn, limited their ability to benchmark their own prices with a competitive market place and provide value for money to LU. This was in stark contrast to the Tube Lines consortium that tendered the majority of its works competitively.

### **4. Selecting the right contractual model.**

LU's PPP contract was a combination of an output-based specification for rolling stock and signalling; and, input-based specifications for track, stations and civil works. Whilst the rolling stock and signalling contracts worked relatively well under Metronet's tied supply chain arrangement, it was unfortunate that track, stations and civil work did not. LU's PPP was unlike traditional PPPs where the scope is clearly specified and asset condition is known. Whilst security of supply is cited as one of the main advantages of the tied supply chain for the consortium and contracting authority, Metronet's tied supply chain was constrained by changing obligations in the case of stations and changing volumes of work in the case of track. A PPP contractual arrangement should not be used where a significant amount of the scope of work is unknown namely, the condition of the asset base, and especially on a large operation and complex environment such as LU's metro.

### **5. Verify and validate bid assumptions.**

Two assumptions were made about Metronet by the PPP bid evaluation team that proved to be incorrect: shareholders within the consortium would prevent 'rogue behaviour' within the tied supply chain; and second, Metronet's lenders would enforce an effective financial discipline if required (TfL 2008). The public sector no longer has the technical ability to precisely define, contractually control and monitor ever increasing complex infrastructure projects. In other words, its informed or intelligent client role had a number of deficiencies (Aritua et al 2009, Aritua et al 2011). Further, this places considerable pressures early in the process on public sector organisations using this form of procurement approach (Aritua et al 2009). The Public Accounts Committee (PAC) added that the 'DfT was naive to expect lenders to exert strong oversight of Metronet's governance and financial health to protect their investment', especially when the UK government guaranteed 95% of lenders' risk (HMT 2010b). It is clear Governments do not have the specialised skills or resources required to ensure the level and degree of control necessarily for such complex undertakings and have to rely on external advisors (Dunn-Cavelty and Suter 2009). Retained in-house government knowledge to support the informed client role becomes very problematic.

## **OBSERVATIONS AND CONCLUDING REMARKS**

The paper has advanced knowledge on the structures and implications of a tied supply chain in the context of PPP arrangements. As a consequence, and taking account of other procurement strategies existing within the construction industry, it has also

proposed that different models of tied supply chains can exist in practice. One example occurs where a network of suppliers are tied together in the form of an equity shareholding as in the case of a PPP arrangement, and, where those same shareholders are also responsible for delivery. A second example occurs where a network of suppliers are tied together to work within collaborative procurement structures, and, where the network jointly bids as a supply chain under a Principal Supply Chain Leader that secures longer term work for the supply chain through Framework arrangements. This exists in the case of the Defence Estates Prime Contracting (Defence Estates 2010) or National Health Service ProCure 21+ Frameworks (NHS 2010). These types of Framework Agreements typically exist for some 3 to 5 years. Whilst they are not a guarantee of work for the tied supply chains in the Framework, there is an underlying assumption that the commercial integrity and success of the supply network relies on the collective reputation of the network. Equally, there is not an associated equity structure in place. This is an example of non-equity based tied supply chain working within a strategic partnering structure. A third example, and similar to the second, occurs where a network of suppliers agree to bid for work on a project-specific partnering arrangement (Bennet and Jayes 1998). There is again a 'reputational consensus' that in bidding for the work a particular composition of key supply chain partners within the network, operating under a lead 'supply chain broker', will have a greater chance of winning than the competition. In contrasting the three examples, the first relies in the long term on both the equity structure of the tied supply chain, and a reputational and appropriate commercial governance structure. The second relies on a reputational consensus within a medium term commercial relationship but with no equity structure in place, whereas the third relies on the same principles but it is for a much shorter duration.

Whilst tied supply chains can be effective for contractors and suppliers they are more appropriate for contracts where scope of work is certain and resource levels are known. They lack, however, flexibility, and, are not appropriate where asset condition is unknown or there are changing volumes of work. The tied supply chain in a PPP context requires strict regulation and legislation to enable an Arbiter to enforce governance and delivery. Furthermore, robust corporate governance arrangements need to be in place across the supply chain, especially where there are equity shareholder and delivery inter-relationships to the fore. There is also a strong argument to suggest that if government reduced its level of guarantees considerably this would force stronger governance structures within the PPP arrangement. Finally, the contracting authority needs to include safeguards within the contractual documentation and ensure bids are compliant with these requirements.

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# COLLABORATIVE PROCUREMENT: AN EXPLORATION OF PRACTICE AND TRUST IN TIMES OF AUSTERITY

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Despite authoritative calls for an increase in collaborative working and partnering practices, recent austerity is causing many companies to move back towards traditional competitive procurement routes. Clients may feel the only way to assure themselves that they are not paying too much is to market test their projects in a highly competitive environment. Organisations may feel vulnerable opening themselves up to partnering and collaborative practices during a time of uncertainty, and are reluctant to take unnecessary risks. This study seeks to explore the effects of the recent economic downturn on collaborative working, with particular emphasis on manifestation in practice and the positioning of trust within such relationships. Eight interviews were carried out with senior industry professionals, all experienced in partnering and collaborative working practices. Austerity was found to have influenced collaborative practices in industry at both individual and organisational levels. Individuals have responded with a quest for job security which has in turn developed risk-averse work practices and affected the establishment of short term collaborative relationships. Organisations have returned to traditional competitive procurement methods, seeking to reduce risk in their practices and maintain control in uncertain times. Sceptical considerations of collaboration have re-emerged; the abuse of collaborative relationships for financial benefits, employing austerity as leverage, have become contemporary legend if not fact. Perceptions of collaborative working have shifted within the austerity context, and there is the potential for industry to lose ground gained before the recession in the development of collaborative practices. Further research is recommended to examine the repercussions of this shift in both practice and philosophy, as austerity-born projects come to completion.

Keywords: austerity, collaboration, integration, partnering, trust.

## INTRODUCTION

Despite perceived advantages, collaborative working practices within the construction industry are still relatively rare (RICS 2007:27), and appear to have become more so during times of austerity. The RICS Contracts in Use Survey (2012) found that partnering contracts during 2010 accounted for only 0.9% of all contracts by value, compared with 6.6% in 2004 and 15.6% in 2007, a trend which could be attributed to the recent UK economic crisis.

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It is felt by some clients that open and competitive procurement systems, that truly market test prices, are the only way to assure stakeholders of lowest possible initial capital cost (Ross 2011); and in this economic context, 'partnering has not lived up to expectations' (Gadde and Dubois 2010: 26).

This study seeks to explore, the concept of trust during austerity in collaborative working and partnering arrangements (Kaluvarachi and Jones 2007). Trust is considered in the literature to be an essential element in successful partnering. The terms 'partnering' and 'collaborative working' are used interchangeably within this paper, referencing a wider philosophy of trust, fairness and equity, rather than specific details of practice.

## **LITERATURE REVIEW**

### **Perfection through Procurement**

Partnering and collaboration have long been championed as the future of the UK construction industry. Latham (1994) sought to 'Construct the Team' and was heavily critical of traditional procurement and contractual routes, largely due to the lack of coordination between construction and design. He suggested a change in culture and a move to partnering to increase fairness, encourage teamwork and enhance performance through collaborative engagement of clients and design teams with contractors (ibid 1994:50).

Egan (1998) saw early establishment of construction teams as an essential aspect of co-operative construction, with contractors able to contribute to management, buildability, health and safety, procurement and supply chain management of projects. It was thought that such early collaboration reduces disputes, reduces tender costs and improves team working practices (ibid 1998:20).

More recently, the benefits of collaboration have been argued to include an increase in profits brought about by sharing expertise, knowledge, ideas, innovation, best practice, and promoting efficiencies and improvements in decision making (Hansen and Nohria 2004:35). Collaborative working has also been suggested to reduce the negative aspects of construction procurement, minimising conflicts and disputes through increased cooperation, and developing relationships built on trust (Larson 1997).

Government support for partnering and collaborative thinking was championed by the Strategic Forum for Construction in the 'Accelerating Change' report (Egan 2002). Projects that had applied the principles of both Latham and Egan in the use of collaborative procurement methods were found to achieve significant improvements in client satisfaction, cost predictability, safety, and time predictability. Yet partnering and collaborative procurement has also attracted its critics. The RICS (2005:2) have argued that successful experiences in collaborative procurement '... are largely anecdotal and focus on the experiences of exemplar organisations.' A similar argument was presented by Morgan (2009:9), formerly procurement director at BAA, who concluded that with major capital projects, procurement routes that promote alliances and partnerships are not always appropriate, being vulnerable to abuse given the scale of the commercial interests involved. Furthermore, partnering projects do not guarantee success, and clients may be paying far too much for their products.

### **Trust as a Collaborative Necessity**

There is an argument that when companies enter into highly complex, uncertain and potentially risky projects as relative strangers, it is not surprising that frequent conflicts and disputes arise in traditional procurement systems (Chan et al 2004: 230). Partnering and collaborative approaches seek to avoid conflicts and disputes by increasing levels of co-operation and developing organisational relationships built on trust (Larsen 1997). It is however recognised that such approaches do not provide guaranteed mechanisms for the development of trust (Marshall and Bresnen 2000:230), and the complexities of developing trust in a single combined operational entity through collaboration are vast. Trust is likely to be dependent on a number of factors, including social interaction, power, identities and expectations. In project teams, individuals may inherently have varying propensities to trust and be trusted (Walker 2009: 158).

The degree of trust between key members of teams has been identified as a critical factor in shaping relationships between all project team participants, as well as a key influence in project outcomes (Walker 2009). Gadde and Dubois (2010:256) referred to the concept of 'the relationship atmosphere', determined by the 'balance of collaboration', encompassing constructive elements such as commitment and trust, as well as negative elements such as power and conflict. Kaluarachi and Jones (2007:1053) also found that communication, trust, change in mindset, and commitment of participants were all major factors in developing successful and innovative partnering agreements.

Morrell (2011) argues that greater co-ordination is needed in the preparation of project documentation to encourage partnering, buildability, standardisation, prefabrication and collaborative working in the pursuit of value for money. Yet in order to enable the communication and sharing of knowledge necessary for fully-integrated practice, trust between supply chain members, from clients to the smallest SMEs, is a fundamental requirement. Through development of their propensity to trust theory, Briscoe and Dainty (2005:230) identified a potential lack of desire amongst specialist supply chain partners to trust their more powerful main contractor partners. They report that specialists have negative experiences in sharing information and prompt payment initiatives, leading to organisational mistrust.

The quality of collaboration can be reinforced or weakened, depending on the behaviour, approaches and attitudes of both organisations and individual participants (Coulson-Thomas 1990:179). There is heavy reliance on relationships within teams, but in practice the time needed to nurture these relationships, is often lacking in construction management procurement systems (Walker 2009:140). The literature suggests that trust is a vital factor in the development of successful partnering and collaborating working practices.

### **Potential Problems for Collaborative Procurement: Trust in Times of Austerity**

The project-based nature of much construction work can be seen as a fundamental barrier to the development of trust in practice, where relationships are perceived to be short term, and true collaborative working practices struggle to emerge (Walker 2009). Furthermore, a perceived 'loss of control' has also been identified as a barrier to collaborative working. There is a concern that sharing of knowledge results in loss of knowledge, adding to a more general uncertainty (Thurairajah et al 2006:7). Such managerial uncertainty is unlikely to encourage new collaborative working

arrangements during a time of economic doubt; austere times suggest a return to familiar and trusted traditional procurement systems.

Reliance on the known and controllable has previously been identified within industry as a symptom of a 'negative culture', sceptical and suspicious of new initiatives. It has been argued that these old behavioural aspects, cultures and attitudes are so deeply embedded in the construction sector that they are proving difficult to change (Thurairajah et al 2006:7). For partnering approaches to be more attractive to clients, they must seek to address problems of cultural indifference, old stereotypes and adversarial views of team members alongside new ways of working being established (Liu et al 2004). Yet it is unlikely that an economic downturn will provide a suitable context for such paradigm shifts in practice. Indeed, the RICS (2012) have suggested that partnering is not compatible with an economic climate of recession; lowest capital cost becomes politically more important than long term best value measures. Research studies have found some clients commonly fixate on obtaining lowest bid price rather than best value (Beach et al 2005).

When partnering is used, there may on occasion be an abuse of power by clients towards main contractors, or main contractors towards their supply chain, to 'squeeze ... too hard' (National Audit Office 2001:62). In times of austerity the desire to squeeze can become a necessity, challenging the benefits of the partnering relationship. Indeed, one of the most prolific barriers to increased collaboration could be psychological; clients who seek to prolong strategies associated with market leverage and power, achieve lowest price, rather than best value, and increase supply chain competition (Findings in Built and Rural Environments 2005:2). This view could also apply to the relationships between main contractors and subcontractors, where the 'buyers' dictate to the 'sellers' the terms of their employment and what is required of them (Mathews et al 2003:167).

In the sense that collaboration is ideally for the long term, and over multiple projects, economic conditions may dictate that clients cannot commit too far ahead. The constraints and challenges for many clients, make partnering a problematic aspiration, and they are forced to limit themselves to mere single project awards (Mason 2006:5).

## **METHODOLOGY**

In order to further explore collaboration and partnering within a contemporary period of economic austerity, and also examine the role of trust within this context, a qualitative study was undertaken (Flick 2009). This approach enabled the exploration of key themes, understandings and attitudes of those who work within this environment on a daily basis.

Semi-structured in-depth interviews (Gillham 2005) were held with eight construction professionals from different construction industry disciplines; an architect, quantity surveyor, project manager, main contractor, subcontractor, property lawyer, mechanical and electrical engineer and a structural engineer. A purposive sampling strategy was employed, selecting professionals with experience in partnering and collaborative working practices. However, beyond these two criteria, the sample was one of convenience. Whilst the small sample size does not allow for generalisation, it does provide insight into the perceptions of those working within the construction industry during the economic crisis, and their understanding of trust in collaborative working. Consultations were carried out to plan and formulate the format and structure for the interviews. A 'pilot' interview was conducted to obtain feedback on

the data collection tool, and tease out any difficulties with the way it was designed and administered.

The interviews were undertaken in a period of austerity; late 2012 to 2013. They were digitally recorded, transcribed verbatim and subsequently coded and sorted (Silverman 2001; Langdridge 2005). Examples of the main qualitative codes included informal engagement, closer interaction and good team working whereas examples of the main themes included factors that instil trust and potential barriers to collaborative working. As recommended by Taylor and Bogdan (1998), the raw data was summarised in tables; codes were listed, themes developed, content analysis data presented, key literature sources identified, data consistencies and inconsistencies noted and propositions made. The tables became a plan to develop a narrative to construct a contemporary picture of partnering and collaborative working in austere times. Due to constraints of space in this paper, the narrative has been interwoven with its discussion, to contextualise the findings of the study.

## **FINDINGS AND DISCUSSION**

### **Challenging the Philosophy of Collaboration**

Collaboration is based on trust, equity and fairness. A shared ethos between partners is essential for collaborative success, and all these philosophies should be embedded in aligned organisational strategies (Thurairajah et al 2006; Bresnen and Marshall 2000). However, whilst supported theoretically, rarely is there realisation in practice. Participants reported that partnering has been tainted by inequitable working arrangements which give little or no benefits to partnered organisations.

The disparity of power between clients and other organisations has allowed the former to take advantage of collaborative arrangements to serve their own organisational needs; arrangements for sharing have become significantly one-sided. Some organisations take advantage of austerity to bully partners further down the supply chain; they use the power derived from scarcity of work elsewhere in the economy to use a 'take it or leave it approach'. The abuse of power to secure organisational gains at the expense of others, appears to have become too much to resist. A shift in philosophy during an operational partnering framework renders organisations highly vulnerable to exploitation as they are virtually held to ransom; to accept revised or reduced terms, or be cast back into a cut-throat market place. Such exploitation through partnering frameworks increases the risk of this procurement option, reducing its attractiveness and contributing to a reduction in willing partners.

However, one practitioner attributed his survival in the current economic climate to collaboration in the widest possible sense, sometimes undertaking work without payment, sharing expertise and providing information, introducing contacts and working at risk without formal appointments being in place.

### **Austerity in Practice**

Although collaborative working potentially creates a less antagonistic and stressful working environment, facilitating better individual performance, and subsequently better team and project performance, it is still met with scepticism. Suspicion of realisable benefits as claimed emerge; for example, cost savings for clients from collaborative working are perceived to have become exaggerated over time. Further, partners lower down the supply chain provide anecdotal evidence of where they have suffered financially. Such 'ghost stories' reinforce fears and anxieties over risks within

the industry, and promote a reluctance to move away from traditional working methods.

Indeed, a continued reliance on experience and the familiar appears to be providing comfort; competitive tendering and traditional procurement have been the norm for many years (Mason 2006). In periods of insecurity and uncertainty, it may simply not be the right time to implement new practices that are relatively untested. This fear of the unknown can also be related to the personal uncertainty felt by construction professionals, unwilling to take risks. Job security and 'playing safe' in times of austerity may be influencing procurement practices.

The perceived lack of financial benefits or incentives to move towards collaborative practices appears to have grown in influence. A short term focus either remains, or has returned to those who embarked on collaborative strategies, favouring contract award through lowest bid price, rather than exploring other criteria which may enable the development of long term collaborative relationships. Initial capital tender costs are seen by some clients as most important, irrespective of the fact that there are many authoritative claims that low bid costs lead to higher final accounts and poor life cycle value. Indeed, as suggested by the RICS (2012) and Morgan (2009), short term commercial interests override the principles and perceived benefits of partnering. As the economic climate puts financial strain on many construction organisations, the management of cash-flow and financial accounting becomes ever more focused.

Other work practices were also felt to have been affected by austerity. The potential for clients to provide a continuous supply of work (Mason 2006) has become more problematic, again minimising the potential implementation of partnering in practice. Resources within organisations have become stymied; investment in CPD, training programmes and systems designed for integration with other partnering organisations has significantly reduced, restricting developments towards more collaborative processes. This has been felt most in the context of Building Information Modelling (BIM), which requires investment in technology and participation in new systems to support collaborative project teams.

For collaborative practices to succeed, a cultural shift is required (Thurairajah et al 2006), and BIM has been put forward as the necessary catalyst. Yet embracing cultural change and engaging in further training, investment and CPD is presently not high on the agenda. Organisations, and the individuals who work within them, are facing an uncertain future. Industry may not feel the time is right to embark on new initiatives and methods of working practice whilst insecurity looms large.

### **Trust within the Austere Context**

Trust is considered vital for the integration of teams and individuals in the development of collaborative working practices, as suggested by the literature (Latham 1994; Egan 1998; Larson 1997). A 'culture' of trust allows projects to move forward effectively, and creates an environment where problems can be shared and therefore solved more easily. Where trust is lost, working relationships can become untenable. However, trust is not something that can be engineered through contractual conditions, nor through procurement routes alone, but needs to be developed, built up and earned over time. The developmental nature of this process aligns with the long term vision of partnering and a procurement framework approach to construction, yet it is now challenged by austerity. The return to short term contracts and the constant quest for lowest initial bid price inhibits the development of trust between organisations.

However, where long term organisational collaboration is a potential future work-stream, the development of trust within such relationships becomes 'incentivised' and consequently active in practice. Strategic, rather than project partnering is felt to be more desirable, especially on a cluster of many projects of short duration. It is therefore suggested that trust can be generated within encouraging contexts. Potential long-term work in times of austerity needs to promote the development of personal relationships and support collaborative working.

The importance of trust was also found to be influenced by organisational position within the wider project team. Within design team-client relationships, trust was considered to be vital and fundamental to project success, however in client-contractor relationships this was less important. Clients' and contractors' roles are considered to be diametrically opposite, and whilst partnerships and collaborative working relationships are desirable, they do not guarantee profit or even survival. Abuse of trust, depending on position within the project hierarchy can lead to abuse of practice. Client and design team changes are expected to be absorbed in budgets in 'the spirit of collaborative arrangements'. This is another perspective to be considered in the challenges of partnering and collaborative working.

One individual was critical of the development and employment of trust within the wider organisational context. Either positively or negatively, communications, commitment, confidence, teamwork and personalities of individual team members were all found to be important elements in the building of trust in organisational operations, as suggested by Walker (2009); although the strength of trust is more dependent on individual personal relationships, developed from mutual respect, rather than simply 'good' working relationships. Austerity has further influenced personal relationships, as individuals become more focused on their own individual situations, rather than wider organisational concerns, reflecting growing uncertainty (Thurairajah et al 2006). Trust generated from previous relationships and dealings and between individuals at senior levels is regarded as critical in the cascading of trust throughout organisations, and between those currently operating partnering arrangements. An integrated project team needs to communicate well and operate within an environment of trust, leading to 'an upward cycle of trust' (Cheung et al 2003).

At an operational level, 'human' factors such as integrity, honesty, consistency, reliability and competency are regarded as important in facilitating good collaborative working. Such factors are suggested by Thuraujarah et al (2006) and Cheung et al (2001) as vital for the greater integration of project teams, providing the right environment for partnering to succeed. Yet, hard factors are also put forward as crucial in the partnering process: experience, technical ability, education and competence of individuals, management systems, resources, and commitment of the organisations. For partnering to succeed, in the contemporary climate, the development of trust needs all the help it can get.

### **Effects of austerity on Collaborative Procurement**

The study revealed for the most part that although trusting collaborative working relationships are desirable, they will not guarantee profit margins and survival in a very difficult and competitive economic climate. Partnering could disadvantage lower levels of the supply chain, especially when dealing with more powerful partners. In certain circumstances partnering arrangements allow clients to 'bully' contractors into accepting unfair returns under the banner of a collaborative arrangement. Members of

the supply chain at higher levels may lead their partners to financial loss on some projects.

Reinforcing the views of Mason (2006) the study confirms that competitive tendering and traditional procurement have been the norm for many years. As such, in times of austerity when there is much insecurity and uncertainty, it may not simply be the right time to be engaging in new practices that are relatively speaking still not properly tested. There is a fear of the unknown and some construction professionals are not prepared to take the associated risks. Job security and 'playing safe' in times of austerity may override the adoption of collaborative working practices.

The research findings support the view of Beach et al. (2005), Oyegoke et al. (2009) and Wolstenholme (2009) in that professional development, education and training, operational and cultural change and commitment to continual improvement would be required if partnering, in austere times especially, is going to succeed in the future. Along with the recommendation of Morrell (2011) this could also bring cost savings to the industry in terms of buildability, standardisation, prefabrication and value engineering. Organisations are still looking to the short term and favouring selection of lowest tenders rather than looking at other criteria which may promote long term collaborative benefits.

The study also found that the current economic climate is putting a financial strain on many construction organisations and this is particularly the case with smaller consultants, main contractors, and subcontractors. Findings indicate that this could be adversely affecting the deployment of resources and affordability of initiatives linked to embracing partnering and collaborative working philosophies. The study also finds that smaller organisations may not be investing in CPD, training programmes and systems designed to integrate with other partnering organisations. This argument is consistent with the findings of Dainty et al. (2001) which suggests that there is sometimes reluctance from organisations and individuals to expend time and resources in developing collaborative relationships, especially when affordability is an issue.

## **CONCLUSIONS**

The current economic climate appears to have significantly influenced the trust element in collaborative procurement. Collaboration appears to have been undermined from a number of positions. From the perspective of individuals, job security has become paramount, influencing choices made within work practices, and leading to reluctance to take risks. From an organisational perspective, collaborative working is no longer an attractive prospect in uncertain economic times. Long-stated, sceptical arguments against partnering have gained credibility as tales of abuse in organisational relationships and the trust on which they are based, have emerged. A return to traditional competitive practices has been driven by perceptions that partnering is expensive; there is a need to assure lowest possible price at bid stage.

Austerity appears to be incentivising some to deploy market leverage to achieve lowest price tenders. Long term best value is less important. This not only hinders, but potentially abuses the development of collaborative working. Clients are trying to 'squeeze' contractors, and, in response, contractors are seeking profit through commercial claims and variations, and by squeezing lower levels in the supply chain.

A return to traditional practices offers psychological security and appears to focus on what matters most in austere times; money. Yet this is a very short term perspective,

and a lack of investment in collaborative training and innovations such as BIM could result in missing the industry's next major technological shift in practice.

Collaborative procurement may be perceived as a risky alternative to traditional competitive tendering, and logically, it is unlikely to be launched by clients as a new initiative in austere times. Given that austerity is forecast to last by some commentators for a decade or more, and many clients who have previously practiced collaboration are reverting back to market testing through open and competitive traditional bidding, it is possible that the market share of collaborative procurement systems, based on trust, will fall further into decline. However, BIM may be the initiative that 'keeps the collaborative procurement flag flying'? More research is recommended to explore the approach to collaboration in current market conditions, and to examine the emergent issues over a longer time period, when the consequences of the shift back to traditional procurement processes has begun to impact on the success of projects.

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## **PROJECT MANAGEMENT**

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# "ALL THAT FUSS, JUST FOR SOME BLOODY BADGERS?" THE POLITICS OF WILDLIFE IN INFRASTRUCTURE CONSTRUCTION

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Across many construction projects, and especially infrastructure projects, efforts to mitigate the potential loss of biodiversity and habitat are significant, and at times controversial. In our paper we do not propose to gauge the success or failure of this effort; rather we are interested in fleshing out some conceptual approaches via Actor-Network Theory through which infrastructure projects can start to address a series of overlooked questions. Some of these questions are firmly located within the realm of construction project management: are animals considered project risks or stakeholders; is wildlife always simply a retrospective cost to a project or can it proactively benefit a project, can we ever manage wildlife, and if so how? These questions in turn lead us to engage with wider debates found in the margins between the social and biological sciences on the distinction between Nature and Politics: to what extent should we seek a place for animals in politics and how can we live with them ethically. Thus far, very little research has addressed the interplay of humans and animals within construction projects. Instead those interested in the politics and ethics of human-animal relations, or Animal Studies, have focussed far more on stable and contained sites, whether organisations like zoos, farms or laboratories, or other places like homes and parks. These largely ethnographic studies inevitably perhaps downplay the unplanned, unexpected and highly politically and ethically charged collision of hitherto rather separate human and animal geographies. Yet, as we argue here, it is often along such colliding spaces, where animal geographies are unexpectedly found at the heart of human projects, that we ask and answer many of the above questions around our respect and response to both animals, and indeed other humans. In this paper we will examine such encounters conceptually, with reference to two infrastructure projects, and discuss their relevance to both construction project management and broader work on the politics of animals.

Keywords: human-animal interaction, actor-network theory, infrastructure, environment impact assessment

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## INTRODUCTION

Construction activity can be extremely disruptive or damaging to animal habitats and wildlife itself. This is particularly the case for infrastructure projects, where anthropogenic effects can often be amplified by the scale and nature of the activity, as well as the long-lived legacies of the assets that they create. Whether this damage relates to the disruption of natural environments, or to the displacement of animals within their natural settings, the consideration of environmental impacts now ranks amongst the most important decision criteria governing infrastructure development, and efforts to mitigate damage to natural habitats are increasingly central to investment decisions in such projects. It is surprising, therefore, that the agency of animals and their habitats have not been studied more extensively within the construction project management field. Indeed, with a few recent exceptions (Sage et al. 2011; Tryggestad et al. 2013) there is a paucity of work which has examined the interaction between human and non-human animals in construction projects. This is despite the burgeoning interest in other nonhumans in construction projects (see Bresnen and Harty, 2010), especially as influenced by Actor-Network Theory (ANT). The need for such research is further underscored by the tendency within the interdisciplinary animal studies field to largely ignore surprising encounters with animals around the construction process, choosing instead to examine sites where animals are more or less deliberately (ab)used, such as farms (Evans and Miele, 2012), zoos (Davies, 2000), laboratories (Greenhough and Roe, 2011) and homes (Wolch et al., 2000).

Extending the scope of this strand of work to the field of construction, we mobilize an ANT derived perspective to examine how non-human animal spaces and places are often, and unexpectedly, found at the heart of human infrastructure projects. By focussing here on such encounters, we shed light on the extent to which humans can anticipate the agencies of other animals, as well as practical concerns about how wildlife habitats and infrastructure might exist alongside each other before, during and after the development process. In doing so we critically examine the extent to which wildlife can (and perhaps should) be seen as stakeholders to infrastructure projects, and the consequences of both failing to, and of accommodating, their habitats through the development process. Singer (1975: xiii) suggested the linguistic boundary between humans and all other animals is based simply on cultural arguments. Biologically, humans are a species of animal. Thus, we will occasionally seek to remind the reader of this point, to problematize such cultural categories. But first, we address how the presence of animals is systematically (mis)framed within infrastructure projects: the Environment Impact Assessment (EIA) process.

## ANIMALS AS RECEPTORS IN ENVIRONMENTAL IMPACT ASSESSMENT

The infrastructure sector has a long history of accounting for the environmental impact of its activities. The legal enforcement and effectiveness of the field of Environmental Impact Assessment (EIA) to encourage a detailed consideration of the impact of all manner of human activity on both natural and human environments, is increasing throughout the world (Tullos 2009). Originally developed in the United States in response to the National Environmental Policy Act 1969, there are now over 100 different legally-supported applications of EIA in operation globally (Wood 2003: 1). The EIA process was legal mandated across Europe in 1985, through the

implementation of Directive 85/337/EEC (amended in 1997, 2003 and 2009 - now all codified in 2011 under Directive 2011/92/EU). The importance of EIA has been provided with additional impetus in recent years under the Corporate Social Responsibility agenda (CSR), not least given the reputational damage incurred by contractors who failed to account for wildlife habitats in road construction projects (see Murray and Dainty, 2009). With the growth in major infrastructure investment the importance of such assessments is set to grow in the foreseeable future.

Although the prevalence of EIAs can be seen as a positive development in many respects, there are some key concerns with regards to the extent to which the needs and agencies of animals and their habitats are accounted for by such processes. While the emergence of the EIA can be seen as generally positive to the mitigation of environmental damage, there has been a tendency to see wildlife, and their habitats, as passive 'receptors' of development, rather than an influence on, or a stakeholder to, construction and development. Indeed, in UK the term 'receptor' is now in popular use across professional bodies (RICS, 2013), charities (FOE, 2008), industry (BP, 2002) government (SNH, 2013) and academia (Morris and Therivel, 2009). The term 'receptor', rather than that of 'stakeholder', is more or less exclusively used to refer to wildlife and their habitats. No doubt part of the explanation for this erasure of non-human agency is the recognition that any EIA is always deeply rooted in a specific political context, and that political or economic factors will often outweigh environmental concerns (Wood 2003: 3). Indeed, the act of developing an EIA is never politically neutral, and can yield actions which fully acknowledge negative environmental effects of infrastructure development. Recent examples of this range from the high-profile third-order effects of the Three Gorges Dam project on the Yangtze River, China to the rare Yangtze River dolphin (Tulloch 2009), to the more prosaic anthropogenic effects of reservoir building on parasite fauna (Morley 2007). What unites these cases is that the broader societal and environmental benefits of these developments were deemed to outweigh concerns for the wildlife which inhabit them; nature appears passive to and separate from Politics (Latour, 2004).

Although the politicisation of the EIA process is clear (see Cashmore and Richardson, 2013), wildlife, their habitats, and their advocates, often themselves play a political role in transforming the outcomes of such analyses. In the UK, environmental groups, such as Friends of the Earth, have criticized EIA processes as often being overly-reliant on desk-based surveys, designed to achieve planning permission at minimal cost, while lacking involvement with local environments and communities (FOE, 2008). Hence unsurprisingly, insights gleaned from EIAs can and are often challenged by emergent encounters during the construction process with wildlife and their advocates. The impact on the local Eurasian Otter population by the Skye Bridge project show how failings in the initial EIA required costly post-hoc analysis and mitigation strategies (Sage et al., 2011). Yet, even long after construction techniques, such as population sampling, deployed within EIA, can successfully improve habitats. For example, Dodd et al (2004) show how the sampling of wildlife road deaths influenced the construction of a barrier culvert system designed to enable animals to cross a long-established Florida highway safely. It is important to note that the act of rendering the road safe to cross also afforded an opportunity for the local population to appreciate wildlife and their habitat that would have been difficult to achieve without the initial infrastructure development. By contrast on Skye, the Otter population have refused to use the expensive mitigation systems (Sage et al., 2011), thus the project displaced the Otter's former habitat.

Infrastructure projects, and effective EIA and other managerial techniques, can be transformed by, as well as productively or adversely impact, habitats and wildlife. This point challenges the notion of wildlife as a passive 'receptor' to the construction project. Thus, the two key overarching questions we pose here are: (i) to what extent can and should wildlife be managed in advance as a passive receptor; (ii) is wildlife always a cost or risk or can it benefit infrastructure development, perhaps in unexpected ways, and if so how? Before addressing the case studies in more detail to engage with these questions, we develop these two questions further with reference to ANT-derived studies of non-human animals. In so doing we seek to address the potential for construction to politicize wildlife, and in the process challenge the long-standing assumption that Nature is separate to Politics, and by extension Society (Latour, 2004).

## **THE POLITICS OF WILDLIFE IN ACTOR-NETWORK THEORIES**

While some work in EIA has recognized its political context (e.g. Cashmore and Richardson, 2013), the *modus operandi* of EIA dictates that 'the environment', or Nature, itself is little more than a complex mosaic of receptors passive to the social interactions of the construction process (and thus Society): "At the simplest level, a whole aspect of the environment could be considered a sensitive receptor, for example, the flora and fauna of a site. As interactions between different aspects of the environment are complex, it is however usually too simplistic to take such an approach, and it is recommended that some attempt be made to break down the receiving environment into receptors" (RICS, 2013).

Set against EIA, there has been a growing interest in the active involvement of various non-human actors in construction management processes (Bresnen and Harty, 2010). Much of the work around non-humans within construction management has been influenced by ANT (Latour, 2005), its derivatives and relations. This body of work opens up an opportunity to consider the complex agency of animals and their habitats in construction projects, as they interact with, and transform, managerial modes of order and control such as EIA. ANT's insistence on the agency of nonhumans offers a useful starting point to this end; while, they appears a tendency within ANT research to focus on objects rather than animals (perhaps influenced by Bruno Latour's noticeable focus on technological projects) a number of ANT studies have explored the interaction of human and non-human animals. This animal-related work includes: Callon's (1986) seminal work on the domestication of scallops; Whatmore's (2002) hybrid geographies; Hinchcliffe et al's (2005) analysis of urban conservation and Law and Mol's (2008) exploration of the politics of boiling pigswill. What unites such work is that animals are afforded the possibility of being more than simply passive intermediaries of human intentions and actions. That is, they could, if empirically evidenced, become, in ANT parlance, actors that "transform, translate, distort, and modify the meaning or the elements they are supposed to carry" (Latour, 2005: 39). And thus: "an animal may become an actor if it make visible a difference to the construction project, for example, by affecting the time schedule, the budget, the design specification, or more generally, other actors' interests and goals" (see Tryggestad et al. 2013: 74)

When an animal becomes an actor it moves the project in new directions, requiring new interests and stakes to be taken into account: thus, an animal, or collective of animals, objects and humans, can, if it makes a difference to the project, be

understood as a stakeholder. In this paper, instead of simply documenting the unexpected influence that animals and their habitats may have on a construction project (as in Sage et al., 2011; Tryggestad et al. 2013), we seek to question how animals are being understood and managed on projects, in relation to EIA and other project practices, and the limitations and opportunities therein of such practices for all involved. By comparing two rather different infrastructure projects we want to say more about the complex interaction of governance systems, cultures, political environments, as well habitats and wildlife. Thus, this paper has a more normative, arguably political, orientation than our earlier work in this area. But, following Hinchcliffe et al., (2005), by 'political', we do not mean to represent the interests of animals more accurately, to provide a more faithful, body of knowledge to identify and evaluate their natural interests and behaviours, alongside those of our own (see Cashmore and Richardson, 2013). After all, following ANT, demands we view interests as open-ended as they are produced through our dynamic relations with others rather than held internally (Callon, 1986; Latour, 2005). In what follows we flesh out a politics of wildlife for construction which allows animals to "object to the stories we tell about them, to intervene in our processes as much as we intervene in theirs" (Hinchcliffe et al. 2005:56-6). ANT proponents have conceptualized this version of politics as 'Cosmopolitics', where: "Cosmos protects against the premature closure of politics [around human actors], and politics against the premature closure of the cosmos [around natural facts]" (Latour, 2004b). This version of politics is set against a representational politics of ecology which only admits the political interests of (naturally) given entities (Latour, 2004). We ask here what unique role construction might have in both inhibiting and realizing such a (cosmo) politics. We will now turn towards the two case studies to address this question, as well as those two posed earlier in relation to EIA.

## CASE STUDIES

### The Hallandsås tunnels project

In October 1997 a large public infrastructure project, the construction of two parallel 8.6 kilometre long railway-tunnels through the Hallandsås ridge in the south of Sweden, was brought to a halt. Farmers living in the neighbourhood of the construction site found paralyzed cattle on the fields and dead fish in the ponds. Three paralyzed cattle were slaughtered 1st October. The farmers went public with their concerns and claimed that the project had caused the sickness and death of the animals. They contacted the media, organized public meetings and demonstrations and demanded the project stop. Investigations confirmed the farmers' claims. The constructor and key contractor Skanska held a meeting with Båstad municipality on the 3rd October which revealed toxic water was leaking from the tunnel and prompted the municipality's to use the media to warn the public about the danger. Båstad municipality filed criminal charges against the client, the National Railway Authority, (NRA) and the contractor, Skanska, for environmental damage. The project was halted on the 7th October. Construction workers had previously expressed concerns to their managers about their own health and safety when working with the composite Rhoca Gil to water seal the tunnels. Workers had expressed feelings of numbness in limbs and itching on the skin. A governmental investigation began on 20th October 1997. It revealed: 27 contaminated wells near the construction site; 333.000 kg milk needed to be destroyed; 370 cattle had to be slaughtered; the value of farm land and property declined and local crop sells suffered; and the crew had not been appropriately equipped and educated to work with Rhoca Gil. Medical examinations revealed that

about 20 construction workers had documented neural effects related to their work with the toxic composite material (Tunnelkommissionen 1998).

The Hallandsås project was carried out by the NRA. The tunnels would reduce rail journeys, increase train and cargo capacity. NRA considered environmental impacts during construction. Due to local geology, construction would cause a temporary lowering of groundwater, requiring NRA to obtain approval from the Water-Rights Court (WRT). For this application to be approved an Environmental Impact Assessment (EIA) had to be conducted. The EIA revealed that some sections of the ridge had high water transport capacity (due to small rocks and clay). This in turn could result in high losses of groundwater with environmental impacts on vegetation, animals, farmers and other inhabitants living on the ridge. The WRT permitted the NRA to release groundwater, but did express concerns regarding the degree of impact, suggesting that additional investigation should be conducted. The WRT also required a chemical control programme to ensure the water-quality (Päiviö, J. & Wallentinus, HG. 2001, 66). The local municipality, the Swedish environmental protection agency and the Ministry of Environment called for further investigation of the environmental impacts (as per 85/337/EEC on railway projects over 2.1km). The Government decided to start the project in February 1992.

The first contractor to work on the task was Kraftbyggarna who was awarded the 690 million SEK key contract in spring 1992 with an estimated completion time in 1996. The contractor used a tunnel boring machine (TBM) that turned out to be unable to handle the variable geological conditions. Small rocks and clay jammed the boring head. Only a few meters were accomplished during the first years. The contractor ended up in a dispute with its client and left the project in 1995. After a new tender process Skanska took over the project with a contract worth 900 million SEK. The company used the well proven method of blasting and excavation. Progress was lagging behind the time schedule as the amount of groundwater that seeped through the cracks was much larger than anticipated and created more difficult working conditions for the construction crew. Moreover, the client and contractor developed new concerns about an eventual violation of the permission issued by the WRT. Growing concerns among local farmers about the water supply were reported by the press. Combined with the growing media-attention, the government took no chances and did not grant the NRA permission to proceed with the plans of lowering the groundwater level. The NRA was thus forced to come up with new solutions to the groundwater problem. Together with Skanska, the NRA initiated investigated ways to seal and contain the water flows. Tests with ordinary lining methods that used concrete showed them to be insufficient. Lining had to be complemented with other methods. The client and contractor decided to do a test on a limited area of the tunnel with the chemical composite material Rhoca Gil, which was a quite well established sealing method for underground construction work internationally. The test results obtained in spring 1997 were encouraging and project management then decided to scale up for production. Large quantities of Rhoca Gil were used during the summer and fall. The environmental scandal emerged shortly after.

The investigations conducted in the aftermath of the scandal revealed some of the subtleties of Rhoca Gil in use. When used under conditions of moderate water pressures, the toxic agent in Rhoca Gil would harden quite swiftly and be contained with relatively little discharges into the waterways. However, when used under high water pressure, the toxic agent would reveal a different behaviour and take much longer time to harden while discharging the toxic chemical acrylamide into the water

flow (Frisk, 2008). The project resumed in 2003 and is estimated to be completed in 2015 at a cost of 10.5 billion SEK, over 17 times over budget, and 19 years late.

### **Ashwood to Oakhampton pipeline project**

The Ashwood to Oakhampton pipeline (AOP) project (fictitious name, but based on a real project) involved the construction of a c.£45m 1200mm high pressure gas pipeline over 18.5km from protected Green Belt land into outlying suburbs of a large conurbation in the United Kingdom. Construction took place between 2007 and 2009. The project sponsor was an international, privately-owned, utility provider (hereafter named 'Gasgen'). The project did deviate from original time and cost estimates (of a spring 2007 start and 2008 end) partly due to its environmental impact. However, it was also regarded as highly successful for its environmental practice, winning an award for waste management. Under the Public Gas Transporter Pipe-line Works (1999), adopted in response to European Directive 97/11/EC, the pipeline required a full EIA as it was over 800mm in diameter. While this act exempts pipelines from the requirement to gain planning consent from local authorities, all pipelines requiring an EIA require approval from the relevant Secretary of State. The EIA was captured in the Environmental Statement (ES) by a team of independent consultants on behalf of Gasgen, in conjunction with statutory and non-statutory bodies, from regulatory bodies to local authorities and environmental charities (the 'consultees'), in addition to landowners. The ES categorized the impact of the project on animal and habitat receptors as temporary minor to moderate adverse, and thus capable of being mitigated. Thus, the ES enacts the split between Nature and Society: on one side there are a set natural entities whose responses can be easily mapped out, and on the other side there is Society, whose capricious political and economic interests are to be evaluated as they act upon Nature.

While the ES was largely viewed positively, and ultimately accepted by the Secretary of State, the local authority expressed concern that the surveys of animals undertaken in some areas were insufficient, and thus biodiversity and habitat could be adversely affected. In effect, animals were said to not being represented well-enough: this is the politics of representation. Yet, we can also detect moves beyond this politics.

One small river crossing above the pipeline was engulfed with Himalayan Balsam and biodiversity was extremely low. The project team identified this site as an opportunity to enhance local biodiversity. A river restoration company was then employed to; clear the river, introduce new riffles to oxygenate the water, plant a range of native aquatic and riverbank species, construct a backwater wetland feature to connect with the original flood plain and grade the banks with biodegradable matting to improve the habitat. While such work helped enrol the local authority in the project, it failed to enrol sufficient flora and fauna: the project team since report that the local authority did not prevent this promising habitat being re-engulfed with Himalayan Balsam, and the river returned to more or less its former low-biodiversity state. Similar examples of non-human animals acting as matters of political concern, rather than fact, appear elsewhere. For example, during open and cut tunnelling near a major road on the AOP project, a badger set was found; under the advice of the Environment Agency (the badger's legal spokesperson) an artificial set was created to entice the badgers away; however, the badgers refused to use it and so the Agency stipulated that the pipeline must be tunnelled under the original set at a cost of £0.5m. One member of the project was so dismayed at the cost of this work, which is ultimately passed onto consumers' energy bills, that he suggested it would have been far easier, and perhaps more

popular (especially in the light of UK badger culls and high energy costs) simply to move the badgers by force.

## CONCLUDING COMMENTS

The two case studies suggest that emphasis in EIA, on seeing wildlife and habitats as mere 'receptors' of development, is flawed. The Hallandsås case reveals how failing to consider the unique agency of local wildlife, and their hydrological and geological environments, can have catastrophic implications not just for local wildlife and agriculture, but, given EIA law, the construction project itself. The AOP project example, on the other hand, reveals that going beyond EIA law and proactively accommodating wildlife and their habitats as part of the development process can positively benefit infrastructure projects and the organisations involved in their development. If you can shelter animals in your project, then they can help you enrol various publics (Callon, 1986). However, if emphasis is solely placed upon the politics of representation, prefigured on the split between Nature and Society, then animals and their habitats will often be as quickly forgotten, as Himalayan Balsam reinstates itself or acrylamide seeps upwards through small rocks. Skanska and the NRA assumed Rhoca Gil was safe based on experience elsewhere; hence they relied upon on assumptions that Nature can be faithfully represented as a set of facts through Science and transported elsewhere, without modification. Yet equally problematic was the assumption by the local authority in the AOP case that the representation of animals in a biodiversity survey, of a recently enhanced habitat, indicated the animals' destinies. After all, we would not assume we could gauge our own fate from a population census.

Cosmopolitics demands we think about interactions between human and non-human animals as an on-going relationship, where we respect their right to behave as actors like us, to surprise us, just as we surprise them (in their sets, ponds and elsewhere). As Latour (2005) puts it we seek to ignite a "burning desire to have the new entities detected, welcomed and given a shelter" (p224). Building sites are surely part of the political front-line in this process. Construction operatives and managers are constantly faced with the spectre of Latour's Cosmopolitics; they cannot simply represent animals in containers of natural facts and social interests as EIA suggests; rather they readily turn animals into matters of concern, even, and especially, as they ask whether it is really worth "all that fuss, just for some bloody badgers!"

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# COMMUNITY CONSULTATION DURING CONSTRUCTION: ATTITUDES, EXPERIENCES AND SKILLS

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Community consultation is traditionally the domain of urban and town planners. But it is often the case that residual community concerns linger into construction phases as the true impact of construction on the community becomes physically apparent. However, too often community concerns are ignored or badly managed, leading to damaging and often costly disputes which harm communities, the firms involved and the industry as a whole. To better understand the reasons for these practices, theories of community consultation are used to explore the attitudes, experiences and skills of professionals working with the construction phase of projects in consulting the communities in which they build. One hundred and fifty construction professionals involved during construction were surveyed and ten were interviewed. The results indicate that the majority of the construction professionals find the practice of dealing with the community during construction a hindrance and that the process is considered an inconvenient, time-consuming and costly exercise. Very few project managers have any expertise in this area and there is an assumption that community consultation is the responsibility of town planners before work starts on site and that further interaction with the community is not needed.

Keywords: community, consultation, risk, skills, project management, construction, education

## INTRODUCTION

There is accumulating evidence over the last decade that Beck's (1992) prediction of an increasingly paranoid society was prophetic. Communities appear to be far more educated and informed about the risks that government and business represent to their lives and increasingly willing to protest if they perceive it to be against their interests. The construction sector arguably has a greater impact on the lives of people than any other industry sector. Unlike most industries, its products are procured in the heart of the communities in which they will remain imbedded for decades and even hundreds of years, influencing the social, cultural, economic and ecological environment in which people live, work and play. It is therefore ironic that research into community consultation during the construction stage of projects is very much in its infancy. Apart from the research of Preece et al (1998), Moodley (1999), Glass and Simmonds' (2007), Teo's (2008) and Chinyio and Olomolaiye's (2010) empirical work in this area is rare. And the research that does exist points to an industry that is ill-equipped to manage community concerns. The consequences of this inadequacy can be extremely costly, leading to acrimonious and costly disputes which disrupt the progress of projects, force late changes to designs and construction methods and

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tarnish the reputation of those involved. It is within this context that the aim of this paper is to explore the attitudes, experiences and skills of professionals working with the construction phase of projects in consulting the communities in which they build. The importance of this work has been recognised by Winch et al. (2007) who argue that public involvement needs to be seen as a vehicle to increase project success and not a hurdle that needs to be overcome to reach project completion.

## **THE COMMUNITY CONSULTATION PROCESS**

The term community usually refers to a social unit that shares common values and interests and normally lives in close proximity to each other (Barzilai, 2003). Holst (2002) describes community consultation as an 'opportunity' to engage with communities to produce a better mutual outcome using a structured and principled negotiation process. In theory, the purpose of community consultation is to listen to the community about their concerns and aspirations, seek feedback from the community about proposed plans and, inform the community about decisions that are in tune with their best interests. Typically this involves attendance at community events like markets and festivals, dedicated community forums and public meetings, surveys, focus groups and workshops, steering and advisory committees, community exhibitions, newspaper articles and advertisements and the use of models and displays (virtual and physical) (Troast 2011). The appropriate level and type of consultation will depend on a range of factors such as the size, complexity and location of the project, the time and resources available, the skills of the proponents and the knowledge and skills of the community to understand the issues at hand. Normally a combination of the above methods will be used.

Regardless of who undertakes the process, community consultation should seek to reach out to as many community stakeholders as possible. Numerous models have been advanced to conceptualise this process. For example, Arnstein (1969) developed 'a ladder of citizen participation' beginning with full non participation and leading to full citizen power (Figure 1). Despite its age, this model is used extensively in practice. In recent times the use of this ladder has been predominantly in community action programs where communities and towns are chosen for government infrastructure projects. The model in short can be broken into three levels of citizen participation: non-participation; tokenism and; citizen power. These are defined by different approaches to consultation. On the bottom rungs of the eight step ladder are manipulation and therapy which are aimed more at educating or 'curing' stakeholder concerns rather than involving them in the project. The next levels on the Arnstein ladder are informing, consultation and placation. These steps form the tokenism section of the ladder where the community is given the opportunity to put forward their points of view and have a voice in the process. However, the community lacks the authority to ensure their views will be acted upon by those in chairs of authority. Citizen power describes the upper echelons of the Arnstein ladder where partnerships, delegated power and citizen control provide communities with a real opportunity to provide input into decision-making processes.

Burby (2001) found that effective community consultation involves a number of key decisions relating to: objectives; timing; participants; techniques and; information provision. Many stakeholder consultations are ineffective because the objectives driving the process are not clearly formulated. Effective consultation also requires effective planning and dedicated time. Ad hoc meetings attached to the end of other meetings send the wrong message to stakeholders. It is also useful to employ a

stakeholder management strategy, which can disentangle the important stakeholders from those which are less important. The appropriate consultation technique also depends on the objectives of the process. And access to adequate and appropriate information is essential in order to empower stakeholders, to secure their involvement in the decision making process and ultimately, to ensure their acceptance of and commitment to any decisions made.

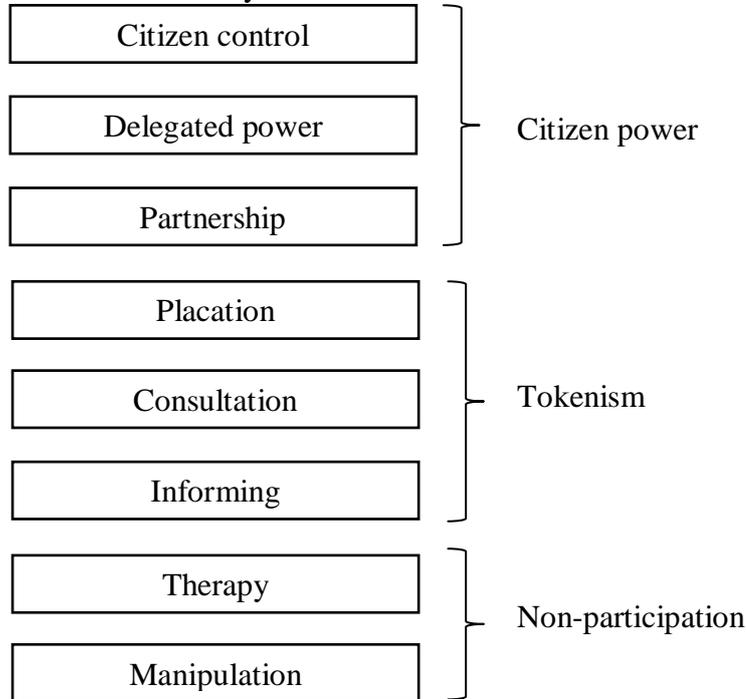


Figure 1 Arnstein's ladder of citizen participation (Source: Arnstein, 1969)

However, as Graham (2010) points out, while all this is good in theory, many communities claim consultation is a charade which disempowers traditionally disempowered members of the community. Graham presents evidence that on many occasions the intended social inclusion becomes an adversarial engagement leading to community protest and sometimes the mobilisation of extremist groups. Certainly, Teo's (2008) study of Australia's longest running community protest in Sydney supports this contention. Aboriginal groups felt they were being ignored in development process, the protest drew in groups from all around Australia and the local community vehemently and sometimes violently opposed the project. More recent research in the field of community psychology and consultation is seeking to explain this breakdown of relations between developers and communities using Actor-Network Theory (ANT). This work argues that present approaches and models of community consultation are inherently adversarial. ANT is being used as a mechanism to conceptualise how consultation might be used as an enrolment mechanism encouraging and promoting local politics during the early stages of construction projects.

## COMMUNITY CONSULTATION DURING CONSTRUCTION

In the construction industry, the process of community consultation occurs in different stages of a project. Traditionally, the majority of community consultation is completed during the planning and design phase when the developer lodges a development application. In theory, once all issues raised by the community have been satisfactorily resolved, the project proceeds to the construction stage. It is normally assumed that

once the project proceeds to this stage the community has less input into the project. However, as Teo and Loosemore (2010) point out, it is often the case that residual community concerns persist and when ignored, erupt into a fully blown protest against the development and the many firms associated with it.

Construction companies will often base their consultation process on a generic and typically rigid community consultation policy or more likely, an environmental management plan. Some projects may even have an individual community consultation plan, although this is rare. Most companies argue that the community consultation process is too in-depth to be managed by an individual Project Manager (Raidén et al 2006). Therefore, it is common for the process to be contracted out to a specialist consultant, as if it were similar to letting any other trade on the job. Cleland (2007) argues that this allows someone to focus on community relationships but as Winch et al (2007) argue, this can be a costly exercise and often portrays to the public a lack of care by the company which might appear to be outsourcing their responsibility to the community.

While many firms outsource their community liaison roles, this is not ideal. Furthermore, many small companies in the construction industry cannot afford the luxury of a community relations manager. Therefore, the management of the consultation process falls fully on the Project Manager and his team. For this reason, it is essential that Project Managers are equipped with the skills to successfully manage this process. Glass and Simmonds (2007) recognised this but also acknowledged that the key skills required to successfully undertake communication with the public are unclear and somewhat difficult to distinguish. These skills will also vary depending on the type of works, the length of the job and the size of the job.

Traditionally, the PMBOK Body of Knowledge (PMBOK 2012) is used as the worldwide guide of skills that are considered essential to completing a smooth project. The eight key skills include: time management; cost management; quality management; risk management; procurement management; communications management; integration management and; human resource management. Hartley (2003) identifies four major functions of the project manager: planning; organising; leading and; controlling. Oberlender (2000) sees the Project Manager as a leader and planner that has the ability to run a smooth transition of trades on a construction project as well as coordinate and organise when certain scope needs to be completed and finished. Oberlender (2000) argued that the most important role of the project manager is decision making and having the ability to make a decisive call in a short space of time. However, although there is extensive literature regarding the skills of a Project Manager there is little that identifies the skills required when it comes to managing the community consultation process (Glass and Simmonds 2007). As Glass and Simmonds (2007) pointed out, there is therefore a need for further research to identify the various skills required for successful community consultation whilst exploring the psychological relationship between the construction professionals and the community.

## **METHOD**

In analyzing and investigating this issue a random sample of 222 construction professionals in the UK, Australia and New Zealand were surveyed. Professionals were contacted through the membership networks of local Professional Institutions. Out of the 222 surveys distributed, 150 questionnaires were fully completed, producing a response rate of 68% and a sample structure shown in Table 1.

*Table 1 Sample structure*

Respondent	Respondent Number	%
Project Manager	54	37
Site Manager	34	25
Architect	23	23
Other (directors, operations managers, sustainability managers, engineers)	39	15
Total	150	

The questions and variables for the survey were designed to explore the community consultation experiences of the respondents, their attitudes towards community consultation and their skill base in being to do so effectively. Structured interviews were also undertaken with ten Australian project managers who volunteered during the survey to be interviewed. Logistics prevented managers in other countries being interviewed although our survey responses did not vary significantly between the countries sampled indicating that we could rely on Australian responses as representative. The purpose of the interviews was to explore in more detail respondent stories and experiences of community consultation and the underlying reasons for any major insights which emerged from the surveys. Like any sampling method, this process of self-selection has some limitations, most notably a possible tendency for certain ‘types’ of respondents to volunteer. However, in this case there were more volunteers than needed and to overcome this potential problem a second round of random sampling was undertaken by the research team.

## **DISCUSSION OF RESULTS**

Figure 2 illustrates the level of influence that respondents believed the community had over projects during the construction period. In Figure 2, the standard deviation of 1.01 shows that 95% of the responses fall relatively close to the produced mean (M=2.97) demonstrating that the community were thought to have “some influence” on construction professionals. A cross tabulation was also carried out for this question in relation to the roles of construction professionals and what each believed the influence was on construction. Interestingly, the results show that it is the site managers who bring the mean down and uniquely believe that communities have relatively little impact on their projects. However, site managers are also the group that has the largest experience of community interaction.

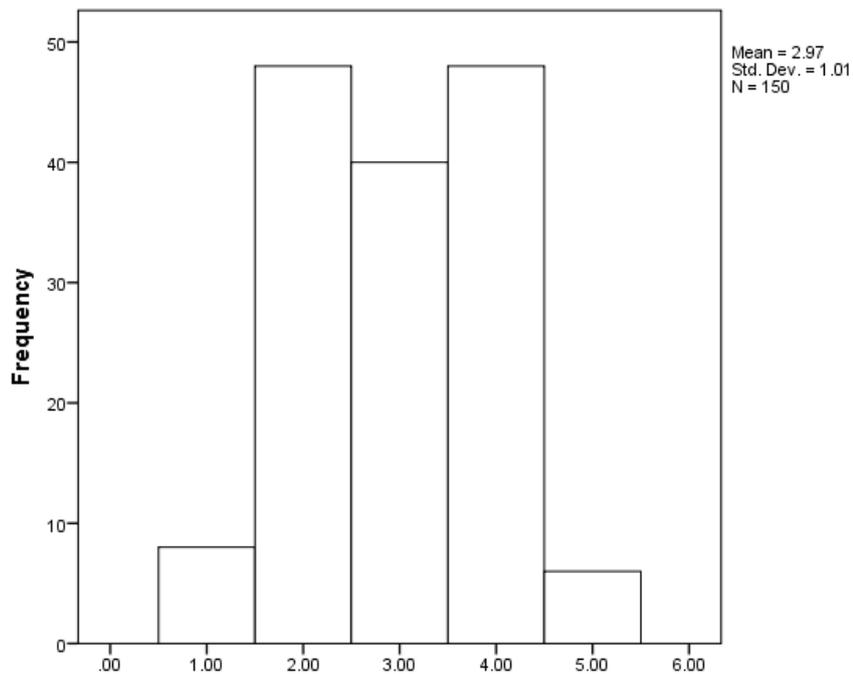


Figure 2 Community influence on projects during the construction stage (1 being no influence 5 being large influence)

Figure 3 illustrates how positive the community consultation experience had been for our respondents.

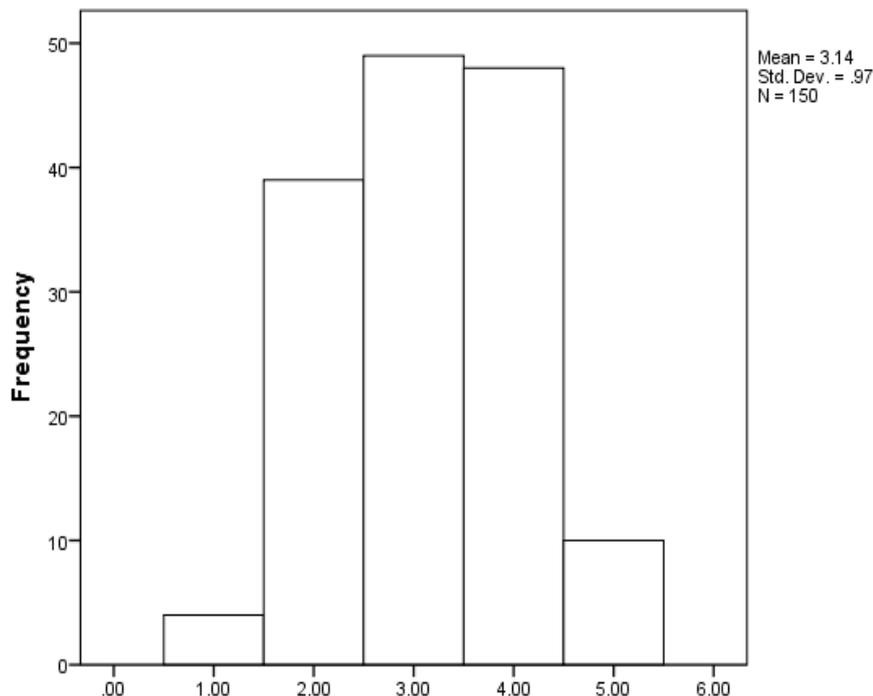
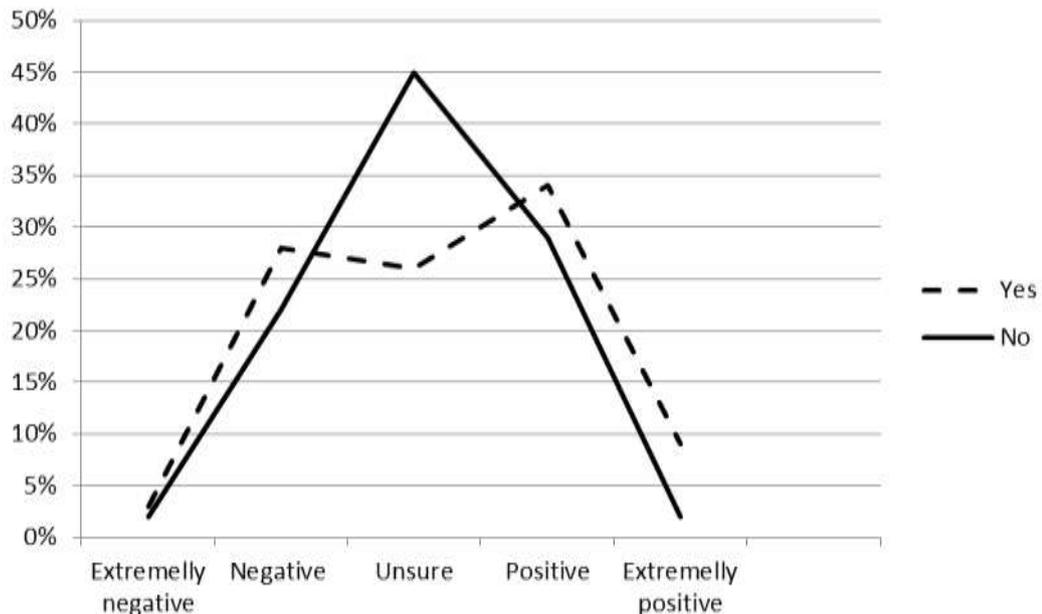


Figure 3 Experiences in dealing with communities during construction (1 being extremely negative lowest and 5 being highest)

Figure 3 shows that majority of respondents (M= 3.14) had a marginally positive relationship with the community during construction. The standard deviation of .97 also shows that responses were quite similar and thus all tended to have a relationship with the community close to that of the mean. A cross tabulation showed quite distinct

differences in the experiences of the sample, with project managers and site managers having markedly worse experiences.

Figure 4 shows the relationship between those who ‘had’ and ‘had-not’ experienced protest and perception of community involvement. Interestingly, this shows that those respondents who had experienced protest had a more positive view of communities than those who had not experienced protest. In other words, negative community perceptions by construction professionals are in part born out of ignorance and preconceived ideas of how they behave. Interview data indicated that the majority of the respondents believed that community relationships depend crucially on the supply of information to, and the amount of contact with, the community. *“Keeping them in the loop keeps them a lot happier.”*.. *“Like any relationship it should improve the more contact there is.”* However, some respondents (a minority) believed that if the community is provided extended input into the project it may be detrimental to the project’s success. *“There is no point giving them a say if it’s going to be ill informed or if it’s a flippant comment rather than constructive feedback. .... I mean you give them an inch they take a mile sort of thing.”*



*Figure 4 Relationship between those who had encountered community protest and their attitudes towards the community.*

Figure 5 relates directly to the Arnstein (1969) model of community participation and shows that the majority of the respondents fell into the “tokenism” level of community participation.

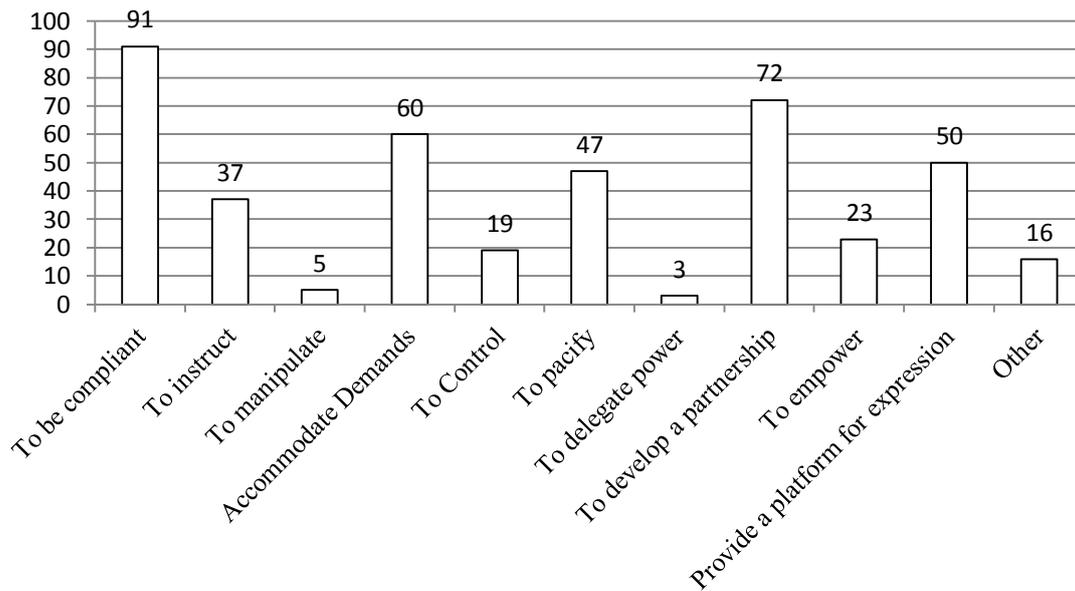


Figure 5 Reasons for consulting with the community

In explaining this, the interview data pointed to a widespread belief among respondents that the time and cost of community consultation was prohibitive. *“Due to time restraints...if the community was to be removed from the project all together, I mean construction professionals would find the task a lot easier as it’s one less stakeholder to deal with.”* ... *“We work big hours and the last thing we want to do is further our days by having to consult with the communities about our projects.”*

Most of the respondents also saw a separation of responsibility for project delivery and consultation. *“I think that the actual process should be left to the town planners only because it is their role during planning and there is no point passing these issues on to the project team if it’s just going to be more of a burden on the project team.”* ... *“I don’t see the point in having to change the professional required to undertake consultation between planning and construction when it is the planner’s job anyway”.*

In seeking to explain this, Figure 6 shows that most of the respondents had received no training in community consultation. Project and site managers were most strongly represented in the ‘no’ category, yet they were the roles most closely connected to the community. The interviews showed that many respondents saw formal training as unnecessary. *“I believe it’s because it’s relatively unnecessary to have formal training in community consultation. ... I reckon that general communication skills are all that is required to deal with the community.”* ... *“I can’t even imagine what they’d teach in formal community consultation training.”* Others pointed to the general lack of tertiary education in the construction industry. *“A lot of Project Managers come off the tools and I suppose come from different paths and just aren’t offered training.”* Finally, others argued that community consultation can only be learnt through experience on-the-job. *“I reckon I’ve gained 95% of my knowledge through on the job experiences and I think that’s the same with consultation.”*

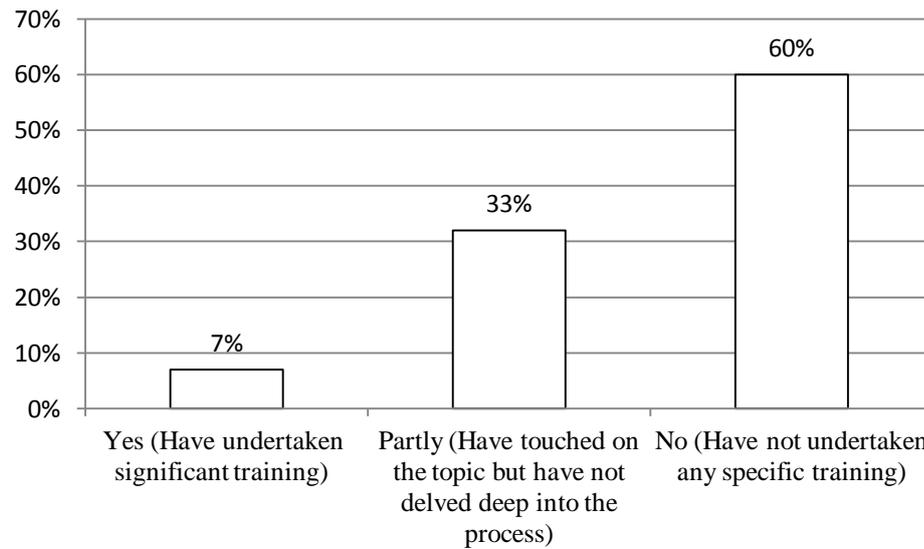


Figure 6 Have you been formally trained in community consultation?

## CONCLUSION

The aim of this paper was to explore the attitudes, experiences and skills of professionals working with the construction phase of projects in consulting the communities in which they build. Our results indicate that most construction professionals in our sample felt that they had a good relationship with the communities in which they built. Experience of community angst against projects was however very common, especially for ‘front-line’ managers who worked on site and interfaced with the community every day. While communities are not ‘cut-off’ from sites, most professionals involved in the construction stage found the process of managing the community during construction burdensome, arduous, time-consuming and costly. The risks of community consultation greatly outweighed the benefits for most, although the greater the contact between the community and project, the more positive this relationship became. The vast majority of construction professionals in our sample were ill-equipped to manage community concerns, lacked training in the process of community consultation and did not see the point of being trained in this area. Most considered it the planner’s responsibility to resolve these issues up-front before work starts on site. There was a perceived and distinct delineation of responsibility for delivery and consultation and when work starts on site, community consultation should cease and the focus should be on delivery with minimal ‘interference’ from the community. Where community consultation does occur, concerns are rarely acted on and the process is considered more of a token obligation than an opportunity to develop a partnership and work side by side with the community.

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# UNDERSTANDING COMPLEXITY IN THE AEC INDUSTRY

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Complexity is not new to the AEC industry. It dates back well beyond the invention of construction management as an independent field within the building disciplines. Yet the introduction of construction management added a new magnitude to the understanding about, and handling of complexity. This however started with a positivistic reductionist approach which was understood as a scientific method and only defensible academic approach to portray complexity. A simple classification of complexity based on the project size or simply dividing it into 'organisational' and 'technological' may have been deemed sufficient as of in 1980s or 1990s. On the other hand introduction of new construction technologies, new building materials, new structural optimisation tools and techniques have introduced new factors into the building process throughout its lifecycle. All those added by more demanding clients' briefs, more complicated and ambitious design intents, ever-tightening legislations and building regulations, and growing awareness about how the buildings behave beyond their physical boundaries and outside their traditionally understood lifespan have introduced new layers to complexity in the AEC industry. Although still valid in some respects and to some extents, our traditional view of construction complexity is not considered 'inclusive' anymore; nor is it ample enough to address the ever-growing 'complexity of complexity'. This paper takes a cross-sectional approach to present a qualitative comparative analysis. It maps out complexity, its definitions and implications and the impact it has upon the construction process. The aim of this review paper is to provide a ground upon which more in-depth systematic research into understanding, management and handling of complexity can be based, thereby suggesting a 're-reading of the concept of complexity' to be able to more informally feed it back into construction process in the AEC industry.

Keywords: complexity, design complexity, organisational complexity, project complexity.

## INTRODUCTION

Advancements in the application of physical agents – both structural and non-structural – as well as non-physical agents – both people and organisations – have resulted in extreme complexity of projects. The diversification of the end users and multiplicity of the stakeholders as a major player in human agents group have also

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added to the degree of complexity. Baccarini (1996) suggests that building projects have become increasingly complex since WWII, to the point that [in 1996] project complexity is now regarded as one of the critical project characteristics that determines its success.

Added by the performance, successful implementation of a project has been acknowledged since Baccarini by many including Austin et al. (2002), Chan et al. (2004), Molenaar and Songer (1998), Raymond (1995), and Wood (2010), to name a few. Despite this very fact to date, there is still no all-inclusive yet clear definition of the project complexity (Bertelsen and Koskela 2002, Corning 1998, Kauffman 1995, Williams 1999, Wood, 2010). Quoting Casti (1994), van Dijkum (1997) suggests that the definition of complexity is connected to the subjectivity of the observer. This is also mentioned by Corning (1998) where he draws attention to 'subjective complexity' as opposed to 'objective complexity'. Also many researchers and scholars have concluded that project complexity would have an impact on time, cost, and quality of a project (Chan 1998, Chan and Kumarawwamy 1997, Dissanayaka and Kumaraswamy 1999, Gidado and Millar 1992, Nassar and Hegab 2006, Raymond 1995, Tatikonda and Rosenthal 2000, Walker and Sidwell 1996, Wood and Gidado, 2008).

This paper attempts to provide a general framework of understanding for the concept of complexity in the AEC industry by reviewing the precedent work on general complexity. It starts with some definitions of complexity in the context. Then touching on the concept of complex systems and complexity theory, it will move forward into aspects, types and viewpoints on, and approaches to complexity in the AEC industry. In the next step the paper reviews the impacts and implications of complexity within the context of this study. Finally discussing the results of the reviews, it will provide a new standpoint which will lead to a new strategic recommendation for more in-depth further studies to revamp and reshuffle the significance and need for a re-reading complexity in the AEC industry.

## **COMPLEXITY DEFINED**

Complexity can be difficult to define as it has a number of different connotations. Etymologically derived from Latin *complexus* [past participle of *complecti* 'to include (many different things)'] (Longman 2005), complexity is defined by the Collins English Dictionary (2006) as "the state or quality of being intricate or complex", where complex is defined as "made up of many interconnecting parts". The definition also highlights that it should be noted that complex is sometimes used where complicated is meant. Complex should be used to say only that something consists of several parts rather than it is difficult to understand, analyse or deal with; what 'complicated' inherently means.

The formal definition of complexity as Stewart (2001) suggests fits into two main categories of 'algorithmic complexity', derived largely from computer mathematics, and 'organisational complexity' resulting from the new biology and a revived systems theory.

As a rather simple algorithmic definition Cohen and Stewart (1995) believe that one may tentatively define the complexity of a system as the quantity of information needed to describe it. Having a language of pattern theory Katz (1986) suggests that

the complexity of a pattern is the size of the minimal precursor pattern – the minimal templet<sup>2</sup> – necessary for its construction.

By contrast, those definitions which may be counted for as an organisational complexity are more concerned about the behaviour of a system and its analysis (Nicolis and Prigogine 1989). For instance as Coveney and Highfield (1995) state, within science, [...] complexity is the study of the behaviour of macroscopic collections (of basic but interacting units) that are endowed with the potential to evolve.

Larsen-Freeman (1997) points out ten characteristics for complex systems as dynamic, complex, nonlinear, chaotic, unpredictable, sensitive to initial conditions, open, self-organizing, feedback sensitive, and adaptive. Although some of those features might look self-explanatory, she attempts to compensate for this by clustering them into groups and carries on by adding ‘...such systems possess strange attractors, which are fractal in shape’ (Larsen-Freeman 1997).

Suh (2005) defines complexity as a measure of uncertainty in achieving the specified functional requirements (FRs). In the framework proposed by Suh, there are two kinds of complexity, each of which breaks down into two sub-categories:

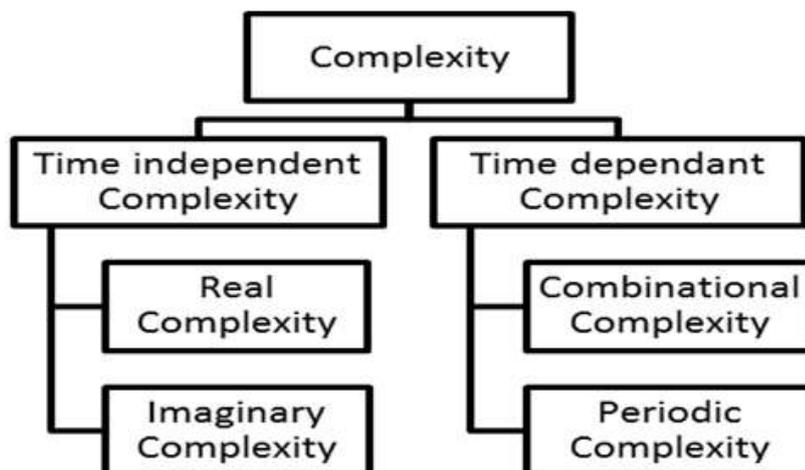


Figure 1: Complexity definition (Suh, 2005)

## COMPLEXITY THEORY AND COMPLEX SYSTEMS

Complexity science represents a growing body of interdisciplinary knowledge about the structure, behaviour and dynamics of change. Complexity theory (within which chaos is a particular mode of behaviour) is concerned with the behaviour over time of certain kinds of complex systems. Over the last 30 years and more, aspects of behaviour became the focus of attention in a number of scientific disciplines. These range as widely as astronomy, chemistry, evolutionary biology, geology and meteorology. Each of these systems evolves in relationship to the larger environment in which it operates. To survive, the system as a whole must adapt to change (Sanders, 2003). Some social scientists like Stewart (2001) believe that using

<sup>2</sup> He develops the notion of “templets” as specific programmes of fabrication.

complexity theory (particularly in social context) with a paradigmatic horizon as a 'metatheory' has itself led to yet another course of reductionism as a result of lack of experience in the field they are entering. However, Morin (2006) suggests that complexity remained unknown in physics, in biology, in social sciences till it irrupted in mathematics and engineering at about the same time, and became connected at once, in the 40s and 50s, with Information Theory, Cybernetics, and General Systems Theory. This paper will briefly go through Complexity Theory and Complex Systems to clarify on the underlying theories. Indeed, there is no unified field of complexity theory, but rather a number of different fields with intriguing points of resemblance, overlap or complementarities (Rosenhead, 1998). The interplays between order and disorder, predictability and unpredictability, regularity and chaos, are characteristics of complex systems. Complex systems abound in the real world and they reflect the world's inherent irregularity. The real world is a world of complexity, of messiness, of change, flow and process and cannot be pinned down to the simple, solid, unchanging objects people like to cut out of it (Merry, 1995). Merry describes complex systems as those that self-organise themselves into states of greater complexity. An overview of the Santa Fe Institute provided by Merry asserts that complex behaviours may emerge from a number of the basic rules controlling parts of the system. That behaviour is not predictable from knowledge of the individual elements, no matter how much we know about them, but it can be discovered by studying how these elements interact and how the system adapts and changes throughout time. This new emergent behaviour of the system is important for understanding how nature operates on the macroscopic level. What looks chaotic at first may be predictable from an understanding of the patterns and rules of complex behaviour. The organisation of simultaneous interaction of many components of a system creates complexity.

Richardson et al. (2000) assert that a complex (adaptive) system can simply be described as a system comprised of a large number of entities that display a high level of interactivity. The nature of this interactivity is mostly non-linear and contains manifest feedback loops. Stacey (2001) concurs with Richardson et al. by summarising the structure of a complex adaptive system as follows: large numbers of individual agents; agents' interaction according to rules that organise the interaction between them at a local level. The only rules are the rules located at the level of the agent itself; interaction is iterative, recursive and self-referential; adaptation of agents to each other based on the non-linear interaction rules; and random mutation and cross-over replication which cause rule variation.

## **ASPECTS, TYPES AND VIEWPOINTS OF, AND APPROACHES TO COMPLEXITY**

Complexity in its own rights can be deemed as a paradigm in modern sciences. More importantly, however, is its contribution to other sciences, disciplines and philosophical standpoints. There are a number of definitions, aspects and types attributed to complexity, distinguished viewpoints of and approach to complexity, heavily determined by the disciplines they belong to, these can be summarised as behavioural; organisational; project' systematic; social; organic; data and; technological complexity. Studying complexity within each of the aforementioned framework will outline a new and unique setting which can cast light on its application to the AEC industry. This however is outside the scope of this paper which attempts to provide a general framework of understanding for the concept of

complexity in the AEC industry. Herein we will review the most directly related ones whose correlation with the construction industry is very well-documented over the past two decades to pave the ground for a more in-depth systematic study of complexity in the construction industry. Those include 'project complexity' and 'organisational complexity' which are intertwined and closely related to the construction process.

### **Design/Project complexity**

Santana (1990) classifies construction projects by scales of complexity into normal, complex and singular. He also takes another step into classifying the characteristics of the construction projects into 10 categories including owner or investor, cost and financing, terms of study and execution, stages of the project, administrative and legal framework, impact on natural and social environment, physical localisation, technology, resources, and finally logistics of the construction, for a more in-depth study of project complexity using a 1 to 10 Likert scale. At a more detailed level which can be accounted for as an expansion to what Santana's classification suggests, Campbell's (1998) information processing approach to task complexity introduces two factors, namely 'multiplicity', which captures the number of approaches that may be employed and end states that must be satisfied to complete the project; and 'ambiguity', which represents the conflict among, and uncertainty in decisions, the team must make to complete the project. McComb et al. (2007) used this approach and developed those factors into four task complexity dimensions: multiple approaches to complete the task; multiple end states to be satisfied by the task; conflicts among approaches and uses that require trade-offs, and; decisions regarding the approaches to be employed and the end states to be satisfied. Mitchell takes another standpoint and defines the complexity of a design as 'the ratio of added design content to added construction content' (Scheurer 2007), or 'the number of design decisions relative to the scale of the project' (Mitchell 2004, Mitchell 2005).

None of the above viewpoints however, discredit the validity of the Baccarini's (1996) proposed definition of project complexity as 'consisting of many varied interrelated parts that can be operationalised in terms of differentiation and interdependency.' Baccarini also explains that this definition can be applied to any project dimension relevant to the project management process, such as organisation, technology, environment, information, decision making and systems, therefore when referring to project complexity it is important to state clearly the type of complexity being dealt with. In a more detailed review, Gidado (1996) suggests that there seems to be two perspectives of project complexity in the industry: the managerial perspective and, the operative and technological perspective. He offers that project complexity is the measure of difficulty of executing a complex production process, where a complex production process is regarded as that having a number of complicated individual parts brought together in an intricate operational network to form a work flow that is to be completed within a stipulated production time, cost and quality and to achieve a required function without unnecessary conflict between the numerous parties involved in the process. Or it can simply be defined as the measure of the difficulty of implementing a planned number of quantifiable objectives. However, it is worthwhile that these viewpoints are revisited taking into account the newly introduced dimensions to the complexity in the AEC industry due to the recent advancements made since 1996. This includes Wood (2010) who defines project complexity as a single or a combination of factors that affect the standard response or actions taken to achieve the project outcomes.

Reviewing Gidado's aspects of project complexity, i.e. the employed resources, the environment, the level of scientific and technological knowledge required, the number of different parts in the work flow, and the interaction of different parts in the work flow (1996); Chan's casual factors of project complexity: client's attributes, site condition/site access problems, buildability of project design, quality of design coordination and quality management (1998); Akintoye's project complexity's principle components, namely expected project organization, type of structure, site constraints, method of construction and construction techniques, scale and scope of the project and complexity of design and construction (2000); Cicmil and Marshall's three aspects of complexity, which are: complex processes of communicative and power relating among project actors, ambiguity and equivocality related to project performance criteria (success/failure) over time, and the consequence of time flux (change, unpredictability and the paradox of control)(2005), Xia and Chan (2011) conclude '...that most of the factors are those broad and vague concepts, and some of them are related to the concept of complexity theory (such as the unpredictability of the work). As a result, it is very difficult to quantify the project complexity based on these findings'. Subsequently they suggest 6 complexity measures for building projects in the People's Republic of China with a Weight Factor for each indexed through Delphi method including building function and structure (WF: 0.189), construction method (WF: 0.179), the urgency of the project schedule (WF: 0.177), project size/scale (WF: 0.157), geological condition (WF: 0.153), and neighbouring environment (WF: 0.145).

### **Organisational complexity**

Construction projects can be studied as organisations. There are numerous parties involved in any construction project which form a temporary organisation. The coordination and relationship between the different parties can greatly affect the complexity of any project. It has been shown that the behaviour of firms differs considerably from what is common in other industries, particularly in terms of the absence of inter-firm adaptations, the pattern of couplings in construction is characterised by the tight couplings in individual projects and loose coupling in the permanent networks (Dubois and Gadde, 2002). Bertelsen (2003a) states how the construction industry is highly fragmented and its firms cooperate in ever changing patterns, decided mainly by the lowest bids for the project in question. As well as individual projects forming complex systems, projects are also interwoven, as every firm at the same time participates in more than one project, utilising the same production capacity. In addition to the aspect of firms creating project organisations, the concept of the social complexity must also be accounted for. The project is a working environment for humans and a place for cooperation and social interaction, which because of the temporary character forms a highly transient social system. This system can be thought of as a virtual firm which employs all personnel involved in the project (Bertelsen, 2003a). Radosavljevic and Bennett (2012) discuss worst case construction projects vs. more straightforward projects, as seen in Figure 2. Worst case scenarios are often related to the organisational complexity of the project, in a complex project, the whole project organisation is beset by massive and repeated interactions with the organisations hostile, rapidly changing and entirely uncooperative ways.

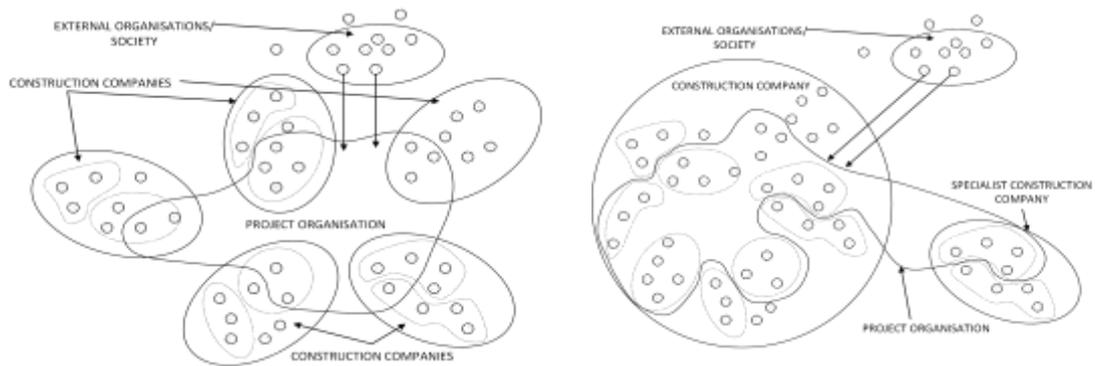


Figure 2: A complex construction project network vs. a straightforward project network (Radosavljevic and Bennett, 2012).

## THE IMPLICATIONS OF COMPLEXITY FOR, AND ITS IMPACTS ON THE AEC INDUSTRY

Complexity can arise from systems with just two variables. However, construction is far more complex, where many more than two interacting variables are involved and the project progress, outcomes, and success in the future depend on an array of intertwined organisational interactions involved in the process, the quality of relationships between interacting agents and their performance variability. In addition there is also unpredictable interface which may arise from numerous external factors which form an additional set of parameters and make construction inherently difficult (Radosavljevic and Bennett, 2012) which follows from what Bertelsen (2003b) discusses of construction as a complex system. He states that the perception of the projects nature as ordered and linear is a fundamental mistake and that project management must perceive the project as a complex, dynamic phenomenon in a complex and non-linear setting. A closer examination reveals that construction, despite the established understanding, is indeed a nonlinear, complex and dynamic phenomenon, which often exists on the edge of chaos. In order to demonstrate this, Bertelsen (2003a) conducts an analysis of the characteristics of a complex system and those of a construction project. Through this analysis evidence is provided which highlights how complex the construction process is.

The implications that complexity may have in a project may vary from trivial – where the mistakes made are ‘Fixable’ – or minor – where a ‘Fault’ may (have) happen(ed). At a higher impact level this may vary from a major defect – which can result in a potential ‘Failure’ of the project – to a catastrophic incident – with a ‘Fatal’ consequence either for the project or the parties involved. This will potentially have an effect on the actions, measures and techniques to address and deal with complexity in construction projects.

## DISCUSSION

Organisational and project complexities are discrete faces of complexity in the construction industry. However, they are not mutually exclusive. In fact in many cases they are too intertwined to be fully and utterly distinguished. Although organisational complexity vis-à-vis project complexity per se stands at a higher hierarchical level, it scales down and fuses with project complexity in many cases. This particularly happens when the outside agents come into play; those whose systemic standing may be lower compared to the organisation(s) involved in a construction project but their roles as commissioner/client and/or user/client is by far more significant. The primary

client i.e. the owner or developer influences the project as per their specifications. The end client as the user will, on the other hand, have their own needs, wants and requirements which need to be taken into account through client brief and project brief. Clients, whether they are primary or end client add to the complexity at project level. On the other hand organisational and inter-organisational agents who develop the project from the conception stage through to the completion stage into the physical product of the built environment are the project complexity enforcement agents on behalf of and for the clients while adding another dimension of complexity inherent in their organisational hierarchy within the AEC industry, i.e. organisational complexity. These agents may include non-structural agents who are in charge of architectural design, structural agents who take care of structures, mechanical agents who deal with MEP and last but not least construction and implementation agents who manage people, contracts, sites and the construction process itself (see Figure 3).

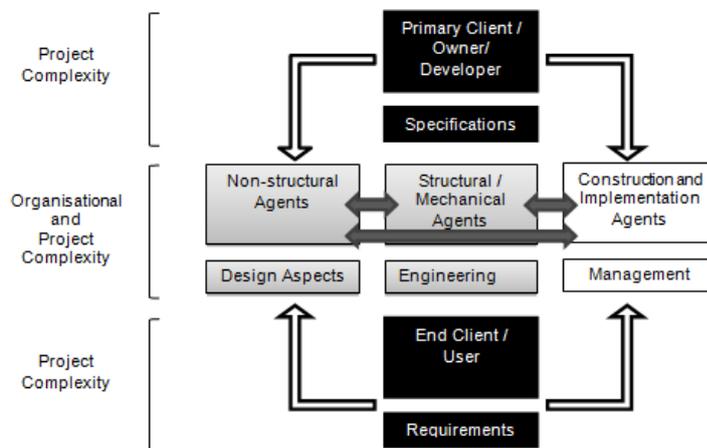


Figure 3: Intertwined Organisational and Project Complexity and their Respective Agents

## CONCLUSION AND RECOMMENDATIONS

Complexity is not a new concept in construction and the issue of complexity has been studied for several years. However, despite increasing complexity in the process of undertaking construction projects, there is still no long-lasting resolution for or understanding of complexity in the AEC industry. Although many scholars have studied complexity in the industry within different contexts, there is still a lack of an in-depth systemic and holistic framework which is proportionate to the level of complexity that the topic itself presents to overarch the different possible approaches to deal with complexity.

As a result, this paper presented a review of the most influential areas of complexity in the construction industry, project/design complexity and organisational complexity. The overview portrays these issues from an alternative viewpoint in order to gain a better understanding of the complexity that affects the industry. More importantly, what is now required is a comprehensive research concerning the origins, disciplines and contexts of complexity and to start a re-reading of the topic in the AEC. We therefore propose a systemic study of complexity in the construction industry with an aim of developing a methodological approach to the concept which is proportionate to specifics of the setting, context and people involved in any particular project.

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# URBAN HIGH-DENSITY CONSTRUCTION SITES AND THEIR SURROUNDING COMMUNITY: ISSUES ENCOUNTERED AND STRATEGIES ADOPTED BY CONTRACTORS

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Inner city developments are a common feature within many urban environments. Where these construction sites are not managed effectively, they can negatively impact their surrounding community. The aim of this paper is to identify and document, in an urban context, the numerous issues encountered and subsequent strategies adopted by on-site contractors and local people, in the mitigation of factors which negatively impact their surrounding community. The objectives in achieving this aim are to identify what effect, if any, an urban construction site has on its surrounding environment, the issues and resulting strategies adopted by contractors on the factors identified, and also what measures are put in place to minimise such disturbances to the local community. In order to meet the requirements, a mixed methodology is adopted culminating in a literature review, case study analysis, contractor and community interviews, concluding in the development of two specific questions for both perspectives in question. The data is assessed using severity indices based on mean testing in the development of key findings. The results indicate that the main forms of disturbance to the local community from an urban development include noise, dust and traffic congestion. With respect to a contractor on-site, the key issues include damaging surrounding buildings, noise control and off-site parking. The resulting strategies identified in the mitigation of such issues include the implementation of noise and dust containment measures and minimising disruption to local infrastructure. It is envisaged that the results of this study will provide contractors operating in such environments, with the required information which can assist in minimising disruption and therefore, avoiding disputes with the local community members. By consulting with and surveying those most affected, this research will illustrate to on-site management, the difficulties faced by those who accommodate such developments within their living environment.

Keywords: community, confined site, site management, stakeholder engagement, urban development.

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## INTRODUCTION

Urban development is not a new phenomenon within the construction sector. With the continued movement of populations from rural to urban conurbations, (United Nations 2011) comes amplified and sustained pressure on local services and amenities to accommodate such population influx (Adams 2012), resulting in overcrowding and congestion (Downs 1981). As of 2007, urban population has surpassed rural growth, thus exemplifying the continued growth and development within urban centres (United Nations 2011). Historically, this issue persisted but with the continued influx of population, this issue is exacerbated further. Such pressure is not only restricted to services but also to the material required in their construction (Brinkman 2011), thus compounding the difficulty and complexities associated with constructing in this inherently congested and complex urban environment. Within these metropolitan areas, construction sites are a common feature with large numbers of construction projects constantly emerging (Hendrickson 1998) and if not managed effectively, can prove disruptive to their surrounding community (Environmental Protection Authority 1996). Hence, this issue has emerged over time and has emerged as a significant issue with the historic levels of population influx experienced in the last decade (United Nations 2011). Various pollution regulations must also be adhered to, but again, it is the management of people within these sensitive environments that takes precedence.

Urban construction sites are very often embedded in a variety of surrounding communities incorporating neighbouring residents, adjoining businesses and members of the general public; thus resulting in increased acrimony and disruption (Gilchrist, et al. 2002). Contractors, who undertake works within an urban environment should, where possible, avoid potential disputes with surrounding community members, thus mitigating acrimony and ill feeling with their various external stakeholders. The aspect of bad practice must also be considered in conjunction with the increased management burden of operating in such an environment. To address this, it is essential from a contractor's perspective, that minimal disruption is caused to the adjacent locality in the form of noise levels, the presence of dust particles and traffic congestion within the vicinity of a construction site (Rojas 2009). To address this aspect of concern, this study provides a critique of the main issues encountered by contractors associated with urban construction sites while also documenting the main strategies to counteract the potential issues faced when constructing in congested urban environments. To complement the viewpoints of contractors, community representatives are also considered, to get a holistic overview from both perspectives. This is achieved through the use of a mixed methodology encompassing qualitative (literature survey and semi-structured interviews) and quantitative (questionnaire survey) data collection and analysis techniques. This mixed method approach aims to merge both research techniques into a single study to achieve a broad perspective (Brannen 2005). From this research, contractors operating within a congested urban environment surrounded and influenced by multiple external stakeholders, can acknowledge the core issues and the suggested strategies in mitigating such concerns. With the significant gap in knowledge identifiable with the limited publication of material on the subject (Gilchrist, et al. 2002), it is essential to address this aspect of stakeholder management. With the advent of Strategy for Sustainable Construction, this has attempted to alleviate the concerns of operating within communities; however, the research suggests that further improvement is necessary (Gilchrist, et al. 2002). On adopting of the results herein, it is envisaged that on-site management professionals operating in a high density environment, can proactively manage one of their most

important resources - the external community. It is envisaged that, where contractors proactively identify the strategies for consideration while also putting in place contingency measures to mitigate or eliminate the occurrence of issues documented.

## **URBAN CONSTRUCTION SITES AND THE SURROUNDING COMMUNITY**

The surrounding community of any urban site face on-going disputes, traffic delays and most of all noise pollution (Gilchrist 2002). All communities have the potential to be both positively and negatively affected by urban developments, where generally most city centre developers and residents of an urban setting can relate to this particular topic. Due to the nature of construction work within such a congested environment, the surrounding community is likely to suffer from noise pollution, high levels of dust and traffic congestion (Islington Council, 2006). Construction work brings with it uncertainties and the level of noise created is the most common form of nuisance created by a construction site (Ng 2000). Noise can be created by a wide range of sources such as cranes, pumps, hand-held machinery and large machinery. A surrounding community will be forced to deal with such nuisance throughout the construction process and if they are unaware of nor consulted on the noise occurring, they tend to be more willing to dispute the matter (Ministry of Defence, 2010).

In relation to the high levels of dust that can be created from construction sites, surrounding communities are often faced with discolouring of roads and buildings. More importantly the dust created can be harmful depending on the source of level of exposure. Vision can also be impaired by dust levels when driving or walking on the roads adjacent to an urban site (Ministry of Defence, 2010). With regard traffic congestion, most urban settings are already faced with traffic disruptions and with the addition of a construction site, traffic levels become increased, both on and off site (Kim and Kim 2010). Construction sites tend to attract increased traffic volumes to an area due to delivery vehicles entering and exiting site (Pheng and Chaun 2001) in conjunction with congestion caused by employees parking in the vicinity of the site. Additionally, buildings generally are not designed with the consideration of noise and dust levels, and a surrounding community may suffer due to this factor (BRE 2003).

## **METHODOLOGY**

One of the key aspects of this preliminary research is its dual focus; firstly the perceptions of various contractors are obtained and secondly, the viewpoints of numerous external stakeholders as also considered. In doing so, a sequential mixed methodology is adopted and detailed as follows.

### **Literature survey**

To gain a thorough insight into the research in focus while also obtaining an exhaustive list of possible factors for inclusion in the subsequent analysis, a comprehensive desk based literature survey is undertaken. A wide variety of sources are considered including, peer reviewed journal publications, conference proceedings, books, web pages and articles. Such a practice provides grounding on the research in focus while also establishing a core basis of factors and supporting material to aid in the semi-structured interviews which follow. Through incorporating the key findings within the literature, it is possible to compound their importance while also affirming their inclusion in the upcoming questionnaire survey by incorporating deductive reasoning the realisation of core factors for further review. The literature review is used to drive the themes within the research while also supporting the questionnaire.

### Semi-structured interviews

To complement the literature survey and to verify the factors identified, nine interviews are undertaken. This also provides a basis on which to explore further factors not considered nor identified in the literature survey. Participants interviewed are a site supervisor, two civil engineers, two health and safety officers, a project manager, two community residents and a business owner. The industry practitioners had on average thirteen years, many of which are accumulated working in confined construction sites in various geographical urban locations. All of the interviews are carried out in person, aiding in the accumulation of data from experienced personnel first hand while also providing the interviewer with an opportunity to obtain the viewpoint of knowledgeable individual's opinions, values and actions (Bond 2006). Semi structured interviews are chosen over structured and unstructured, due to the fluidity and ability of the interviewee to discuss freely, while also providing the interviewer with some control over the direction and focus of the discussion in question. By interviewing nine participants, this also provides an opportunity to ensure the removal of bias and to aid in triangulation of data, to assist in conformity in the qualitative data collection process. Each of the participants are nominated based on selective and convince sampling rather than random sampling, in order to ensure that the participants are knowledgeable and amiable to being interviewed on the topic in question. The interviewees are identified and questioned with respect to their relevant inner city confined construction site. In total, all nine participants are related to a culvert works project, a footpath reconstruction and the construction of a light railway line, all of which are located throughout Ireland in various locations.

### Questionnaire survey

The catalogue of factors identified are reviewed, with repetitions factors reviewed and included in a questionnaire survey. In order to gain the perspective of both on-site management and that of the various external stakeholders, two variations of the questionnaire survey are designed, to gain a comprehensive insight into each viewpoint. The questionnaire is circulated using selective and convenience sampling to ensure that potential recipients have the prerequisite knowledge and applicable environment on which to complete the questionnaire. Each of the questionnaires is circulated electronically and manually, to improve return rates while also aiding in the quantification of the data within. Each factor was ranked using the Likert Scale from 1 (Not Important) to 5 (Most Important). Accumulated responses from both questionnaires located in the Republic of Ireland (58%), Northern Ireland (12.5%), England (7.5%), Scotland (11%) and Wales (11%) were recorded, with Table 1 documenting the return rate per survey and the overall total number of questionnaires with usable data. Although the response rate is low, it meets the requirements for data analysis using SPSS™, therefore beneficial for further scrutiny. Due to the location of the researchers and associated contacts, the responses are focused on the island of Ireland with significant difficulty encountered in acquiring community participants outside of this geographical location.

*Table 1: Breakdown of responses by location for each of the questionnaires returned*

	Rep. of Ire.	Northern Ire.	England	Scotland	Wales	Total q'naires
Contractor q'naire	44%	13%	13%	20%	10%	52
Community q'naire	72%	12%	2%	2%	12%	35

## ANALYSIS

Relating to the contractor questionnaire survey, a total of 51 factors are identified and included in two core sections; strategies in minimising disruption to the surrounding community (29 factors) and issues facing a contractor in an urban setting (22 factors). In addition, 18 factors are incorporated in the questionnaire circulated to external stakeholders, to obtain their viewpoint on the overall effect of urban construction sites on the surrounding community. Each of the factors posed is ranked based on the perceptions of the respondent in question. From the resultant means testing, it is possible to identify the top three factors in each applicable section of the two questionnaires circulated. The top three most prominent factors are illustrated in table 2, 3 and 4; all of which are subjected to further discussion. Due to the limitations on space and considering two separate questionnaires for discussion, it is only possible to review the most prominent factors in each aspect. This provides a platform on which to develop the topic further at a later date.

*Table 2: Leading Contractor Issues*

	N	Mean	Std. Deviation	Std. Error Mean
Damage to surrounding buildings	51	4.000	.774	.108
Noise levels difficult to control	51	3.922	.996	.139
Providing off-site parking for construction workforce	51	3.843	.833	.116

*Table 3: Leading Contractor Strategies*

	N	Mean	Std. Deviation	Std. Error Mean
Implementation of noise mitigation systems	51	4.294	.831	.116
Implementation of dust containment measures	51	4.284	.672	.094
Non obstruction of local business entrances	51	4.216	.756	.105

*Table 4: Leading Community Issues*

	N	Mean	Std. Deviation	Std. Error Mean
Duration of road closures is curtailed	35	4.143	1.00	.169
The presence of physical obstacles is minimised	35	4.000	.907	.153
Pedestrian walkways provided and maintained	35	3.942	1.08	.183

## DISCUSSION

### Leading Contractor Issues

#### *Damage to surrounding buildings*

The leading issue documented from the questionnaire survey is the issue of damaging adjacent structures while operating and constructing in a city centre congested site environment. Three quarters of the respondents either agreed or strongly agreed that this posed a significant issue in the management of an urban project, with respect to the surrounding community. Regardless of the project in question, any work located within an urban environment has the potential to cause harm to neighbouring structures. Even at the outset of an urban development where underground activities

are considered, Sterling and Godard (2002) further exemplify the dangers present when working in the vicinity of other structures. Tweed and Sutherland (2007) acknowledge such an issue by even looking beyond structural issues by considering pollution and other factors while Tao and Zhang (2012) consider damage due to piling works on-site. This illustrates the importance and multitude of sources of damage to surrounding building which must be considered, specifically when operating in a confined construction site within an urban context.

#### *Noise levels difficult to control*

The second most problematic issue encompasses the difficulty in controlling the level of noise emitted from site. Again almost 65% of contractor respondents agreed or strongly agreed with the severity of this issue, thus its high mean score (3.922). This issue is problematic on the vast majority of sites within an urban environment, but it is exemplified where residential occupants are located within the vicinity of a project. Armagh City and District Council (2011) argues that increased noise levels in the vicinity of an urban construction site have been found to be second most problematic issue of nuisance caused to a surrounding community, hence the importance of mitigating this issue on-site. Where noise levels are not monitored and controlled, it is inevitable that conflict will materialise. Cushman, et al, (2001) compounds this point by articulating that noise levels are considered to be the main form of disputes between a contractor and a surrounding community.

#### *Providing off-site parking for construction workforce*

The third factor is the issue of off-site parking for the workforce, where 72% questioned, concurred with the severity of this factor. Each of the residents interviewed expressed significant concern with regard to this aspect, as employees working on the adjacent site tend to park on the surrounding roads, thus occupying parking places normally reserved and assigned to the local residents. This point is further articulated by the residential interviewees who also note that road closures or block parking bay through their acquisition to accommodate site parking or other amenities as being particularly frustrating, thus leading to further disruption (Gannapathy 2009). Where such issues arise, contractors should be willing to seek alternative means of transportation for their workforce. By implementing a car-pooling system between employees, this will reduce the number of vehicles in the surrounding area of the site or by subsidising the workforce for parking away from the site and using public transit or shuttle buses to travel to the site. By subsidising employees to undertake these measures it will reduce the number of vehicles on the surrounding roads of the site (British Research Establishment, 2003).

### **Leading Contractor Strategies**

#### *Implementation of noise mitigation systems*

Of the respondents surveyed, an overwhelming 84% concur that the leading strategy in the reduction of community strife while operating and constructing in an urban confined construction site is noise mitigation. This corresponds with the need to mitigate the severity of the issue documented earlier. Generally contractors will install temporary noise mitigation systems to reduce the impact on the surrounding community (Schexnayder and Ernzen 1999) on an urban construction site; however these generally are inadequate where proactive and sustained contingencies are considered. Mitigation of undesired sounds should consider source control, path control, and receptor control. It is the case however that a majority of contractor's tend to ignore this fact and put mitigation systems in place that are ineffective and

inadequate. By implanting effective systems, contractors are showing to the surrounding that they are in fact taking necessary precautions to reduce noise levels. On the other hand by using inadequate systems they will be deceiving the various stakeholders who may contend with the matter (US Department of Transport 2008).

#### *Implementation of dust containment measures*

The second most strategic approach in the mitigation of community issues when constructing in an urban city centre environment, is the use of dust containment measures (for example, watering down, debris netting, alternative construction techniques, etc.). In this instance, the vast majority of respondents agree that this strategy is of paramount importance, with in excess of 92% either agreeing or strongly agreeing with the introduction of this measure with Griffiths and Griffiths (2007) further emphasizing its importance. Contractors should aim to ensure that there is no health risk posed due to the emission of dust from a particular construction site to the immediate surrounding environment. Dust suppression systems are the main form of dust containment (Environmental Protection Agency 1996) and principally incorporate watering down procedures, particularly during demolition and removal of material from site. To compound the importance of this strategy, two interviewees from a single urban development articulate the importance of this countermeasure, by indicating that management often underestimate the importance of and the effectiveness of watering down, particularly during demolition and site clearance.

#### *Non obstruction of local business entrances*

This is one of the core strategies identified, both in the literature (McFadden 2010) and from each of the interviewees; particularly from the business owner. McFadden (2010) argues that direct sales of shops and businesses can be affected by the presence of construction sites in the vicinity of the premises. The business owner who is interviewed expresses a significant distain for works which block or obstruct his entrance. The interviewee acknowledges the findings of McFadden (2010) in that his sales are adversely affected. However, particularly in the case of a convince store, the interviewee is swift to argue the point of there being any advantages. The construction site workforce will generally pass trade to a local business, especially in the case of a convenience store. However the business owner is not convinced that this compensates for loss of trade due to the presence of a construction site. In this case, the interviewee would like to see more proactive measures been taken by management of adjacent projects to mitigate the business lost while also minimising disruption to the customers who frequent the various adjacent business. This point is particularly evident where Jaraiedi, et al. (1995) outlines issues where entire road networks are closed, inhibiting customers from accessing local businesses and amenities.

### **Community Issues**

#### *Duration of road closures is curtailed*

The first and most striking issue evident from the results is the aspect of road closures and not noise as stipulated by Cushman, et al, (2001). In this instance, over 77% of respondents either agreed or strongly agreed with this issue being the most severe. Gannapathy (2008) agrees with the severity of this issue due to the lack of information often provided with respect to road closures. Interestingly, on further examination using regression analysis, this issue emerges again as the leading contentious issue raised (43% of the overall variance explained), when considering how to minimise the overall disruption caused by an urban project on the local community. Both the site manager and project manager interviewed also articulate this issue and highlight that,

where possible, this factor is mitigated against through effective project management and scheduling work packages around the feasibility of road closures. Downs (2004) also reiterates the importance of mitigating this issue, identifying that where management proactively alleviates such occurrences, it is perceivable to assume that disturbances caused by urban projects will be minimised substantially.

*The presence of physical obstacles is minimised*

The second most contentious issue identified from a community perspective is the need to eliminate the presence of physical obstacles around site. Again over 73% of community correspondents agreed or strongly agreed with the need to mitigate or eliminate the presence of such obstacles. Examples of obstacles in this context include barriers, hoarding, fencing, unnecessary signage, temporary works material, etc. Physical obstacles littered around a construction site are often not considered by a contractor; however they can have a direct effect on the surrounding community. Site perimeters generally consist of plywood sheeting or mesh fencing units, most frequently for security purposes only, but it must be erected, monitored and maintained to ensure that it is not providing an unnecessary burden on the local community (excluding general site security and for the safety of those in the vicinity). The overall aesthetics of these obstacles do not appeal to the surrounding environment and local community, therefore to mitigate the adverse effect, temporary fencing should not be left unattended for long periods of time where they may become vandalised and in-turn, become an eye-sore on the surrounding community. The existence of such obstacles inhibits the flow pattern of passer-by's, resulting in congestion on foot pavements and overcrowding, resulting in increased acrimony among the general public and the neighbour community.

*Pedestrian walkways provided and maintained*

The third and final community identified issue is that of pedestrian walkways. Within this aspect, it not only considers providing the walkways, but also maintaining these structures for the duration of the works. With this factor, 76% of the respondents agreed or strongly agreed that this is a pertinent issue that contractors in urban developments often fail to address. In the case of a variety of projects, pedestrian pathways are included to alter footpaths and walkways and in-turn, prohibit people from entering an area under construction. Where this occurs, measures must be taken to mitigate the disruption caused in conjunction with ensuring proper maintenance of the structure throughout the works. Many contractors identify the importance of effective walkways to protect bystanders and the local community, but the key point argued by the community based interviewees is the lack of upkeep of these structures. However, such structures are often the key factor in serious and in one case, fatal accidents (Moncarz and Taylor 2000), further justifying the importance of not only providing but maintaining such structures. Two of the interviewees provide supplementary argument to the necessity of providing and maintaining such structures, by articulating that with the constant movement of pedestrians around the site perimeter, residents are often faced with the daily task of walking on different types of surfaces and gradients.

## **CONCLUSION**

In essence, this study focuses on urban construction sites and their capability of providing a variety of disruptions to their surrounding community. Urban areas tend to be difficult to operate within, due to high volumes of pedestrian and vehicular traffic along with highly populated residential areas. Therefore the addition of a construction site within an urban setting can prove highly disruptive to a surrounding community

and contractors must effectively manage the level of disturbance caused by their presence. Inevitably contractors will aim to avoid disputes with local community members, but in order to do so they must consider a number of points. Firstly identify a number of issues which must be acknowledged and effectively management and secondly, possible strategies to counteract such issues must also be identified, considered and where appropriate, implemented, to mitigate such issues. To supplement the viewpoint of contractors, community representatives are also considered in order to identify the issues which they feel require redress. To summarise, the top three contractor issues are; damage to surrounding buildings, noise levels difficult to control, and providing off-site parking for construction workforce, while the corresponding leading strategies are; implementation of noise mitigation systems, implementation of dust containment measures, and non-obstruction of local business entrances. From the aspect of the community representatives, the leading issues for redress are; duration of road closures is curtailed, the presence of physical obstacles is minimised, and pedestrian walkways provided and maintained. As articulated, the continued development of our urban centres is of paramount importance and is unrelenting, but with this development comes strife and discontent among its inhabitants. Contractors working within such an environment are encouraged to take note of the findings and to proactively manage the various core issues documented in conjunction with those identified by community members. Through adopting an array of strategies, three of the most prominent of which are discussed, it is anticipated that through proactive management, project managers can successfully complete their project in question, with a minimum of disruption on their most influential external stakeholder - the local community.

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# DOES THE DEPLOYMENT OF PROJECT MANAGEMENT ITSELF PROVIDE BENEFITS? BOTH TANGIBLE AND INTANGIBLE

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In the project management literature, it has been argued that value encompasses more than the iron triangle especially as value means different things to different stakeholders along the continuum from project lifecycle to product lifecycle. However, examination of the extant literature on project management suggests that when value is discussed, it is usually considered in terms of the benefits of the project outcome. More recently, the additional value derived from deploying project management (management of projects) methodology itself has been recognised. By identifying the benefits from project management deployment and applying an intangibility test, intangible benefits were identified to be types of Organisational, Human and Social capital. The value derived from project management deployment itself can therefore be subdivided into tangible and intangible benefits; where the intangible benefit contributes to organisational competitiveness and human intellectual capital. The authors have also found that whilst organisations have an understanding of the tangible value of managing work by projects, there is a lack of recognition of the intangible value derived from undertaking the project management process itself.

Keywords: intangible benefit, project management, value.

## INTRODUCTION

Intangible benefits from project management deployment are not concerned with the effectiveness of project management or project management maturity; rather the benefits generated from the project management methodology itself. Extant literature argues that project management deployment generates value but the value is hard to define and measure (Thomas and Mullaly (2007), Hurt and Thomas (2009), Mathur et al. (2007), Jugdev et al. (2007), Murphy and Simon (2002)). The traditional view of project management deployment is to deliver a project (product or service) that meets the cost, time and quality specified usually described as the iron triangle (Atkinson, 1999, Toor and Ogunlana, 2010). This approach is changing as Winter and colleagues argued that there is a shift from this traditional view of project management to one that emphasises that project management creates value and benefits (Winter et. al, 2006). From the perspective of permanent organisations, the value of an organisation is usually described in terms of intangible or tangible aspects (Lonnqvist, 2002).

Jugdev and Mathur (2006) have shown that project management creates value and competitive advantage. This was based on a conceptual model linking the achievement of the VRIO characteristics (Barney's VRIO framework helps to allocate

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the different strategic assets into Valuable (provide economic value), Rare (unique), Inimitable (difficult to copy) and involve Organisational Support (management support, processes, and systems) (Barney, 2002) of project management process (dependent variable) to tangible and intangible assets (independent variable). Fortune and White (2002) captures the real world experiences of people active in project management reporting desirable and undesirable effects from project management deployment. Similarly, Hurt and Thomas (2009) investigated three organisations project management offices and their value contribution. The study identified both tangible and intangible benefits of project management deployment. Kerzner (2006) also gives a summary of the benefits organisations believe to accrue from project management deployment. More understanding of intangible benefits of project management is required. Three reasons have been identified by the authors for why intangible benefits matter for value from project management deployment, therefore for project management practice and project based organisations. They are:

1. It matters for permanent organisations; as the gap between book value and market value has been argued to be as a result of intangible value (Kaplan and Norton 2004, Roos et al 1997, Brooking 1996, Lev 2001). Therefore it matters for project management and project based organisations as they exist in the same business environment.
2. How organisations create value due to effects of globalisation and over-competition; influencing the business strategies of organisations informing mergers and acquisitions (Carillo (2001), Delaney and Wamuziri (2001), PWC (2012)); the type of product/services offered (Wikström et al., 2010); new forms of division of labour, competitive products based on more complex scientific knowledge and more demanding customers (Welzl 2011) etc
3. Traditional none users of project management now deploy project management as part of operations or business (Thiry and Deguire, 2007, Gareis, 1991) and as coping mechanism (Hobbs et al., 2008, Hurt and Thomas, 2009) even though projects mostly miss targets for time, cost and quality (put refs). The author argues that the intangible benefits generated, at least partly, explain the motivation for deployment of project management.

## **DEFINITIONS, TERMINOLOGY & THE RESEARCH PROBLEM**

The default interpretation is that value is related solely to the project outcome i.e. from the value management research work by Thiry (2002), Male (2007) and Hamilton (2002). Therefore there is a need to differentiate between project outcome and project benefit. Zhai and colleagues make this distinction clear; that there is value generated as a result of the project outcome and value from the project management deployment itself (Zhai et al. 2009).

### **What is an Intangible Benefit or Dis-benefit**

Intangible benefit and dis-benefit are two sides of the same coin. Using dictionary definitions (The Free Dictionary (2011a), (Oxford Dictionary 2011) and the work of other researchers (Bradley (2010), Murphy and Simon (2002)) the authors therefore define a benefit as ‘an outcome of change that is perceived as positive that enhances and promotes the wellbeing of an organisation and including staff’. Furthermore, the term dis-benefit is defined as ‘the outcome of change that is perceived as negative that inhibits the wellbeing of an organisation and including staff’.

Therefore intangible benefit of project management implementation is defined as

"The outcome accrued from deploying project management that is perceived as positive that enhances and promotes the wellbeing (the ability to remain competitive and sustainable) of the project stakeholders, the base organisation and the society and it is not the project objective(s) itself. The inverse is also true for intangible dis-benefits."

### **Criteria to be an Intangible benefit or dis-benefit**

From literature reviewed (Kaplan and Norton (2004), Yang (1978), Edvinsson (1997), Roos et al. (1997), Kitts et al. (2001), Brooking (1996), Lev (2001) and Ulrich (1998) to mention a few), and dictionary definitions (The Free Dictionary (2011b), Oxford Dictionary Online (2011)) there are two conditions to determine if a benefit is intangible, the 'Intangibility Test' (put refs):

- Immateriality, not easily identifiable or concrete and
- The value of the asset must be difficult to measure precisely

Within the context of project management, intangibility must also meet the criteria for immateriality and realisation of value. This suggests that project management implementation has two value streams, the conventional and the hidden where the conventional covers all the tangible benefits like meeting the cost, quality and time specifications and the hidden will cover the intangible benefits with the definition and characteristics discussed above.

### **Defining the Research Problem**

The research problem is twofold:

1. What are the intangible benefits of project management deployment that generate value and competitive advantage?
2. How can intangible benefits be measured; managed and optimised within an approach that organisations can use in practice?

This paper is part of a wider research on the investigation of the generation of intangible benefits which will map out the areas within an organisation where intangible value from project management deployment manifests itself; helping to develop an approach that helps organisations therefore identify; measure, manage and optimise value generated from project management deployment. The first part of this paper reports on the research that has been done so far while the second part describes further work which is underway to develop an approach that will help organisations maximise the value from project management.

To determine what intangible benefits are, knowledge about tangible and intangible value is required. This involves the review of literature on value from the perspective of permanent organisations and temporary organisations (projects) as these would have been captured in the text of existing literature (Kolltreit et al., 2007). The data should show the differences in how value is perceived in permanent organisation and temporary organisations (e.g. frequency of the use of term 'value' in titles, keywords and abstracts; what other terms are used in place of term 'value' etc.). It should also highlight the differences between tangible and intangible value and throw more light on how this is perceived in permanent and temporary organisations. For example in project management literature, tangible value often equates to the iron triangle. This should then help to generate a list of what researchers say are the value generated from project management deployment and by applying the new knowledge about value in permanent organisations, categorised into tangible and intangible benefits.

## RESEARCH METHODOLOGY

Given the nature of the research problem and the aims of the research; a mixed method approach, using both qualitative and quantitative research methods is likely to be the most appropriate. Cresswell (2008) defines methodology as types of qualitative, quantitative, and mixed methods design or models that provide specific direction for procedures in research design. Quantitative and qualitative approaches are strongly associated with objectivity (quantitative) and subjectivity (qualitative) (Hughes, 2006). Tshakkori and Teddlie (1998) opine that the term 'mixed method' typically refers to both data collection techniques and the analyses given that the type of data collected is so intertwined with the type of analysis used.

Qualitative research provides a means of accessing unquantifiable facts about actual people researchers observe and talk to (Berg, 2009) and researchers speak a language of 'cases and contexts' (Neuman, 2003). According to Hughes (2006), the problem of adequate validity or reliability is a major criticism because of the subjective nature of qualitative data and the viewpoints of both researcher and participants have to be identified and elucidated because of issues of bias. For example, the questionnaire used in a case study can gather data that are both objective (fact: eg what project management methodology is used in your organisation) and subjective (opinion/perception: what is the most effective to share knowledge in your organisation). Another weakness is that contexts, situations, events, conditions and interactions cannot be replicated therefore challenging generalisations (Hughes 2006). Yin (2003) addresses this by arguing that case studies provide the opportunity for analytical generalization whether in single (from theory) or multiple case study (predict similar results (literal replication) or predict contrasting results but for predictable reason (theoretical replication)).

In contrast, quantitative methods seek to gather factual data, to study relationships between facts and how such facts and relationships accord with theories and the finding of any research executed previously (Fellows and Liu, 2008). In quantitative research, researchers speak a language of 'variables and hypotheses' (Neuman, 2003) and uses reliable measurement, is controlled, uses statistical techniques to allow for sophisticated analyses and is replicable (Hughes, 2006). Some of the weaknesses of quantitative research are that quantification may become the end in itself and does not take into account people's unique ability to interpret their experiences, construct their own meanings and act on these (Hughes, 2006).

To gather data whether through qualitative, quantitative or mixed methods, several techniques can be used including interviews, case studies, surveys, experiments, observation, measurement, photography and questionnaires Yin (2003). Fellows and Liu (2008) also include content analysis as a research strategy. The different research methods have their strengths and weaknesses and in selecting the ones applied in this research, critical evaluation of the available methods was undertaken.

According to Fellows and Liu (Fellows and Liu, 2008) action research involves participation by the researcher in the process under study, in order to identify, promote and evaluate problems and potential solutions. However given the research objectives, the authors need to be independent of the process and inquiring looking in.

Fendt and Sachs (2007) consider grounded theory method to be essential research method for the development of new insights into social phenomena and involve the generation of theory from data through inductive and deductive thinking. However

this method is not appropriate as the development of theory is not the aim of this research.

Fellows and Liu (2008) state that the experimental style of research is best suited to 'bounded' problems or issues in which the variables involved are known, or at least hypothesised with some confidence. Experiments are inappropriate as it is difficult to have a 'control' as people behave differently as they engage with different people, technologies and different project scenarios.

According to Cresswell (2008) ethnography is a strategy of inquiry in which the researcher studies an intact cultural group in a natural setting over a prolonged period of time by collecting primarily observational and interview data. This research has limited time and is not concerned with why the project actors behave the way they do.

Krippendorff (2004) defines content analysis as "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the context of their use". Content analysis could be quantitative e.g. used in media research or qualitative e.g. used in nursing and education (Graneheim and Lundma, 2003).

Qualitative content analysis is defined as a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes and patterns (Hsieh and Shannon 2005). One of the major criticisms of content analysis is the issue of trustworthiness of the written text (Graneheim and Lundma, 2003) as texts always involve multiple meanings and there is always some degree of interpretation required.

According to Neuman (2003), the researcher often uses sample or a smaller group from a larger group of people and then generalises the results for the survey for that larger group or population. Surveys operate on the basis of statistical sampling with samples commonly surveyed through questionnaires or interviews (Fellows and Liu, 2008).

Yin (2003) states that the case study method is an empirical inquiry that investigates a contemporary phenomenon within its real life context especially when the boundaries between phenomenon and context are not clearly evident. According to Eisenhardt (1989) case studies typically combine data collection methods such that triangulation of data is possible providing stronger substantiation of constructs and hypotheses. Similarly, Yin (2003) argues that by using multiple case studies, the research is considered more robust. Yin (2003) opines that case studies provide the opportunity for analytical generalization whether in single (from theory) or multiple case study (predict similar results (literal replication) or predict contrasting results but for predictable reason (theoretical replication)).

The research literature on project management intangible value so far is limited and fragmented; often touching different areas of project management work (PMOs; Hurt and Thomas 2009), (real project experiences; Fortune and White 2002), (intangible aspects of project work, Aronson, Shenhar and Patanakul (2013)). For this research therefore, the mixed method approach is the preferred approach. The use of the mixed method approach in project management research is evidenced from the literature review where over thirty journal papers were identified to have used the mixed method approach; combining mostly surveys, single/multiple case study and action research using research methods such as observations, interviews, use of company information from documents and websites etc. Examples include work by Kasvi et al. (2003), Modig (2007), Becerik (2006) and Wikström et al. (2010).

## ADDRESSING THE FIRST PART OF THE RESEARCH PROBLEM

This section reports the work done so far in answering the research question using literature review and content analysis. Hart (1998) says that a systematic search and critical reading of the literature is essential to contributing to knowledge. Content analysis is complimentary to literature review as it can help make sense of the information been found out. Therefore qualitative content analysis using both frequency and latent content analysis (interpretation of content (Hseih and Shannon 2005) on the journal articles and relevant text books and online articles was conducted on literature reviewed on value both from the perspective of permanent organisations and temporary organisations (projects) and project management benefits based on common databases (Ebsco host, Science direct, Wiley Online library and ASCE library) and relevant text books and online articles. The research approach is shown in figure 1. However, the issue of trustworthiness of the sources been investigated was not considered an issue as the findings will be further tested by the multiple case study research method.

Content analysis has been applied in the project management research field. Kolltveit et al (2007) using content analysis on selected text books on project management investigate what perspective today’s authors mostly used in the field of project management. The choice of content analysis was based on the fact that content analysis of what is published reveals what is thought to be important and disseminated also influencing what is used. Similarly, Yu et al (2006) conducted a qualitative content analysis on data generated from survey questionnaires investigating the critical success factors of construction project briefing.

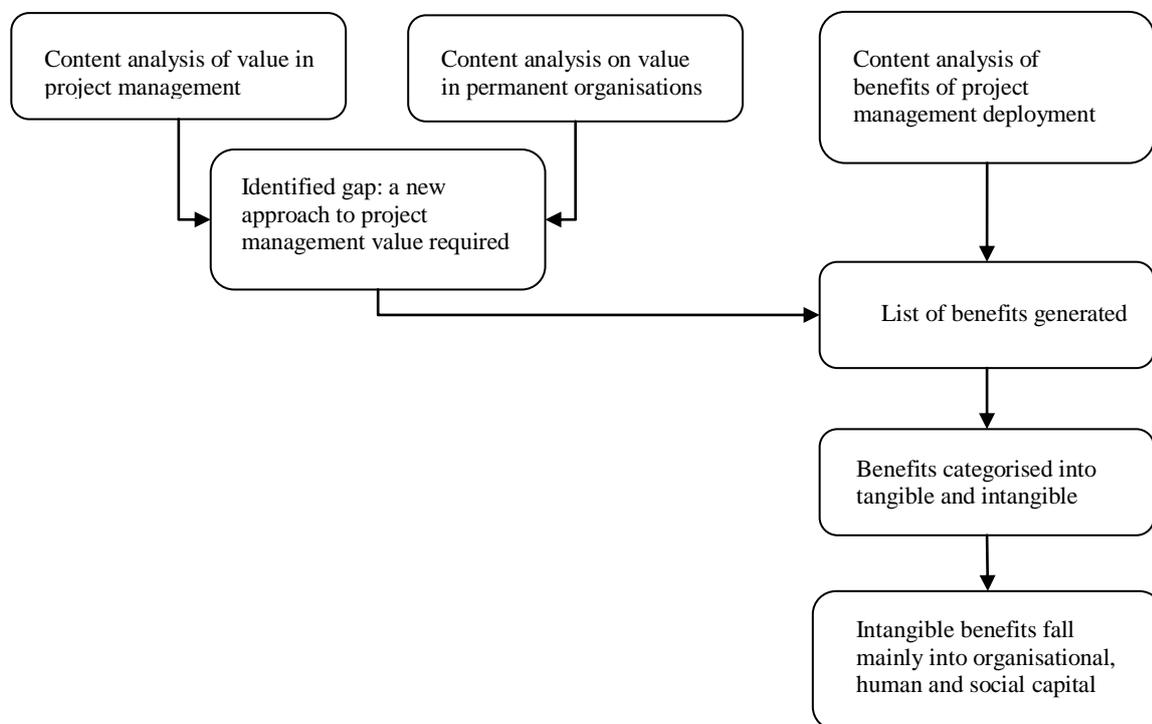


Figure 1: Research approach

A search of the term ‘value’ and ‘project management’ in the title, keywords and abstract of journal articles in the several databases usually returned articles that

referred to value in the context of value management only a few referred to value in the context of organisational value or competitive advantage. It was found that within the project management literature tangible and intangible benefits were often used to refer to value when viewed in the context of organisational value.

The second task involved content analysis on value from the perspective of permanent organisation. The measurement of intangible assets has been studied mostly in two main fields and the perspective of the intellectual capital and intangible assets field closely related to knowledge management field (Lonnqvist, 2002) was more suited to achieve the research objective. Value was discussed in terms of tangible or intangible assets and often argued that intangible value creates competitive advantage (e.g. Brookings, 1996, Lev, 2001, Sveiby, 2001, Kaplan and Norton, 2004). It was also argued that intangible liabilities also existed which had a negative impact on the organisation (Harvey and Lusch 1999). Some of the assets include organisational capital, human capital, social capital, intellectual capital, innovation related capital etc; however the discussion of these is beyond the scope of this paper. There are four main measurement categories for intangible assets; the direct intellectual capital method, the market capitalisation method, return of assets methods or the scorecard methods (Sveiby, 2001), however the authors concluded that these methods are more suited to permanent organisations and their operations and that a different approach based on extant project management literature may be more appropriate for intangible benefits generated from project management deployment.

The third task involved content analysis carried out on the project management literature and a list of benefits was generated from what researchers said were the benefits of deploying project management. A key finding was that the benefits were not obvious from the articles title or keywords and may not use the term 'benefits' to describe it.

Equipped with the lens of value from permanent organisations, the next step involved categorising the benefits into tangible or intangible using the 'Intangibility Test'. Several benefits were categorised clearly as either tangible or intangible while a few were categorised under tangible or intangible by the participants (involved in project management) depending on their own understanding and personal experience. The authors concluded that benefits fall within a continuum from tangible at one end and intangible at the other with a fuzzy area in the middle; where both tangible and intangible characteristics may be observed. This is also supported by existing literature where Bradley (2010) argues that categorising as tangible or intangible implies that in each instance there are only two states but that there is a spectrum of benefit value types and using just two words ignores useful distinguishing information.

This theoretical approach allowed learning from how intangible value has been investigated from the perspective of permanent organisation to be applied to temporary organisations (project management context). The use of content analysis also fits into the pragmatic approach (Aubry and Hobbs, 2011) to understanding the intangible value generated by project management deployment. By capturing what other researchers have argued to be the benefit of project management from existing texts and studying the patterns and relationships and comparing the intangible benefits with characteristics of the different types of 'capitals' identified from the literature reviewed on value from the perspective of permanent organisation, the authors identified that the intangible benefits of project management deployment fall into

organisational capital, human capital and social capital which is now the subject of further study in phase two of the research.

## **ONGOING WORK: ADDRESSING THE SECOND RESEARCH QUESTION**

The research approach for this part of the research is to use the multiple case studies in phase 1 (data to be generated from semi-structured interviews and documents) to investigate the organisational, human and social capital generated from project management deployment and the findings would be used to generate hypotheses that will then be tested by survey in phase 2. According to Johnson and Onwuegbuezie (2004), time ordering of the qualitative and quantitative phases is an important dimension amongst several dimensions of mixed method approaches. They also opine that it can occur sequentially or concurrently and this part research uses the sequential arrangement. The rationale is to test the resultant hypotheses across a wider range of projects and organisations to further investigate to determine the prevalence or frequency of a particular phenomenon (Yin 2003) and will determine whether they are contextual, general or industry specific. This approach will also add to the robustness of the research process and outcome.

Some of the criticism against case study research has been the possible lack of generalisation and external validity (Yin (2003) and Cresswell (2008)). In order to reduce the effects of this and to ensure that the findings are robust, the research design involves multiple data sources (interviews and documents); use of both semi-structured interviews in phase 1 and survey in phase 2. Also the impact of subjective and objective data have been considered and the interview questionnaire has been designed to capture both data types and will also be considered in the analyses and interpretation. In line with the argument by Yin (2003), by using multiple case studies and triangulating the data (Eisenhardt, 1989) external validity can be achieved. The case study protocol (Yin, 2003) will also be used in this research to maintain objectivity of the interview process and the researcher.

The case study part of this research is in the early stages, four organisations who are members of the Major Projects Association have agreed to participate in the research and one serves as the pilot case study. Interviews with semi-structured questions are currently being conducted at two organisational levels: project level to capture project specific data and organisation level to capture organisation specific data all within the context of project management. Once the pilot case study is completed, the data will be used to validate the research methods and test the analysis before the other remaining case studies can be analysed.

## **CONCLUSION**

This is on-going work and the authors would be interested to hear from researchers or practitioners who wish to contribute or collaborate in this work. The final outcome of this research would be to develop an approach for organisations to be able to identify, measure, manage and optimise the intangible benefits generated from project management deployment.

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# COMBINING LEAN CONSTRUCTION WITH MATURITY MODELS

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It has been widely acknowledged that maturity models provide organisations with benefits when implementing a change or improvement strategy. The construction industry has shown particular interest in maturity models as it increasingly seeks to manage organisational change. One type of change some organisations in the construction industry are seeking to manage is the implementation of Lean Construction (LC). The aim of this research is to explore the benefits of bringing together LC and maturity models. Hence data relating to the views on the topic amongst eleven LC practitioners, based in six different countries, was gathered through interviews. The qualitative data collected were analysed using the framework approach. The findings reveal that some of the interviewees already take advantage of maturity models in their practices. Further the findings unearth new potential benefits, applications and possible limitations from the use of maturity models in LC. Overall the data supports the tentative proposition that a focus on investigating a synthesis of the maturity model and LC concepts is a worthy avenue of further research for the academic community in construction management. As a pre-cursor to such investigation the paper introduces a framework of attributes of LC maturity, which is derived from the results of the interviews.

Keywords: framework approach, innovation, lean construction maturity, maturity model, organisational analysis.

## INTRODUCTION

It has been two decades since Lean Construction (LC) first appeared within the construction management research. Since then it has received a significant amount of attention from both practitioners and academics, which is evident through the amount of publications available on the topic. Nesensohn and Bryde (2012) observed that the first occurrence of the term LC was in 1993 through the “1st workshop on Lean Construction” co-ordinated by Lauri Koskela. Recent literature reports that LC is a new paradigm and project delivery system with the potential to deliver outstanding performance improvement in the construction industry (Sage *et al.* 2012). This is confirmed by reports of projects in the UK and US utilising LC. For example claims are made of projects such as a hospital building, a medical office building, HEI buildings and an outpatient facility which have an out-turn of approximately 19% below market cost (Mossman *et al.* 2011).

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However LC is criticised as being not applicable to all types of construction projects (Winch, 2002; 2010). Moreover Green (1999) in particular criticised the ideology that underpins Lean in terms of its appropriateness to construction activities in the UK; with a specific focus on the (perceived) neglect of human resource management in the Lean paradigm. Despite these criticisms it is undeniable that LC is prominent as a strategy for innovative management practices within parts of the construction industry.

It is argued that LC involves not only applying certain tools or principles but it contains the organisation, production and management of construction from an holistic perspective (Koskela and Ballard 2012). Hence the transformation towards LC lead to changes at both the temporary organisation (project) and the strategic management level (Ballard and Howell 1998). Furthermore the organisational transformation towards LC requires long-term and deep-rooted cultural change. This is necessary to embed a Lean philosophy as an integral part of how the organisation operates (Nesensohn *et al.* 2013). Correspondingly, it is necessary to have a clear direction of where an organisation wants to go within their Lean journey.

Moreover the transformation process requires the involvement of the top management, in financial terms as well as managing human resources. Although even with this support success is not guaranteed (Almeida and Salazar 2011). Since LC is seen as innovative improvement approach, a strategy to implement LC often needs changes to the organisational culture and its people (Green *et al.* 2008). However the expected benefits of such innovation are not always clear to see. Hence organisational assessments are a crucial part of an innovation strategy (Mcelroy 1996). Such assessments provide guidance for the enterprise transformation, information about strengths and weaknesses and a prioritising of planned improvement efforts (Perkins *et al.* 2010a). One way to guide such organisational assessments is through the utilisation of a maturity model (MM).

## **MATURITY MODELS**

MM have been mainly studied in organisations within software engineering. The Capability Maturity Model Integrated (CMMI) is the best known MM to emerge out of this sector (Wendler 2012). Research has focused on MM in other contexts, such as: portfolio management, project management, and knowledge management. Some of these studies stress the advantages of the concept of a MM in general terms. So it is claimed that MM enable organisations to assess their current organisational capability/maturity and allow them to implement a change or improvement strategy in an organised way (OGC 2010). Furthermore, it is claimed that an MM provides people with directions and information to prioritise improvement actions, and initiating a cultural change (Pennypacker 2005). Moreover the developers of the CMMI posit that MM guide and improve the ability within an organisation to develop a culture of excellence (CMMI Product Team 2010). In addition to these claimed benefits a main driver of the development of new MM seems to be the information generated. Such information is essential to organisations in planning and directing their on-going transformation efforts (Perkins *et al.* 2010b).

Nevertheless, both the CMMI and its predecessor the Capability Maturity Model (CMM) have not escaped criticism (Hartman and Skulmoski 1998). For instance the CMMI was criticised for its lacks of a guaranteed pay-off in relation to the additional effort and cost of moving upwards in maturity (Anthes 1997). Furthermore there were early sceptical voices. Benbasat *et al.* (1984) highlighted the absence of empirical

support for the concept of maturity stages (levels) within the research domain of information systems - a domain bridging computer science and business management.

Despite these criticisms the construction industry has recognised the potential of MM. Practitioners and policy makers in the UK have signalled agreement of the usefulness of developing MM in construction. This has been through collecting empirical data in the form of questionnaires, case studies and expert panel surveys (Amaratunga *et al.* 2002b). Attempts have been made to contextualise an MM, such as the CMMI, to the construction processes to influence the industry. In fact there are examples such as the Standardised Process Improvement for Construction Enterprises (SPICE) which is a model for construction processes (Sarshar *et al.* 2000), and the development of a standard model for e-procurement from Eadie *et al.* (2011).

In relation to LC and MM there has been limited attention paid to the topic in the literature. One area that received attention is the research on cultural maturity in Lean-managed organisations (Chestworth *et al.* 2010). Likewise is some attention towards lean reported in the form of the organisational self-assessment tools i.e. the Lean Enterprise Self-Assessment Tool (LESAT) within the aerospace industry developed by the Massachusetts Institute of Technology (MIT). This provides an understanding of the Leanness (maturity of Lean Manufacturing) of the organisation to guide the transformation (Perkins *et al.* 2010b). Another example within Lean Production environments is the Shingo Prize Model®. This includes some of the most comprehensive methods to assess the Leanness of an organisation (Bergmiller and Mccright 2009). However the LC literature has neglected to give much attention to MM so far.

Looking outside academic literature in terms of LC and maturity shows some notable attempts within the government and other institutions to advance the topic. For instance the UK Highway Agency (HA) contextualised the LESAT to a Lean Maturity Assessment Toolkit (HALMAT). The aim being to determine the Leanness of the supply chain in relation to the objectives of the HA (Highways Agency 2010). Work has been undertaken regarding the maturity in LC by industry policy makers such as the European Construction Institute (ECI). They developed a scoring system on the basis of a maturity grid (ECI 2012). Such maturity grids are characterised by a text description of each maturity level. This is different to the CMMI-like models that consist of a formal and more complex architecture (Fraser *et al.* 2002).

So it is posited that study of the application of an MM contextualised to LC will be a fruitful avenue for research. It will support organisational transformation towards LC. Therefore the purpose of this research is to gauge the normative views of LC practitioners (LCP) of the benefits of bringing together LC and MM. However, it is important to note that the interviewed LCP are selected on the basis of their experiences of using LC, be they good or bad, rather than as being particular advocates of LC. Indeed the data reveals that some of them concur with Green's (1999) well known critiques of the "dark side of Lean".

## RESEARCH METHODOLOGY

Given the exploratory nature of this study a qualitative research strategy was adopted. It made use of semi structured interviews as the data collection method (Amaratunga *et al.* 2002a). This form of interviews is a powerful and flexible way to understand the attitudes and opinions of individuals (Fontana and Frey 1994, Kvale 2007). Furthermore semi structured interviews have been recommended as appropriate to

increase the depth and breadth of knowledge about the specific phenomena within the construction sector (Shehu and Akintoye 2010). Additionally this form of interviews is frequently utilised to good effect in built environment research (Fellows 2009).

Hence a purposive sample of selected LCP was constructed. The selection criteria was as follows: (1) at least two years of practical experience in LC; (2) experience in a senior management (SM) position; (4) at least five years of working experience in construction management either in an operative or consultative role. The sample contained people from six different countries. These were: UK (LCP#2 and #11), USA (LCP#05, #06, #07 and #10), Germany (LCP#01 and #08), Spain (LCP#03), Peru (LCP#09) and Chile (LCP#04).

The research focuses on two domains: LC and MM. Yet the sample contains only practitioners from LC. This must be considered as a limitation of the study. However it seemed to be more appropriate to concentrate on LCP rather than to interview MM practitioners from outside the construction management domain.

The selected LCP were provided with a one page written summary of MM prior to the interview to ensure a base level of understanding about the MM concept existed. Each LCP confirmed at the beginning of the interview to have read and understood this summary. Additionally the summary was outlined verbally by the interviewer before commencing the interview. Each interview lasted approximately 45 minutes. They were tape-recorded and transcribed afterwards.

The transcripts were analysed using the framework approach (Ritchie *et al.* 2003). This approach utilises charts or matrices to organise the data. It distils key topics for each of the participants while focusing on the central element of the thematic framework (*ibid.*). There are six systematic steps that have been sequentially performed within the research: (1) Familiarisation, (2) Identify descriptive categories, (3) Indexing or (4) Pilot charting, (5) Charting and (6) Investigation and interpretation (Ritchie and Spencer 2002).

## RESULTS

The analysis of the data produced two broad themes and the next section presents the results for each.

### **Theme 1: Combining LC with MM, a LC maturity framework**

The first theme within the interviews focuses on issues related to the potential synthesis of LC and MM to produce a LC maturity framework.

#### *Applicability*

A potential application was identified by LCP#01, #04, #10 and #11. They expressed the view that an LC maturity framework could be applied to monitor and measure where an organisation is placed in terms of a Lean transformation programme. As such it could identify areas for further improvement. LCP#01 pointed out that "this could be something that is applied before LC implementation takes place as a preparation stage".

A limitation to its application was identified by LCP#02. They stated that it would be applicable for big projects that run for years but much more limited for smaller and everyday projects. LCP#04 expressed the view that it was more applicable to owner than contractor organisations. This view was shared from LCP#02 who stated that owners should only measure themselves to see how good they are - not their suppliers.

### *Focus*

There was a general agreement amongst LCP#01, #04, #05, #07 and #11 that project organisations with an embedded owner perspective are a likely focus of any LC maturity framework. However this doesn't exclude its adaptation to all kinds of organisations. LCP#01 emphasised that: "in a project organisation there are the key players, and they come up with valuable and useful information...if it would focus on only one, a very important part of the project would have been left out". This point was built upon by LCP#07 who stated that it has to be focused on the whole project organisation. A slightly contrasting view was put forward by LCP#02 and #06. They pointed out that such narrow focusing would limit any future framework. Furthermore, all parties involved in LC should use such a framework.

### *Usefulness*

Amongst all interviews there was a general acknowledgement that a LC maturity framework would be very useful. This was explained by LCP#02 and #08 through the benefits of an evaluation of their own development in terms of LC. For instance it would have been beneficial for them in terms of getting an idea of where they were and whether they were getting better or not. This point was also made by LCP#11, #04 and #10. As articulated by LCP#10: "if you don't have any measurement you can measure against then you running into the fog or into nowhere". A similar argument was made by LCP#04, who commented that "if you don't measure where you are at this point, it's very difficult and very hard for an organisation to improve". As summarised by LCP#09, who stated that without such a framework you might be "thinking that you are applying things that you not really are".

## **Theme 2: Attributes of LC maturity**

The second theme identifies attributes that can measure or, at least, be used to recognise maturity in LC. Seven attributes were identified: customer-focus, thinking, culture & behaviour, business results, continuous improvement, processes & tools and expertise. Together they provide a framework of attributes of LC maturity (as shown in Figure 1).

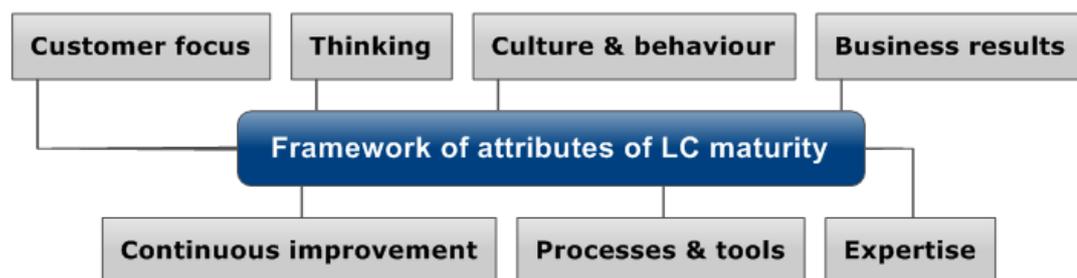


Figure 1: A framework of attributes of LC maturity

### *Customer focus*

The first attribute identified, especially by LCP#04, #05 and #09, was the importance of customer focus. This takes the form of first understanding and then measuring and monitoring customer value. This was neatly summarised by LCP#05: "the first thing I ask is do you understand your customer's value? The second thing is: do you know [by] how much you are deviating from your customer's value?" By answering these two questions maturity in LC focuses on establishing if the organisation or project is customer-driven. A link here was made between the identification and measuring of waste and the thinking of the organisation in terms of what the customer really wants

and need (LCP#04). A final element of this attribute was measuring the actual satisfaction of the customer (LCP#08).

### *Thinking*

Thinking as an attribute for LC maturity was predominantly identified by LCP#01, #05, and #07. Its importance was stressed particularly by LCP#05 and reflected in the statement: "maturity is not just behaviour, but also the thinking because the thinking leads to behaviour". Three types of thinking were identified: 1) process thinking (LCP#01); 2) systemic thinking (LCP#05 and #07); 3) scientific thinking (LCP#05 and #07). Systemic thinking was explained by LCP#05 through the example of seeing the customer and the processes in a systemic way. They further described that "scientific thinking is the ability to collect data to support the decision making or to support the creation of their processes and how they test their hypothesis and how they put measures in place in order to make adjustments".

### *Processes & tools*

That processes and tools are a significant attribute for maturity was noted by several interviewees. For instance: LCP#05 - "systemic processes"; LCP#01 - "process oriented work"; LCP#11 - "different processes and standardised work"; LCP#04 - "value stream maps for [their] processes". This attribute was elaborated upon by LCP#11, who described how "maturity could be seen in all processes and [the processes] should be reflect a Lean philosophy, Lean approach or Lean thinking". In this point LCP#09 concurred. They stated that "maturity is about "how much the process is aligned to really encourage Lean". LCP#07 introduced the topic of tools, arguing that any deployed should be used in a Lean way.

### *Expertise & learning*

The importance of having expertise in LC was elaborated through the actual knowledge that is required about Lean i.e. by LCP#04, #05, #08 and #09. According to LCP#05 knowledge is needed of the five elements of Lean thinking: 1) identify customer value; 2) identify the value stream; 3) create flow; 4) create pull; 5) pursue perfection (Womack and Jones 2003). LCP#02 highlighted that the degree of learning about Lean is the absolute critical indicator in terms of LC maturity. The importance of learning was further emphasised by LCP#04, #07 and #10. They stated that the amount and focus of training, how people engaged with the training and how successfully they applied what they learnt would show how mature an organisation was.

### *Culture & behaviour*

The interviewees described various indicators in terms of culture and behaviour, such as: communication, trust, collaboration and leadership. LCP#03 stated: "I would say communication is the most important aspect in this regard". They also pointed out that it is important to have trust between the people. An example of the collaboration attribute was given by LCP#01. They described how people who are more mature in LC work better together and collaborate more. The issue of leadership was neatly summarised by LCP#10: "leadership is one of the most important ones. The leaders have to understand [LC] and to believe [in it]". In this context the vision or mission of the organisation was regarded as important. For instance LCP#04 and #08 described how it had to be directly aligned with the goal of becoming Lean. Whilst a constancy of purpose and approach after setting the vision/mission was a key attribute of behaviour as identified by LCP#05, #07 and #11.

*Continuous improvement*

LCP#02 and #05 indicated that a mature LC organisation will practice continuous improvement in a systemic way.

*Business results and approach*

Finally the actual business results achieved were identified by LCP#1, #07, and #11 as an attribute of LC maturity. This involved the achieving of targets, especially the level of quality and of costs. In addition the commercial approach was highlighted; for instance, whether it was price-driven or a cost-driven approach.

**Additional notes**

An important point emerged from the interview discussions related to the fact that LCP#07 and LCP#05 actually used a MM for their own Lean purposes. The MM were developed and being used internally within their organisations to support their LC transformation challenges and to gather information of LC maturity. For instance LCP#07 had a MM "... that we use for the Last Planner® System and a generalised MM that we use for Lean management". LCP#05 called their MM a "maturity tool", which was developed to assess projects in terms of their maturity for LC. This is an important point because due to the gap in the literature it wasn't expected that the LCP are more advanced in the development and use of the concept of MM for LC transformations than the academic community.

**DISCUSSION**

Conceptually there is no reason why LC and MM cannot combine. This is supported by the fact that 2 out of the 11 LCP interviewed had developed and used their own MM for LC. But the interview findings stress the gap in knowledge in terms of LC maturity. The research revealed general agreement amongst the LCP in terms of the potential benefits offered by such a combination. Overall MM have the ability to facilitate the transformation of an organisation towards LC. This ability can be harnessed for temporary project-based organisations as well as single entities within projects, such as owners/clients or contractors. In this context the required information about LC maturity would have to consider the owner/client perspective as well as that of the designers, contractors and project managers - if it was being applied within a temporary project-based organisation.

The interview findings are consistent with the reported benefits of MM in general within the literature i.e. Perkins *et al.* (2010b). However the data revealed new ideas, limitations and claims in terms of LC maturity and the absence of a MM for LC. Such ideas, limitations and claims cannot be confirmed or refuted through a lack of evidence in the existing literature. For instance the interviews revealed the normative views of the LCP on new ideas to apply a MM within LC practices. There are issues to address in terms of limits and exclusions of any MM for LC. One viewpoint is that a MM for LC ought to be limited to projects of a certain size. Another viewpoint is that such a model ought to have a focus on the temporary organisation. In such an organisation key players will reside with the required information in terms of assessing LC maturity.

To date the academic community within construction management and LC has not developed a unifying MM for the discipline. The development of such an MM would need to be done through rigorous research, to enable a critical investigation of the claims and experiences of adherents of LC and construction industry practitioners. This paper has made a small contribution to the development of a LC MM by

considering the normative views of a small international sample of LC practitioners. Analysing these views has enabled a framework of attributes of LC maturity to be formed. This framework makes a significant first contribution towards a MM for LC.

## CONCLUSIONS

LC is receiving increasing attention within the construction industry but supporting mechanisms for organisations seeking to transform themselves towards LC are lacking. MM are present in the construction industry but are predominantly used within the project management and process management areas. The literature shows that MM can provide guidance to support organisations dealing with change i.e. to introduce LC. Through 11 interviews with industry practitioners this paper explored normative views of the topic. The findings revealed that a combination of LC with MM could potentially deliver some of the same benefits as claimed from the wider MM literature. The findings further suggest that such a combination is perceived as providing a useful supporting mechanism for organisations transforming themselves towards LC. Whilst some views of the practitioners are aligned with the existing literature, there are some whose veracity can best be tested through the development of a LCMM by the academic community. A framework of attributes of LC maturity has further been proposed based on the interview findings. This framework provides a structure in which LC maturity can be measured or at least recognised. The framework provides a solid foundation on which further research can be built in relation to using MM in LC.

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# IMPROVEMENT OPPORTUNITIES FOR EVIDENCE-BASED DESIGN: AN APPLICATION OF A CRITICAL REALIST'S PERSPECTIVE

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Both industry and academia consider Evidence Based Design (EBD) to be a positive way forward to improve the quality of the health service through better utilisation of rigorous evidence during the design process. The use of rigorous evidence is not a distinct activity of the design process; it materialises on different routes and activities scattered throughout the design process and which presents many prospects for improvement. The aim of the reported research is to identify how the evidence based design process could be improved. The research takes a critical realist's perspective. An overview of evidence based design, and critical realism are discussed in the background literature. Twelve semi-structured interviews with professionals working on healthcare built environment projects were used to gather data pertinent to their choice and application of different sources of evidence. Results validated a conceptually derived model of current practice of EBD and highlighted prospects for improvement. Interviews were thematically analysed to identify the rationale behind current practices and such themes were then used in deriving mechanisms and contingent conditions of the EBD. Six mechanisms that are causally efficacious prospects for improvement and four contingent conditions that flourish or suffocate these prospects were derived. Several suggestions are proposed several to improve EBD in the UK together with a discussion of the experience of adopting a critical realist's approach.

Keywords: critical realism, design, evidence-source, healthcare.

## INTRODUCTION

With the ambition of improving health outcomes through built infrastructure, evidence based design has captured attention of the researchers for the last three decades. The research reported in this paper forms part of a three PhD programme based in the Health and Care Infrastructure Research and Innovation Centre (HaCIRIC). The purpose of the overall research is to identify improvement opportunities for evidence based design for healthcare. In the first phase of the research, interviews were conducted to establish EBD current practice and identify the rationale behind it. The EBD current practice has been articulated into a conceptual model which has been previously presented in detail (Wanigarathna et al. 2012) and is summarised briefly in this paper. This paper mainly discusses the analysis of the rationale behind current practice to identify mechanisms and contingent conditions of the EBD, while explaining how critical realist view applied in this research.

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## **EVIDENCE BASED DESIGN**

It has long been recognised that the surroundings of patients can affect their healing, for example, Florence Nightingale's (1820-1910) notes reveal her experience of how surroundings impact on healing. Prior to the last three decades, most of this knowledge was based on anecdotal evidence, however, during the 1980s, a growing body of rigorous research has investigated how built infrastructure can impact on physical, physiological, psychological and behavioural outcomes of staff, patients and other users (Codinhoto et al. 2009; Ulrich et al. 2008; Phiri 2006). Evidence Based Design (EBD) emerged as a concept of healthcare design to increase the use of rigorous-research evidence. In addition to health outcomes, EBD is also argued to support whole life value savings, operational efficiency (Berry et al. 2004) and innovation (Lawson 2005; Suttell 2007) for healthcare and provides a competitive advantage for its users (Stankos and Schwarz 2007; McCullough 2009). EBD is now recognised as good design practice that can be used for the design of other locations such as offices and learning environments (Hamilton and Watkins 2009).

Evidence as in EBD stands for up-to-date research based knowledge, derived through the highest rigour as defined by the world view within which research is conducted (Moore and Geboy 2010). Such evidence can be generated by researchers in academic and other research institutions as well as practitioners in the industry. Opportunities for the practitioners to produce rigorous evidence is claimed to be restricted and most rigorous evidence is currently generated by researchers and published in peer-reviewed journals (Hamilton 2010). However, uptake of such evidence is limited for reasons related to lack of time and cost resources in accessing them (Martin and Guerin 2006 and 2007; Lawson 2010; Becker and Parsons 2007) and practitioners' negative perceptions about the effectiveness of such evidence (Lawson 2010; Dijkstra et al. 2006; Stankos and Schwarz 2007). The aim of this research was to identify ways to increase the utilisation of rigorous research evidence during the design process.

## **RESEARCH METHODOLOGY - CRITICAL REALISM**

Researches contained in the peer-reviewed journals are not a primary source of evidence in designing. However, research could be disseminated in the design process through alternative routes. Exploring the rationale behind designers' choice of different sources of evidence would disclose prospects for different routes of EBD. This view of analysis follows the philosophy that of critical realist's.

Critical Realism (CR) is a philosophy derived primarily from the work of Bhaskar and his colleagues (for example: Bhaskar 1978; Archer 1995). It has since been adapted, developed and described further by other scholars (for an example Archer 1995; and Sayer, 1992). Researchers in organisational management and construction management have adopted this world view Ackroyd and Fleetwood 2000; Fleetwood and Ackroyd 2004; Reed 2008; Easton 2010). Ontologically, CR assumes a stratified reality that comprises three strata: 'empirical'; 'actual'; and 'real'. The empirical layer is the socially construed (not constructed) reality observable by individuals, while the actual layer is the events that exist in time and space and the real layer is the social objects possessing a structure and tendencies/mechanisms that are causally efficacious to the production of empirical events (Bhaskar 1978)(see Figure 1). Therefore, CR is an advanced alternative to interpretivism, which often stops the search at socially constructed empirical reality.

Mechanisms play a major role in CR's explanation; these are particular ways of acting (Sayer 1992) or what an entity is capable of doing, or being acted upon, if it is triggered and not prevented by other events (Bhaskar 1978). Mechanisms necessarily exist by virtue of their object's nature (Sayer 1992). Social objects have necessary relationships with their mechanisms. However, the relationships of mechanisms to actual events are contingent upon 'conditions'.

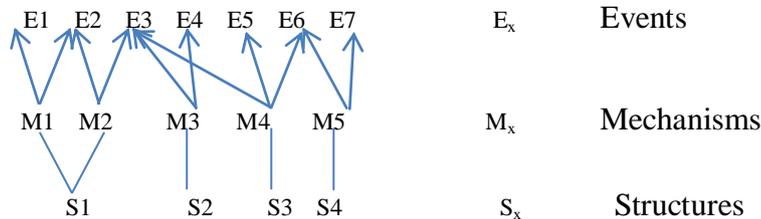


Figure 1: events, mechanisms and structures (source: Sayer 1992)

These are conditioning of causal mechanisms which turns (or fails to turn) causal potential (mechanisms) into a causal outcome (Pawson and Tilley 1997). The existence of a mechanism does not guarantee the occurrence of a particular empirical event; it could flourish or be suffocated by contingent conditions. Epistemologically, CR does not assume privileged access to the 'real' strata of reality (structures, mechanisms and contingent conditions). Bhaskar's classic example for this is that irrespective of our (early) perception that the earth is flat; the earth has always been spherical.

Identifying events at the empirical level provides a good starting point. Yet, the point of CR in social science is not merely to provide an external description but to identify opportunities for change. Researchers need to hypothesise social objects and their tendencies/mechanisms that have the capacity to produce actual events. Identification of a hypothesis for social science phenomena is often considered to be easier than in natural sciences since we have 'internal access', through practice, to many of the structures, mechanisms and reasons and beliefs similar to our own which may function as causes (Sayer 1992). Further, even though natural sciences have a flat ontology over the time (since the universe began), scholars acknowledge the temporal nature of single reality for social phenomena. Bhaskar (2008), in his transformational model of social activity, acknowledges this by explaining the emergent properties of social structures. Archer (1995) and Mutch (2010) explain this temporal dimension through the 'morphogenesis' nature of critical reality. Sayer too (1992) acknowledges the ability to redefine social structures and change the mechanisms/tendencies of social objects by introducing radical changes. On this stance, CR's analysis could identify opportunities to redefine social structures to incorporate better mechanisms that result in more favourable empirical events.

Explicit literature on how to analyse data by a CR method is limited (Bygstad and Munkvold 2011). Sayer's (1992) explanation the reason for this that CR is more concerned about ontology over epistemology and that CR researchers takes a pragmatic approach in search for reality. But, Bygstad and Munkvold (2011) also highlight that this could act as a barrier to novice researchers to follow CR. Therefore, this paper contributes to CR methodology by adding an exemplar application of CR to a construction management research as described in the next sections.

## APPLICATION OF CR TO THIS RESEARCH

### Research process and research methods

The research followed two steps, identifying firstly current practice of EBD in the industry (empirical and actual levels of reality) and secondly, the mechanisms and contingent conditions behind such practice.

**STEP I:** Literature, relating to evidence based design and design knowledge sources were used to determine empirical level practice concerning the use of different design information (including rigorous research evidence). These were then summarised in to a conceptual model (see Figure 2) (Wanigarathna et al. 2012) to better illustrate the complicated phenomena. Weak data flows are illustrated by intermittent lines. The model was verified by a series of interviews with academics and validated through industry interviews, even though this process is not discussed in this paper.

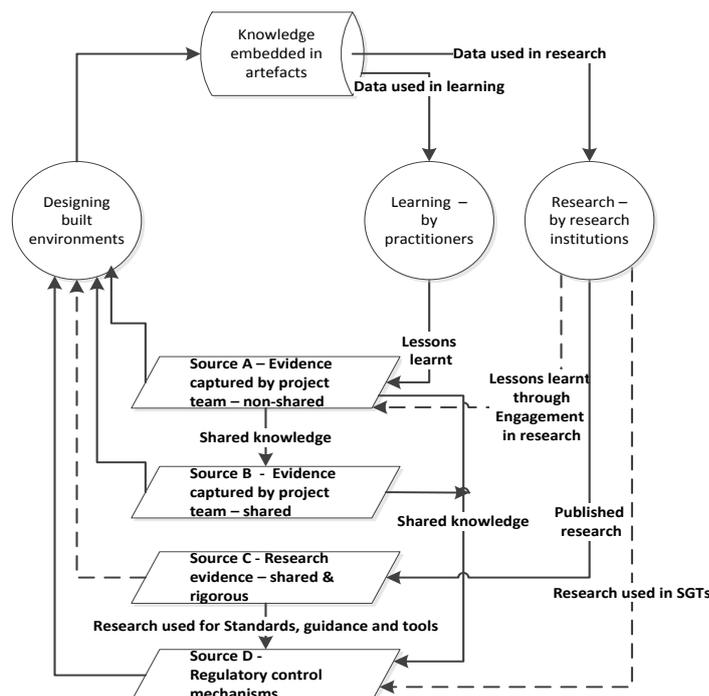
**STEP II:** Twelve semi-structured interviews with professionals working on healthcare construction projects gathered data pertinent to their choice and application of evidence. The reasons for obtaining evidence from four sources and the reasons for not being limited to a particular evidence source were identified separately for the four sources using the model as an aid.

In natural sciences, it is harder to observe mechanisms, but, in social science it is usually possible (Sayer 1992; Bygstad and Munkvold 2011). The rationale identified by interviews was categorised thematically to distinguish logic for each of the four sources of evidence. These were classified as reasons that suggest mechanisms (tendencies) or contingent conditions and subsequently used to postulate mechanisms and contingent conditions that impact the use of evidence from different sources.

## RESULTS AND DISCUSSION

### Step I - Current practice of evidence-based design (empirical and actual levels)

The model below, derived as discussed in the previous section, differentiates evidence flowing into the design process into four evidence sources (see Figure 2).



*Figure 2 – Process of evidence based design*

They are:

- Source A: organisational specific non-shared evidence;
- Source B: shared evidence from the industry;
- Source C: rigorous research evidence; and
- Source D: standards, guidance and tools.

Source A evidence is often considered to be anecdotal, resulting from poor data collection and analysis practices due to practitioners' lack of resource to conduct systematic research. Source B evidence is of higher rigour compared to source A, as industry best practice is often been subjected to a certain level of evaluation and has higher levels of reliability due to repeated use. Evidence from source C has the highest rigour and tallies with the definition of evidence associated with EBD. Source C is often constituted of evidence produced by universities and other research institutions. Evidence from source D, includes design standards and guidance (such as Health Building Notes/HBNs, Health Technical Memoranda/HTMs, etc.,) published primarily in the UK by the Department of Health. The rigour of the evidence from source D is dependent upon the base evidence (from either source A, B or C) which supported the generation of the information. Several empirical-level events that would increase the use of rigorous evidence can be identified from the model.

- a. Increase the use of source C– identifying the rationale for using types of evidence would help to develop source D evidence into a more practitioner friendly source.
- b. Increase the use of source C evidence to produce source D evidence – improve the process of SGT development.
- c. Increase the rigour of evidence in source A - improving learning from projects.
- d. Increase the flow of evidence from source A to source B– through improved knowledge sharing.

This research is limited to identifying opportunities to improve EBD through 1, 3 and 4, which are related to project level practices. The next sections describe the research methods used to collect and analyse data to identify causal mechanisms and contingent conditions that could bring changes to the practice through 1, 3 and 4.

## **Step II - Mechanisms and contingent conditions of practices**

Table 1 shows the rationale and the limited use of the four sources of evidence, with classification of the rationale as mechanisms (indicated as 'M') or contingent conditions (indicated as 'C') needed critical thinking. Some of the reasons (such as availability of time and money, availability of access) were clearly categorised as conditions. Similarly, weakness (such as incompleteness, inadequacy) of source A evidence sources are clearly mechanisms, i.e. 'exist necessarily in virtue of the nature' (Sayer 1992) of source A. But some were difficult to classify, for example the weakness of some of the evidence sources such as 'evidences are biased', 'evidences are not up-to-date'. Sayer's (1992) explanation of characteristics of mechanisms/ tendencies and conditions for social sciences was useful in determining the status in these situations. He explicates that some interventions are concerned with exercising mechanisms by manipulating the conditions in which they operate, while radical changes could alter social structures (necessary conditions) by virtue of which of the mechanisms exist (Sayer 1992). Accordingly, the reasons that remain largely unchanged over a considerable period of time and thus need radical intervention to change them were categorised as mechanisms (tendencies), whilst those that could be changed within a short period were categorised as contingent conditions. Existing

literature regarding evidence sources were considered to determine the time and effort needed for the change or to determine whether the change would be radical or minor. For instance, EBD scholars suggest that the research evidence base is still growing and thus, will remain incomplete for a considerable period of time. Even a radical change would not be able to remove this inherent tendency. Such reasons were therefore identified as tendencies.

*Table 1: Rationale for using evidence from four types of evidence sources*

Source of evidence	Reasons for use	Reasons for not being limited to the source
Evidence from source A	<ul style="list-style-type: none"> <li>- weakness of other resources (M)</li> <li>-for evidence can only be found internally(M)</li> <li>- no faith in knowledge transfer (C)</li> <li>- strong resources found internally(C)</li> <li>- to make an added value to SGTs (M)</li> <li>- to understand what other sources to seek (M)</li> <li>- for project unique issues (C)</li> </ul>	<ul style="list-style-type: none"> <li>- internal resources reflect their own interests (M)</li> <li>- take advantage of additional evidence (M)</li> <li>- inadequacy of internal resources (M)</li> <li>- incompleteness of internal knowledge (M)</li> </ul>
Evidence from source B	<ul style="list-style-type: none"> <li>- can bring expertise in (M)</li> <li>- to select the best available source (M)</li> <li>- inadequacy of internal sources</li> <li>- reliability (M)</li> <li>- to evaluate design (M)</li> <li>- obtain a lot of information (M)</li> <li>- the form and format of evidence (M)</li> </ul>	<ul style="list-style-type: none"> <li>- not tested (M)</li> <li>- unique nature of projects and systems (C)</li> <li>- lack of time (C)</li> <li>- access (C)</li> <li>- different languages (M)</li> </ul>
Evidence from source C	<ul style="list-style-type: none"> <li>- identify best practices (M)</li> <li>- difficulties in producing internally by project stakeholders (M)</li> <li>- characteristics of research (M)</li> <li>- have access through collaborations (C)</li> <li>- to justify the design decisions (M)</li> <li>- ability to afford the cost (C)</li> </ul>	<ul style="list-style-type: none"> <li>- discrepancies of evidences (M)</li> <li>- lack of evidence (M)</li> <li>- not available in a central place (C)</li> <li>- not enforced through SGTs (M)</li> <li>- not easily available (C)</li> <li>- unique nature of projects (C)</li> <li>- academic language and format(M)</li> <li>- need to be supported by operational practices as well (M)</li> <li>- cost and time (C)</li> </ul>
Evidence from source D	<ul style="list-style-type: none"> <li>- legal enforcement (M)</li> <li>- is involved in SGTs development (C)</li> <li>- advantages of standardisation (M)</li> <li>- characteristics of SGTs (M)</li> <li>- other (C/M)</li> </ul>	<ul style="list-style-type: none"> <li>- above SGTs is better (M)</li> <li>- for areas that are not covered by SGTs (M)</li> <li>- not always rigorous (M)</li> <li>- local contextual restrictions (C)</li> <li>- SGTs lagging behind the practice (C)</li> <li>- considered only as a brand (M)</li> <li>- cost (C)</li> <li>- other (C/M)</li> </ul>

The following mechanisms and tendencies that were capable of influencing a particular source/type of evidence were postulated through above results.

*1. Weaknesses of evidence source require the use of more than one source:*

Interviewees revealed the weaknesses inherent in all four evidence sources. Evidence from source A was recognised to be weak because they ‘reflect their own interests’ are ‘inadequate’, and ‘incomplete’. Evidence from source B was also identified as weak because it was ‘not tested’ and source C with ‘having discrepancies’, being ‘inadequate’ and ‘has limitations to results’. Evidence from source D was described as ‘some areas of design are not covered by any of them’, ‘not always rigorous’, ‘very loose’ and ‘not up-to-date’. These weaknesses have necessitated practitioners perusing

evidence from more than one source. Therefore, a single source of evidence source does not dominate the flow. Improving the rigour of evidence contained in all four sources is therefore important to increase EBD during the design stage. Specifically, both feeding research evidence (source C) into the SGTs and other sources and increasing the rigour of the evidence produce by project organisations are important.

*2. Sources that contain evidence that can be found only in one source confirm the use of that particular evidence source:*

Commercially sensitive evidence can be found only in source A, and rigorous evidence contained mostly in C sources. For these reasons evidence from source A and C are inevitably sought by practitioners, unless they are restricted by any contingent condition. This suggests the ability to increase the flow of rigorous research (source C) evidence into the design process, by manipulating contingent conditions (see next section).

*3. Evidence in user-friendly forms and formats encourages use:*

User-friendly forms and formats of evidence have been identified as a reason to pursue evidence from source B sources. However, some of the evidence was considered less than useful since they are 'not written for the laymen' (source D) and use 'academic language and format' (source C). These views suggest that evidence with user-friendly forms and formats tend to increase their usage. In this respect, databases of research summaries, which are developed to improve the form and format of evidence (for instance, the safer environment evidence-database developed by the UK's Department of Health and the InformeDesign evidence summary database developed by Minnesota University) has a better chance of increasing the direct flow of rigorous research evidence into the design process.

*4. Evidence that is legally enforceable encourages use:*

Legally enforceable evidence has a tendency of attracting use, but only found in source D (not even source C.) Therefore, if the evidence from source C can be transmitted into any other source to promote indirect-use, transmitting the evidence into STGs (source D) offers a unique advantage.

*5. Other compelling characteristics of evidence that encourage use:*

Similar to weakness in the evidence that has a tendency to decrease usage, compelling characteristics associated with evidence has a tendency to increase it. In addition to the above major tendencies, interviewees have identified compelling characteristics associated with all four types of sources. They identified evidence from sources A and B as 'reliable' since they have experienced them directly or indirectly. Evidence from C sources were acknowledged as 'rigorous' and that from source D as 'tested', 'well-structured', 'clear about what evidence it is based on, 'provide reference of where to look' and 'evidence that provides advantages of standardisation'.

*6. Practitioners tend to search evidence from different sources to add more value:*

The above tendencies are related to the nature of evidence and its sources. The rationale behind evidence use revealed the existence of organisational related tendencies. Several interviewees acknowledged that they peruse evidence from every possible source to increase the value of their work to clients. Some of them also regarded maintaining a strong evidence base internally to be a competitive advantage that makes them 'an organisation of choice' by clients.

In summary, these results reveal that there is no single evidence source that contains supreme tendencies to encourage their specific usage: all four types possess tendencies towards use and non-use. However, have unique tendencies that do not

exist in other sources. For instance, the tendency of 'rigorous' has been identified as the only tendency with competitive advantage, with source C identified as 'rigorous', whilst only evidence in source D was considered as 'legally enforced'. These unique tendencies can provide competitive advantage. Standards, Guidance and Tools (source D sources) have more positive tendencies than any of the other type, although, possessing such tendencies does not necessarily mean that Standards, Guidance and Tools will always be used.

As stated earlier, existence of tendencies does not guarantee the use of evidence from a particular source. The use or none-use may suffer or flourish or be suffocated by contingent conditions. The following contingent conditions (see Table 2) were identified through interview data analysis. '\*' denotes that the particular condition has an impact on the designated evidence source.

Table 2: Contingent conditions

Condition	Source A	Source B	Source C	Source D
1. Availability of evidence	*			
2. Time and cost resources to access		*	*	*
3. Preferences for active knowledge over passive knowledge		*	*	*
4. Local contextual restrictions, project unique nature		*	*	*

Firstly, even though all four types of evidence have tendencies that influence the use of those sources, availability of evidence controls the use or none-use. This was identified as a key barrier for evidence in source A. When the design team acquires a new project that is unfamiliar, they do not possess sufficient internal evidence to cope. In other cases the internal evidence base was identified as 'not large enough' (a lower number of similar projects that the design team has previously undertaken) to obtain firm conclusions. These reasons determine the need to seek evidence from other sources. Secondly, time and cost resources have an impact on seeking evidence from external sources (B, C and D). This is a significant issue for source C, since evidences are scattered in a number of journals and the time and cost to access them creates a large burden on the project. An instance for attracting use of source C evidence occurs when these two barriers are not prominent. When healthcare clients have access to a great number of journals for medical purposes, they also search for therapeutic building evidence when they are involved in a building development project. This creates a flow of evidence from source C into the design process. Similarly, the need to pay for standards and guidance has been a barrier for D sources. Thirdly, lack of faith in current knowledge transfer mechanisms has been a barrier to the use of external knowledge. Some interviewees expressed a preference for using the research evidence (source C) and guidance (source D) that are produced in conjunction with them. This suggests the importance of collaboration between academic institutions, those who produce standards, guidance and tools and practitioners. Finally, local contextual issues can also prevented use of evidence from external sources, even the use of mandatory evidence in source D. These are primarily site related and service/care model related issues, such as shape of available land, local building regulations, type of patients treated in the facility. For project unique issues project teams are obliged to devise solutions based on knowledge and experience.

These research findings are part of an early stage of abductive analysis that was used in the CR method. The next step is to postulate middle range theories (from the

identified tendencies) that could explain empirical level practices and then validate them with further rounds of data collection in a comprehensive abductive process. During these early steps, the researcher's experience was that postulating middle range theoretical level mechanisms for social science researches is easier than in natural sciences as claimed by Sayer (1992). For instance, from this analysis it could be hypothesised that some procurement arrangements have mechanisms that encourage better use of evidence. Similarly, different forms of evidence have different mechanisms encouraging the same. Yet, completing the whole research process needs either more time or involving more resources. Further, differentiating between causes that lead to mechanisms and contingent conditions was complicated and required critical thinking. This is due to some contingent conditions for the phenomenon concerned in this research could be a mechanism for some other phenomenon.

## CONCLUSIONS

Previous researchers have identified barriers to transmitting research evidence (source C) into actual practice and in not taking a holistic approach. This research contributes to this gap by identifying the rationale for using various design knowledge sources during the design stage. Since all four sources contain inherent weaknesses, single forms of evidence source do not dominate evidence flows. Improving the rigour of evidence contained in all four evidence sources is therefore important to increase the practice of EBD. The rigour of the evidence provides a competitive advantage for source C, so removing the blocking contingent conditions should increase its application. However, its inherent weakness would still limit usage and it is hard to imagine a radical change that would resolve this, as Cama (2009) suggests, improvement will evolve with time. Standards, guidance and tools (source D) have many compelling characteristics that tend to increase the evidence contained within them. So their discontinuation, as recently contemplated due to changes in healthcare provision in England, is not appropriate and this was made explicit throughout the interviews. Lack of literature explaining the data analysis process for deriving mechanisms and contingent conditions from data make it difficult for novice researches to apply CR.

The step in the research will be to conduct three case studies to identify the practice of EBD in depth and explore opportunities to improve it. A framework guiding how to improve EBD at project level will be subsequently derived.

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# ORGANIZING CONSTRUCTION PRACTICES IN DIFFERENT CULTURAL CONTEXTS

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This paper presents in-depth case studies of construction practices with a specific focus on understanding the emergent and dynamic nature of construction management in different cultural contexts. The cases are based on actual working-experiences by the author as an assistant project manager participating in the construction management on site working for three different contractors in different cultural contexts: (1) Construir Futuro S.A. in Quito, Ecuador; (2) Anker Hansen & co. A/S in Copenhagen, Denmark; and (3) E. Pihl & Soen A/S in Stockholm, Sweden. Based on these explorative case studies a number of characteristics and challenges related to the cultural context have been identified highlighting a central issue in existing and future construction practices due to the globalization and thereby increasing importance of cultural understanding in project-based organizing. The empirical findings emphasize a significant influence of the cultural context on construction practices and suggest a general need to recognize the diversity rather than suppressing it. Lack of cultural understanding and recognition of its diversity may lead to considerable managerial challenges in construction practices.

Keywords: case study, construction practice, cultural context, modularity, project-based production

## INTRODUCTION

Project-based organizing is to an increasing extent applied in production practices today. As a consequence an increasing interest is shown by researchers into the field of project management. Although this has led to extensive work into the field some authors argue that the general scope and focus has been much too narrow (Söderlund, 2004). According to review of the literature by Packendorff (1995) the research suffers lack of empirical studies. This may question to what extent the existing organization theories are consistent with project management in practice. This calls for a practice-based perspective on project management where practices are perceived as individual, social and material entities which are context dependent. Accordingly, Söderlund (2004) calls for in-depth case studies in order to grasp and understand the dynamics, diversity, and fundamental issues in project-based organizing in its real-life context.

Addressing the call for empirical studies, this paper is based on three in-depth case studies of existing project-based production (PBP) practices within the construction industry in different cultural contexts. These working experiences across cultural

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contexts prepare the ground for an explorative and comparative investigation of the influence of the culture and social values on organizing construction practices.

Looking into the literature considerable empirical research has been made on the relationship between management practices and culture. Many of the findings from these studies (e.g. Pheng *et al.* 2002) support the thesis by Hofstede (1980) that each culture has a preferred coordination mechanism, implying better business performance is achieved when management practices are congruent with cultural values. However, whereas most of these empirical studies present findings based on quantitative investigations this paper is explorative and based on a qualitative research.

## **METHODOLOGY**

This research combines an analytical framework with empirical data from three ethnographic studies. In contrast to many other empirical studies in the field of construction management research (e.g. Almahmoud *et al.* 2012 & Ling *et al.* 2012) the data collection is based on actual working experiences by the author as part of the construction management in three PBP practices in different cultural contexts. However, some methodological problems of participant research do exist as subjective interpretation by the researcher is inevitable. To accommodate this issue a general theoretical perspective is applied to substantiate and verify findings.

The three cases on PBP practices encompass: (1) *Construir Futuro S.A. in Quito, Ecuador*; (2) *Anker Hansen & co. A/S in Copenhagen, Denmark*; and (3) *E. Pihl & Soen A/S in Stockholm, Sweden*. These working experiences, of a period of 3-8 months each, have taken place in the period from June 2010 until August 2012.

The author was present in the projects, participating on a daily basis in the 'main' activities, which covered central meetings, workshops, and production activities. In addition to participant observation project members were interviewed. An extensive part of the material was codified field notes. Furthermore, formal project documents have been made available. This empirical material has been analyzed using an analytical framework combining Practice Based Theory and Modularization.

## **THEORY**

According to Schilling (2000), modularity is a general systems concept, typically defined as a continuum describing the degree to which a system's components may be separated and recombined (p. 312). Given the open-ended nature of the concept, Campagnolo & Camuffo (2009) argue that every system is modular to some extent.

However since modularity mostly have been studied in stable settings (mass production environments) Thuesen (2012) develops a reinterpretation of modularity based on Practice based Theory (Nicolini 2012) in order to understand the dynamic and socio-technical nature of PBP practices. In the practical analysis of the modularity of socio-technical practices Thuesen (2012) suggests the following guiding questions with a special focus on how stability, standardization and repetition is practiced:

- What is produced/delivered (product modularity)
- How is it produced/delivered (process modularity)
- Who is producing/delivering it (organizational modularity)

Since every socio-technical system is modular it is interesting to start analyzing the modularity of different PBP practices in order to discover differences and similarities.

Given our interest in understanding the practices of PBP in different cultural contexts, the above mentioned framework is extended by a cultural dimension represented by the work of Geert Hofstede.

According to Hofstede, culture is formed through a series of drivers such as nature, climate, religion, history, and politics. It may be defined as *"the collective programming of the mind which distinguishes the members of one human from another"* (1980, p. 25). Based on a very comprehensive study of how values in the workplace are influenced by culture Hofstede identified four major value dimensions for comparing cultures. A numerical scale 0-100 indicates low to high values in the respective dimensions. Table 1 shows an overview of the four cultural dimensions.

*Table 1: Characteristics of the four cultural dimensions by Hofstede (1980, 2013)*

Cultural dimension (0-100)	Low score	High score
Power Distance Index (PDI) <i>Acceptance of hierarchy</i>	Low acceptance Equal rights Disagreement accepted	Hierarchy has privileges Subordinate awaits instructions No open disagreement
Individualism (IDV) <i>Handling relationships</i>	The group: "we" In-group opinion Indirect communication	The self: "I" Personal opinion Direct communication
Masculinity (MAS) <i>How we motivate</i>	Moving objectives/targets Interesting job, quality of life Consensus	Clear objectives/targets Career, wealth, status, success Confrontation
Uncertainty Avoidance Index (UAI) <i>Handling uncertainty</i>	Generalists Need for guidelines Informal/relaxed	Specialists, experts Need for rules and structure Formal/stressful

A central point of criticism with regard to the application of Hofstede's work is the assumed 'illusion of stability'. In relation to the cultural drivers it is possible that, over time, Hofstede's (1980) country scores used to create the cultural distance indices have lost predictive validity. However, most cross-cultural researchers assume that cultures are relatively stable systems in equilibrium (Brett et al., 1997, p.79). Even if these considerations suggest that the country scores applied in this paper may not reflect the present real-life cultural context to an exact degree, the scores still indicate the relative difference, thus not affecting the essence and ambition of this paper.

## ANALYSIS

In order to better understand the practices of project based productions in different cultural contexts three cases have been investigated. An overview of these cases on construction practices is shown in Table 2.

Table 2: Cases on PBP practices in different cultural contexts

	Case 1	Case 2	Case 3
Company name	Construir Futuro (CF)	Anker Hansen & co. (AH)	E. Pihl & Soen (Pihl)
Project name	Victoria	Soelvgade School	Årsta-Älvsjö Railway Bridge
Construction sector	Housing	Education	Infrastructure
Project location	Quito, Ecuador	Copenhagen, Denmark	Stockholm, Sweden
Relative project scope	Medium scale	Medium scale	Large scale

Although these cases reflect three very different construction sectors it does not remove the frame of reference to better understand the cultural influence on the construction practices as each case is analyzed in its project-specific context by looking into the socio-technical modularity.

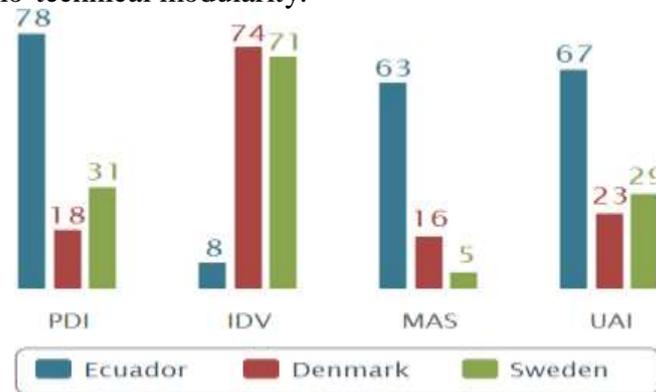


Figure 1: Cultural value scores of Ecuador, Denmark, and Sweden (Hofstede, 2013)

In accordance with the theory by Hofstede (2013), Figure 1 shows the values of the cultural dimensions for each of the three national contexts which frame the PBP practices investigated. In agreement with the analytical framework we will now analyze the three PBP practices as listed in Table 2.

### Case 1 – Ecuador

#### Product modularity

In order to accommodate a market demand of low cost family homes CF has developed a product design based on low complexity and high standardization allowing a low cost high speed construction practice.



Figure 2: Standardized concrete segments applied at Victoria

Inspired by scientific management the multistory mass housing scheme of Victoria is based on a standardized and modular formwork system of concrete segments enabling

a standardized installation and integration of water, ventilation and electricity. The standardized concrete segments applied at Victoria are illustrated in Figure 2. Only a few materials are used like concrete, piping, cables, tiles, painting, glass, and wood.

#### *Organizational modularity*

Organizing construction practices of CF is based on an extensive integrated value chain covering all main processes from buying the lot to the final sales to the end consumer. This model is enabled by a series of sister companies including real estate, concrete delivery, pre-fabrication, and contracting (CF) extending to the management on site across all primary crafts. These conditions allow a flexible production practice on site and across similar projects based on the same modular and standardized product design. A continuous optimization and allocation of workers in the specific PBP practice and across projects may be made in respect to variable local sales.

In accordance with the standardized construction practice the project-based organizing is characterized by structure and rules. Each actor has a specific role with specific pre-defined tasks, however, subject to temporary collective activities across disciplines in times of variable local production needs on site. This project-based organizing is supported by a hierarchical framework. At the top, project management and the project manager is in charge of the daily production on site by communicating with the so-called “Maestro’s”, or foremen, of the respective crafts. In relation to the low complex product design only a few crafts interact in the PBP, primarily: masons, plumbers, electricians and unskilled construction workers doing the groundwork and formwork.

#### *Process modularity*

Inspired by scientific management the industrialized construction practice by CF separates design and production as two clearly distinct phases. By the design the entire building may be decomposed into a number of standardized subsystems with scientifically well-defined interfaces which also define the related production processes. In this way, the design and production are two integrated phases which link the rational construction together, through structure, standards and transparency.



*Figure 3: Pre-fabrication and installment of tiles*

CF has developed a number of standard designs and procedures applied across all projects. The well-known design is described through detailed drawings and plans, but most importantly through similar practices across projects which enable a low cost and highly efficient construction practice. The standardized and modular concrete segments indicated in Figure 2 represent the cornerstone of the construction practice. In relation to the integrated value chain a parallel pre-fabrication of construction elements are made. These include, among others, concrete pipes and tiles. An example is illustrated in Figure 3 by the production and installation of tiles.



Figure 4: Soelvgade School

## Case 2 - Denmark

### *Product modularity*

In contrast to the standardized product design used by CF in Ecuador, Soelvgade School is characterized by its unique design driven by unique customer needs and supported by the complex technical evolution within the industry. Not only is the amount of different materials applied substantial, but the composition and general design is also very unique. Figure 4 shows a picture of Soelvgade School.

The unique and complex product design can be described by the diverse flooring in the building. Nine different types of flooring exist and in different colors: rubber floor (3), linoleum (4), tiles, parquet, sports floor, vinyl (3), painted, rubber mat, and epoxy cover. Additionally, greater fragmentation is identified between the design and production phases as six different specialists take part in this work.

### *Organizational modularity*

The customer has teamed up with an engineering firm and an architectural firm as their project advisors assisting and guiding the customer to identify their needs in the complex world of construction and to follow-up on the actual product realization.

For the product realization the customer has signed a general contract with the contractor AH. No standardized construction practice similar to the one by CF in Ecuador frames the work by AH, nor the associated project-based organizing. Instead a network of specialists participates in the PBP to accommodate the unique customer needs. This implies an extensive use of skilled workers represented by various crafts and specialists such as sprinkler installers, window fitters, and joiners. All actors participating in the PBP practice are individual sub-contractors who each refer directly to the project management of AH.

Although this project-based organizing enables a high degree of flexibility it also leads to significant managerial challenges by the presence of a very fragmented value chain. Special requirements are demanded by the construction management to continuously organize the PBP across multiple disciplines and different individual agendas.

### *Process modularity*

In contrast to the construction practice of CF in Ecuador much greater fragmentation between the design- and production phases characterizes the practice of AH. This is, among others, related to the organizational split to have someone to do the product design and someone else to do the product realization. Moreover, the combination of new technical solutions in an evolving construction industry and a fragmented value chain of cross-disciplinary sub-practices lead to a general fragmentation.

Based on these conditions, managing complexity is a key issue in the construction management. In comparison to scientific management other strategies and values are

applied to organize and manage the chaotic and complex project-based production. To achieve flexibility greater focus exists on values such as creativity and innovation rather than efficiency and standardization. These values become apparent by the application of continuous project-planning. That is, in order to learn and improve processes in the dynamic and emergent PBP practice the plan is continuously revised to reflect reality in the best way possible. Changes are made based on a continuous dialogue between the project management and the various disciplines and stakeholders participating in the PBP. The planning is divided into three degrees of specification: weekly plan, 6-week plan, and a total project plan.

Moreover, in order to deal with the complexity a comprehensive set of detailed drawings and associated product- and production descriptions exist and frame the PBP practice. These and other project documents are supported and handled by the means of, among others, information technology like CAD and document handling systems.

### **Case 3 – Sweden**

#### *Product modularity*

The product design of the Årsta-Älvsjö Railroad Bridge (ÅÄRB) reflects the contractual foundation which it has been agreed upon. Based on a turnkey contract which describes a total responsibility of both the product design and realization Pihl has developed the overall best solution in accordance with customer needs; the best price, time, quality, etc. The contract encompasses the basic concrete structure (foundation, pillars, and deck) thus no specialized railway installation is included.

Although thousands of concrete bridges have been made before no bridge design is alike. Nor is the ÅÄRB similar to any other bridge. The fact that the bridge crosses a highway and other railway tracks twice on special designed portals during the 1.4 kilometers it spans indicates a unique and complex product design. In response to these challenges Pihl has created an innovative product design which combines aesthetics and quality with integrated standardized production processes.

#### *Organizational modularity*

In relation to the scope and complexity of the project the Swedish project owner has chosen to engage in a turnkey contract with the Danish contractor Pihl. In order to ensure conformity with the contract and local standards and norms representatives have been employed by the project owner to supervise the construction practice.

Pihl has organized the construction practice by a network of individual subcontractors taking care of the various processes in the realization of the product design. In relation to the product design and low material complexity only few crafts are present: construction workers, carpenters, and various specialists such as equipment- and blasting specialists. These are mostly represented by skilled workers.

Although the project-based organizing reflects a less fragmented value chain in comparison to the PBP practice of AH in Denmark other special challenges are identified in the construction management. In this case the contractor is responsible of both the design- and production phases, however, subject to the customers supervision and design approval with reference to the contract and local standards and norms. This model implies that a mutual understanding on when you know enough to initiate the production is crucial for a fluent PBP. However, this case shows two different perspectives on the link between the design- and production phases leading to a continuous dispute in the construction management



Figure 5: MSS applied for the construction of the bridge deck sections

### Process modularity

In comparison to the two other PBP practices investigated this case reflects a partly integration between the design- and production phases. Based on the contractual framework Pihl has integrated and arranged a number of standardized production processes in connection with the unique product design. Most striking is the Movable Scaffolding System (MSS) applied for the bridge deck construction illustrated in Figure 5.

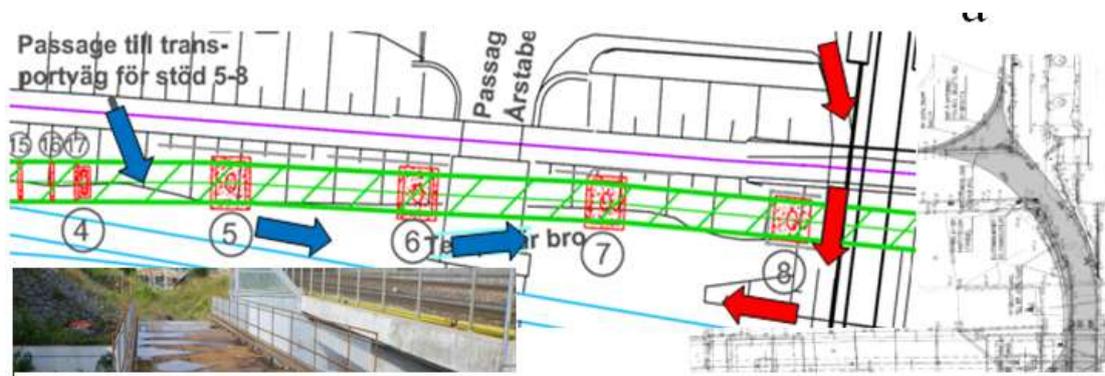


Figure 6: Change in access road to pillar 7 and 8 (red arrows indicate originally planned design and blue arrows indicate employed access road)

The MSS enables a standardized construction process of the bridge deck sections by a sequential preparation of the formwork, casting of concrete, and relocation of the MSS. However, due to the special curve traditional formwork is also required in the section interfaces which reflect the partial integration.

Similar to the construction practice of AH in Denmark continuous project-planning is applied allowing for gradual improvements to be integrated in the PBP based on project learning. An example is illustrated in Figure 6 showing a change in the access road to complete the bridge pillars 7 and 8. According to the original plan comprehensive ground work and sheet piling should be made. Instead an alternative solution was developed based on learning from similar challenges on site in achieving mobility near other pillar excavations: a temporary steel bridge solution was made across a passage to the existing train station resulting in substantial savings in comparison to the original plan.

## SUMMARY

The following two Tables summarize the socio-technical modularity of the different PBP practices in different cultural contexts and identify its characteristics.

Table 4: Summary of the socio-technical modularity of the different construction practices

Case study	Cultural context	Modularity in PBP practice		
		Product	Process	Organization
<b>Case 1</b> <i>Ecuador</i> <i>CF</i>	<i>Hierarchy cluster:</i> Hierarchy has privi-leges, collective dependence, formal confrontation, rules and structure, no open disagreement, etc. PDI: 78 IDV: 08 MAS: 63 UAI: 67	<i>Type:</i> Standardized mass housing scheme, medium scale <i>Material:</i> Concrete, reinforcement, glass, piping, electricity	Design and production integration 'No contract' (series of associated companies) Detailed drawings & plans, industrialization, standardized, disciplinary collaboration Scientific management	Collective Skilled(40)/Unskilled(60) Crafts: masons, plumbers, electricians, construction workers Designers: architects, engineers Managers: architects, engineers
<b>Case 2</b> <i>Denmark</i> <i>AH</i>	<i>Network cluster:</i> Independent cooperation, autonomy, consensus, egalitarian, informal, open disagreement, etc. PDI: 18 IDV: 74 MAS: 16 UAI: 23	<i>Type:</i> Unique school building, medium scale <i>Material:</i> Concrete, (sheet) piling, steel, insulation, wood, linoleum, vinyl, rubber floor, tile, drain, piping, sprinkler system, alu, painting, fireproofing, glass, facing, heating, ceiling sheet, acoustic, IT, ventilation, electrici-ty, automation, elevator	Design and production fragmentation General contract Detailed drawings, plans (weekly, 6-week, full scope), learning, IT, industrialization, creativity, cross-disciplinary collaboration Project management	Fragmented Skilled(90)/Unskilled(10) Crafts: masons, plumbers, electricians, construction workers, carpenters, floor-ring fitters, painters, joi-ners, sprinkler installers, window fitters, roofers, elevator installers, etc. Designers: architects, engineers Managers: engineers Contractors
<b>Case 3</b> <i>Sweden</i> <i>Pihl</i>	<i>Network cluster:</i> Independent cooperation, autonomy, consensus, egalitarian, informal, open disagreement, etc. PDI: 31 IDV: 71 MAS: 05 UAI: 29	<i>Type:</i> Unique railway bridge structure (1.4km) excl. railway system, large scale <i>Material:</i> Concrete, reinforcement, (sheet) piling, steel, piping	Design and production fragmentation/integration Turnkey contract Detailed drawings, plans (weekly, 6-week, full scope), learning, IT, industrialization, creativity, cross-disciplinary collaboration Project management	Fragmented Skilled(70)/Unskilled(30) Crafts: construction workers, carpenters, MSS fitters, blasting specialists Designers: architects, engineers, contractors Managers: engineers Contractors

*Table 5: Characteristics of the modularity of the different construction practices*

Modularity	Case 1	Case 2	Case 3
<i>Value chain</i>	Integrated	Fragmented	Fragmented
<i>Interfaces</i>	Scientifically well defined	Blurred and locally negotiated	Locally negotiated
<i>Complexity</i>	Low	High	High
<i>Productivity</i>	High	Low	Low-Medium

The analysis shows that the socio-technical modularity of the different construction practices reflects the cultural context supporting Hofstede's proposition of preferred coordination mechanisms (1980). By looking into the differences and similarities across the three cases a central dilemma in PBP becomes apparent; stability versus flexibility. The modularity of the Ecuadorian PBP practice (*case 1*) is characterized by low complexity and a high degree of repetition resulting in high productivity. This construction practice is based on a primary focus on stability. In contrast, the Danish and Swedish PBP practices (*case 2* and *case 3*) are characterized by high complexity and a lower degree of repetition resulting in lower productivity. In these cases flexibility has a higher focus. This difference in focus and practice reflects the cultural context as the customer/market and institutional requirements, which are related to the same societal drivers as culture, generate different degrees of complexity and uncertainty to frame the PBP. In consequence different construction practices are needed.

## DISCUSSION

By the cultural contexts a series of social values seem to be closely linked to the socio-technical modularity of the PBP practices leading to different ways of coupling and practicing the design and production processes.

### **The influence of societal development on PBP practices**

As culture is formed through a series of societal drivers such as nature, climate, religion, history, and politics it emphasizes constant changes in modularity and PBP practices in a dynamic and turbulent world. This may to some extent explain the differences and similarities identified between the three cases and in particular between the PBP practice in Ecuador in comparison to those in Denmark and Sweden.

Although this diversity may lead to a series of challenges in international PBP it also prepares the ground for opportunities. In a globalizing world where companies are moving activities and production abroad in an attempt to lower cost and become more competitive this is particularly interesting. In order to move such activities successfully the findings suggest that the activities must fit into the specific cultural context. That is, standard tasks may be moved to countries and cultures which support such practices while other more complex tasks calling for other social values should be handled elsewhere. The major challenge in such international companies is how to balance this and establish a 'perfect split' aligning practices with the cultural contexts.

### **Managerial practices in different cultural contexts**

The cultural context of Ecuador is characterized by social values such as formality, acceptance of hierarchy, collective dependence, and a demand for structure and rules. This cultural context indicates a reinforcing nature on the Ecuadorian PBP practice. The cultural context is consistent with the ambition to create a 'best practice' and to shape a social behavior and PBP practice based on scientific management and an

integrated value chain controlled by formal and codified agreements. Accordingly, the design and production processes are well integrated based on low complexity and scientifically well defined interfaces in the modularity. Everybody knows what to do and when to do it.

Similarly, the cultural context of Denmark and Sweden indicates a reinforcing nature on the respective PBP practices. However, in these cases both cultures are characterized by informality, network, autonomy, egalitarianism, and a perspective of rules as guidelines. These social values reflect and support a PBP practice characterized by its ability to deal with diverse, unique, and complex projects. Due to unique demands and a high degree of uncertainty the ambition is to create a 'local practice' and shape a social behavior and PBP practice that allows for creative ideas and initiatives to emerge and continuously be integrated in the production practice. Based on project learning the plan is continuously revised to optimize the production processes and get as close to reality as possible. These conditions emphasize the general fragmentation between the design and production processes.

Although the cultural context of Denmark and Sweden are similar a relative difference exists (ref. Figure 1 p.4). Based on these characteristics one may argue that the cultural difference generates or intensifies the existing continuous dispute in the construction management framing the PBP described in case 3. The Swedish project owner expects much greater detail, information and planning for the PBP. The cultural difference in the dimensions of MAS and UAI may to some extent explain this tendency. That is, the Swedish culture is characterized by a greater focus on processes and following rules and structure in comparison to the Danish culture. It indicates how cultural values influence and add to the complex and diverse nature of PBP.

## CONCLUSION

The socio-technical modularity of the PBP practices indicates a significant influence by the cultural context. In agreement with research in the field this paper, which is based on an explorative and qualitative collection of data by participant research, verifies that cultural and social values are closely linked to the modularity of the PBP practices. Consistent with the value scores developed by Hofstede (2013) the cultural context reflects a reinforcing nature on the specific PBP practice. Similarly, challenges have been identified when different cultures interact in the construction management.

As culture is formed through a series of drivers in parallel to the societal development in a dynamic and turbulent world this also implies that modularity and PBP practices are in the making. This underlines the importance to acknowledge the dynamics and diversity in organizing construction practices.

The findings emphasize the importance of cultural understanding in organizing and managing PBP practices in different cultural contexts and suggest a general need to recognize the diversity rather than suppressing it. Managing PBP practices is rooted in the cultural context and need to be handled accordingly. In a world which is getting smaller and where handling cultural differences has grown into a competency of high importance it reflects to an increasing degree a fundamental issue in project management. This calls for special attention on the subject in a time where project-based organizing increasingly is applied in production practices.

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## **PROJECT PERFORMANCE**

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# REVISITING THE CRITICAL FACTORS CAUSING FAILURE OF CONSTRUCTION PROJECTS IN VIETNAM

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The Vietnam construction industry has considerably developed since 1986 as a result of “Doi Moi” or all-round renovation process, stepping in the general development trend and the process of gradual globalization and regionalization. However, despite the pace of economic reforms, obstacles and risks have continued to plague the construction industry. This paper attempts to elicit the perceptions of construction professionals by revisiting some of these critical factors causing the failure of construction projects in Vietnam. A triangulated data collection approach involving 10 interviews and 45 questionnaires was administered to construction stakeholders to elicit their perceptions on the 20 factors causing the failure of the construction projects. The quantitative response data was subjected to descriptive statistics such as frequency analysis whereas, content analysis was used for the qualitative (interviews data). The results revealed that the ten most critical factors causing the failure of construction project were as follows: (1) “disregard of the significance of project planning process and project planning”, (2) “lack of experience in executing complicated project”, (3) “poor design capacity and frequent design changes”, (4) “lack of knowledge and ability in managing construction projects”, (5) “lack of financial capacity of owner” (6) “poor performance of contractors”, (7) “lack of a systematic approach to managing the project and entire organisation”, (8) “corruption and bribery in construction projects”, (9) “the delays in payment”, and (10) “economic volatility and high inflation”. The originality and value of this study lies with the identification of the lessons which are necessary for enhancing understanding and improving the awareness of project risks. This provides an appropriate approach to risk management, thereby tackling and mitigating the impacts of negative events in managing construction projects in Vietnam. The study further provides insights on the factors contributing to the failure of construction projects across the Vietnam construction sector.

Keywords: project failure, performance, critical factor, risk management, Vietnam, construction industry

## INTRODUCTION

While factors causing failure of construction projects has been studied in other countries, the revisiting of studies undertaken in the context of Vietnam deserves particular attention. It cannot be denied that the Vietnam construction industry has considerably grown and significantly contributed to Vietnam economy during “Doi Moi” (Renewal) process. Vietnam’s economy has been growing impressively for the last two decades. The annual average rate of the economy has been at 7.3 per cent and

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the capital income has also increased five-fold from 1990 to 2010 (World Bank, 2011). In 2011, Vietnam's GDP was predicted to stand at 5.9 per cent with growing 5.5 per cent in industry and construction fields (World Bank, 2011). According to Uyen (2003 cited in Nguyen *et al.* (2004a), the construction industry has been one of the main sectors contributing to the growth of the Vietnam economy in recent years. However, despite its contribution, the same study established that construction project management has been fronted with many difficulties and constraints which negatively impact on the effectiveness of many construction projects. For example, 30% of total construction capital is not used properly for construction purposes during project duration because of poor management (Uyen 2003 cited in Nguyen *et al.* 2004a). The Vietnam's construction industry has been confronted by many complicated issues in management. This needs to improve so as to manage construction project successfully and smoothly.

A number of studies have argued that the adoption of risk assessment and management practices are closely aligned with overall project performance (Imbeah and Guikama, 2009; Nguyen, Ogunlana and Lan 2004a; Nguyen, Ogunlana and Dey, 2007). For example, in the context of Vietnam, Nguyen *et al.* (2004) state that construction projects are often confronted with many complexities which involve a range of uncertainties including deadline. In addition cost target or quality, this can result in risks within project management and cause the failure of a construction project. Similarly, Nguyen *et al.*, (2007) also refers to the ineffectiveness of the Vietnamese construction projects as a result of poor management and inefficient risk management application, with many projects failing to meet the deadline, and spending over. Regardless of the advocated and noted benefits of systematic risk management, this is not a new concept, and it continues to draw little attention for construction projects in Vietnam. Obviously, the lack of understanding and awareness of risk management can cause adverse impacts on meeting ultimate targets of construction projects.

The study aims to seek the perceptions of construction professionals by revisiting some of these critical factors causing the failure of construction projects in Vietnam. The study will inform the stakeholders of the reoccurring factors causing failure, and re-evaluate present strategies of overcoming these factors. It is also anticipated that some of the recommendations proposed would enhance the current and future projects' success rates, which would at least reduce risks relating to project management knowledge of labour workforce.

This paper will give an overview and status of construction project management in Vietnam. It will summarise and present brief discussions on the extant literature on risk management and critical factors causing the failure of construction projects. The paper will also outline significant issues that allow justification for revisiting critical, and discuss methodological approach and findings. In addition the paper illustrates the research methods, implications and limitations of the study. The implications and recommendations made and conclusions are summarised in the final section.

## **LITERATURE REVIEW**

### **Overview and status of construction project management in Vietnam**

There is a plethora of studies pointing to the construction project management related problems in Vietnam (Nguyen *et al.*, 2004b; Luu *et al.*, 2008a; Ling *et al.*, 2009; Ling and Hoang, 2010). By and large, some of the studies have reported on and

acknowledged the situation of poor management in construction projects in emerging countries, including Vietnam (Luu *et al.*, 2008a). If not they have demonstrated the links between failure of large construction projects and poor management during project duration. This has often lead to project delays, cost overruns, labour accidents, low quality and disputes between parties (Nguyen *et al.*, 2004b). Other studies such as Ling *et al.* (2009) have attributed the problems to lack of high-quality project managers within the Vietnamese construction industry. Accordingly, this has acted as a barrier for construction firms in recruiting appropriate applicants for complicated projects; especially in projects which are invested by foreign capital. This has resulted in foreign firms often resorting to holding training courses in project management for their staff. This helps them to recognize that a good project management competency is so important to construction projects.

Ling *et al.* (2009) found that, Vietnamese construction companies are lagging behind foreign companies not only in management capability, but also in financial capacity, experience in complex projects, knowledge in advanced design and construction technology. Other setbacks acting as constraints have focussed on the corruption and complications of the legal system for construction companies. This applies especially to foreign firms working in Vietnam (Ling *et al.* 2009, Ling and Hoang 2010 and Nguyen *et al.* 2004b). Problems such as complicated and burdensome regulatory procedures cause severe difficulties and confusion for both local and foreign practitioners (Ling *et al.* 2009). According to Ling and Hoang (2010), it highlights the weakness of the legal system in Vietnam. This is often manifested through its ineffectiveness and inadequacy of the legal framework. For example, construction firms have to work in an environment where government policy changes quite frequently. Laws and regulations are inconsistent. In addition, it is not productive to apply Vietnam's court system in commercial disputes due to its ineffectiveness.

### **Risk management in construction projects in Vietnam**

Given the established linkages between risk management and project success, the following subsection provides a summary of the studies within the area of risk management as conducted in Vietnam. In their seminal study Edward and Bowen (1998), observed that research on construction project risk management occurred from 1960s. The result of research is well established as an application process. Accordingly, a systematic approach of risk management is required in order to minimise failures and maximise benefits. However, the lack of a systematic and efficient risk management system is one of the major factors leading Vietnamese construction projects to failure (Nguyen *et al.* 2007).

The consequence of risks in Vietnam construction projects is similar to common situations of construction projects worldwide. The risks often lead to delays and cost overruns in projects. Risk management is not carried out effectively (Nguyen *et al.* 2007, Le *et al.* 2008, Nguyen *et al.* 2004a, Nguyen *et al.* 2004b, Luu *et al.* 2008b). It is therefore predictable as these issues have been attracting the interest of many researchers and practitioners. Nevertheless, time and cost constraints often occur frequently in developing countries. Vietnam is not an exception (Nguyen *et al.* 2007, Le *et al.* 2008). Drawing upon Vietnam and other selected countries as an example, Le *et al.* (2008) established that, delays and exceeded budgets in construction projects not only cause loss of financial benefits, but more seriously cause the decreasing belief of citizens, especially in projects funded by government.

As mentioned in previous sections, Vietnam construction market is dynamic and open to both domestic and international investors. This makes the construction project risk management in Vietnam to become more and more competitive. It also gets complicated as there are a wide range of factors impacting the project success. As stated by Nguyen et al. (2007), Project managers today have to deal with various risks from political, financial, legal risks to risks coming from the differences in practices of local and foreign stakeholders. All these risks will have impacts on achieving project objectives if they are not managed efficiently. Particularly, it is suggested that international firms' effectiveness in identifying and managing political, economic and legal (PEL) risks will enhance the chance of project success in Vietnam (Ling and Hoang 2010). The authors namely list major PEL risks that include corruption; bureaucratic administrative system; termination of public projects; fluctuation of exchange; interest and inflation rates; inconsistent regulations and inadequate legal framework.

### **Summary of key critical factors identified in the Vietnamese Construction Industry**

Table 1 denotes a summary of selected studies on the critical factors causing failures of construction projects in Vietnam. As can be seen from Table 1, there are nine critical factors which had been cited by more than half of the studies reviewed. The highly cited factor was “poor design capacity and the frequent design changes” by three quarters (6) of the studies. This was followed by half (50%) for “bureaucratic administrative systems”.

## **RESEARCH METHODS**

The main objectives of this study were to elicit the perceptions of construction professionals. By revisiting some of critical factors causing the failure of construction projects in Vietnam, a triangulated data collection approach (mixed methods) involving interviews and questionnaire was adopted for this study. The following subsections now describe the methodology undertaken for each of the methods.

### **Measurement instrument**

The questionnaire was designed based on the extensive literature review and encompassed all the critical factors causing the failure of construction projects (Table 1). In general, the questionnaire was divided into the following three sections as follows; **Section one: Background information** - This section comprised three questions pertaining to the general demographics as follows: (i) type of organisation; (ii) designation; and (iii) length of experience; **Section two: The importance of risk management** - This section comprised two questions associated with (i) the respondent's perception on the importance of risk management; and (ii) responsibility for managing risk; and finally **Section three: The practice of risk management** - This section comprised of five questions associated with the practice of risk management as follows: (i) approaches; (ii) standards; (iii) obstacles; (iv) achievement of project objectives; (v) ranking of 20 critical factors categorised into the following four groups as follows; (Table 3). For sub section (v), the respondents were asked to provide the ranking of each of the 20 critical factors (Table 1) as identified from the review of the literature that may lead construction projects to failure. The ranking was based on a sliding scale (based on the severity of extent) from 1 to 20, where 1 was the most serious and rank 20 as the least serious. The results presented in this paper only relates to the first and second sections of the questionnaire. It was beyond the scope of this

study to report on all the findings. The full listing of the critical factors, associated ID and the four categories are shown in the following sub section.

Table 1: Critical factors causing the failure of construction projects

ID	Critical factors causing the failure of construction projects	Le <i>et al.</i> 2008	Ling & Bui 2010	Ling & Hoang 2010	Ling <i>et al.</i> 2009	Luu <i>et al.</i> 2008a	Luu <i>et al.</i> 2008b	Nguyen <i>et al.</i> 2004b	Nguyen <i>et al.</i> 2007	Number	Agreed Frequency	Ranking
01	Poor design capacity and the frequent design changes	x	x		x	x	x		x	6	75%	1
02	Financial difficulties of contractor	x	x		x		x	x		5	63%	2
03	Obsolete or unsuitable construction methods	x			x	x	x	x		5	63%	3
04	Incompetence of project team					x	x	x	x	4	50%	4
05	Poor site management and supervision	x	x				x	x		4	50%	4
06	Slow payment of completed works	x	x			x	x			4	50%	4
07	Financial difficulties of owner	x	x		x		x			4	50%	4
08	Corruption			x	x	x		x		4	50%	4
09	Bureaucratic administrative system			x		x		x	x	4	50%	4
10	Interest and inflation rates	x		x			x			3	38%	10
11	Lack of accurate historical information	x	x					x		3	38%	10
12	Unpredictable government policies and priorities	x	x	x						3	38%	10
13	Lack of experience in complex projects		x		x		x			3	38%	10
14	Inadequate legal framework			x	x					2	25%	14
15	Incompetent subcontractors	x	x							2	25%	14
16	Slow site handover						x	x		2	25%	14
17	Defective works and reworks	x					x			2	25%	14
18	Owners' site clearance difficulties						x	x		2	25%	14
19	Lack of capable owners						x	x		2	25%	14
20	Improper planning and scheduling							x	x	2	25%	14
TOTAL		11	9	5	7	6	13	11	4			

### *Survey administration*

The questionnaire and responses were distributed and received via email. The targeted key respondents were drawn from the Vietnam construction industries including officials in government bodies; lecturers of universities; managers; consultants; designers and site supervisors working for Vietnamese or foreign construction companies. As the survey was conducted in Vietnam, this required the questionnaire to be translated into Vietnamese with the same purpose described in interview for the research section.

### *Statistical methods*

The obtained raw data from the questionnaires was input and analysed using the *IBM Statistical package for social sciences* (SPSS) computer programme version 20.0.0. SPSS was used to look at single variables that focussed on descriptive statistics for preliminary data analysis and frequencies.

The 'frequencies' procedure was applied to the literature review and actual descriptive (questionnaire) survey.

According to Forza (2002), this type of analysis is normally used to ascertain the number of times various subcategories of phenomenon occur. Accordingly, in conducting the literature review on the critical factors causing the failure of the construction projects, the number of times (frequencies) that these studies mentioned the identified twenty critical factors causing the failure of construction projects was determined. Furthermore, this was based on the selected eight studies in Table 1, the ranking and establishment of the importance of these risk or critical factors was achieved (Table 1).

## **Interviews**

The aim of conducting interviews was to understand the research issues from the interviewees' perspective in order to discover information from participants prior to scientific interpretations (Brinkmann and Kvale, 2009). Interviews not only provide enormous amounts of data, but also bring to researchers an insight of the problems deeper than other researcher instruments (Birmingham and Wilkinson, 2003). The interview process was conducted following five stages as suggested by Birmingham and Wilkinson, (2003, p. 44): (1) draft the interview; (2) pilot the interview questions; (3) select the interviewees; (4) conduct the interviews and (5) analyse the interview data. The following sub section presents a brief discussion of some issues associated with five highlighted stages.

Ten interviews were conducted between industry and the academic community. As pointed out in stage 3 of the process, this required selection of the interviewees (see subsequent section). Hence the importance of taking a flexible approach for the interview to be successful. Against that background, the semi-structured interview was selected for this research. The noted advantages of this approach, such as flexibility, and enabling the researchers to make a closer relationship with their participants, are well documented in Birmingham and Wilkinson (2003).

### *Stage one: drafting the interviews*

A set of criteria for drafting interview questions was undertaken. This was to ensure that the questions posed were relevant to the research circumstance, comprehensive, easy to understand as well as facilitate collecting useful feedback. In view of that, interview questions were structured in four sections as follows: (1) Background information - This contained two demographical questions associated with tenure such

as length of time of working in the construction industry, and professional background; (2) The second section was composed of two questions and aimed at ascertaining the importance of risk management in construction projects. (3) The prevailing practice of risk management in the Vietnam construction industry was addressed through three questions in this part. (4) The main question associated with this paper was addressed in the fourth section titled “constraints and risks in managing construction projects in Vietnam”. In particular, two questions were posed: (i) in your opinion, which objectives of the construction project are usually not achieved in Vietnam?; and (ii) In your opinion, what are the major factors which could lead the construction projects to failure?. The findings reported in this study relate to the first and fourth sections of the interviews.

#### *Stage three: selection criteria of Interviewees*

Interviewees were selected on a number of criteria ranging from experience and professional background. This resulted in 10 participants drawn from both academia and industry. The selection process via phone or email for the interviewees was carried from July to August 2012.

#### *Stage four: conducting the interviews*

The interviews were carried out from September to October 2012. All interviews have been held in Ho Chi Minh City, the largest city in Vietnam, and lasted for 1 to 1.5 h. Each interviewee had a clear interpretation of purpose, content of the interview as well as their risks; rights and benefits for participating in the research. This is compliance with the commitment of the researcher to Human Research Ethics Committee before taking the interview.

## **SURVEY RESULTS**

### **Characteristics of sample (respondents)**

Nearly a third (31.1%) of the respondents were project managers, followed by site supervisors (24.4%) and designers (20.0%). It would have been more desirable if the majority of the respondents were associated with the monitoring of the projects. Proportions of the respondents in terms of the type of the organisation were: private company (55.6%), state-owned organisation (24.4%), and government departments (11.1%). The minority 2.2 % (1) were drawn from “100% foreign invested enterprise and joint venture with foreign company” (6.7%).

### **Analysis of the top-ten critical factors causing failure**

Table 2 shows the list of the ranked factors including the 20 factors sorted in ascending order according to their impact on causing the failure of construction projects. As can be seen from Table 2, the “disregard of the significance of project planning process and poor project planning” factor was ranked first with the mean score (6.24).

This finding is also consistent with literature on Vietnam (Nguyen *et al.* 2004b; 2007). Consequently, due to emerging countries, Vietnam lags behind advanced countries worldwide in construction project risk management in terms of experience, knowledge and technology. Moreover, projects managers also have to deal with various risks in relation to all economic, political and social aspects. Nevertheless, Vietnam is gradually integrating into the common development stream of the world. Many managers and practitioners working in Vietnam construction industry have recognised the important role of risk management in obtaining the project goals and objectives. In particular the success of their organizations in general. Interestingly, although

corruption and bribery are considered the most major obstacles in carrying out projects (Nguyen *et al.* 2004b; Thuyet *et al.*, 2007; Ling and Hoang, 2010), the factor relating to “corruption and bribery in construction projects” was only ranked in the 8<sup>th</sup> position (MS = 9.52).

The top-ten critical factors as identified in Table 2 were further classified according to these four categories: (1) knowledge and technical issues; (2) management issues; (3) financial issues; and (4) social and legal issues. The ranking of these factors is shown in Table 3.

Table 2: Critical factors ranking causing the failure of construction projects

ID	Critical factors causing the failure of construction projects	Mean	R
07	Disregard of the significance of project planning process and poor project planning	6.24	1
02	Lack of experience in executing complicated projects	7.18	2
01	Poor design capacity and the frequent design changes	8.36	3
04	Lack of knowledge and ability in managing construction projects	8.70	4
11	Lack of financial capacity of owner	8.91	5
03	Poor performance of contractors/ sub-contractors	8.91	5
08	Lack of a systematic approach to manage the project and entire organisation	9.42	7
18	Corruption and bribery in construction projects	9.52	8
15	Delays in payment	9.91	9
12	Economic volatility and high inflation	10.45	10
06	Ineffectiveness in managing construction site	11.09	11
09	Lack of effective communication system in implementation of projects	11.24	12
14	The ambiguousness of contractual terms and conditions	11.33	13
17	Lack of transparency in procurement process	11.45	14
13	Lack of capacity in forecasting market demand and trend	11.76	15
05	Out-dated construction technology and facility	12.00	16
19	Bureaucratic government system in relation to regulations on project procedure	12.58	17
10	The ineffectiveness in resolving disputes and conflicts among project stakeholders	12.58	17
20	The instability and inefficiency of government policies and legal system	13.15	19
16	Low ethics in doing business of project participants	15.21	20

As can be seen from Table 3, there were four factors related to the knowledge and technical issues in the top-ten category – the “lack of experience in executing complicated projects” factor placed second (MS = 7.18), “poor design capacity and the frequent design changes” placed third (MS = 8.36), “lack of knowledge and ability in managing construction projects” placed fourth (MS = 8.70) and “poor performance of contractors/ sub-contractors” placed fifth (MS = 8.91). The rankings are also consistent with the observations made during the interviews.

On the other hand, the result obviously proved that the biggest problem leading Vietnam construction projects to failure is issues associated to project management elements. These being knowledge; technical skill of project managers as there are 4 in 5 factors of “knowledge and technical issues” category occupied the top five of the

ranking table. The remainder of the factors as identified in Table 3 were confirmed by the Interviewees as being of paramount importance.

*Table 3: Categorisation of the top ten factors causing the failure of construction projects*

Category	ID	Critical factors causing the failure of construction project	R
Knowledge and technical issues	01	Poor design capacity and the frequent design changes	3
	02	Lack of experience in executing complicated projects	2
	03	Poor performance of contractors/ sub-contractors	5
	04	Lack of knowledge and ability in managing construction projects	4
Management Issues	07	Disregard of the significance of project planning process and poor project planning	1
	08	Lack of a systematic approach to manage the project and entire organisation	7
Financial and economic issues	11	Lack of financial capacity of owner	5
	12	Economic volatility and high inflation	10
	15	The delays in payment	9
Social and Legal Issues	18	Corruption and bribery in construction projects	8

## IMPLICATIONS & LIMITATIONS

Relative to the critical factors causing failure of construction projects, the study has a number of managerial implications for the researchers, policy makers and practitioners (top management) within the Vietnamese constructional related organisations. Given that the majority of the highly ranked critical factors affecting the construction projects were drawn from the category of ‘knowledge and technical issues’. It is recommended that, for construction companies to improve and enhance their competency in the construction project management, a concerted effort in specialising in risk assessment and management practices is required.

## CONCLUSIONS & RECOMMENDATIONS

This paper provided an overview of the construction professionals in Vietnam on the critical factors causing failure of construction projects. Research established that, despite the all-round renovation process or “Doi Moi” undertaken in Vietnam, the construction industry is still plagued by the same critical factors as identified from eight studies spanning a period of 2004–2012. These views were further reinforced by all of respondents. Generally, the major or critical factors were associated with knowledge and technical issues. The most pressing five factors were as follows: (1) disregard of the significance of project planning process and poor project planning; (2) lack of experience in executing complicated projects; (3) poor design capacity and the frequent design changes; (4) lack of knowledge and ability in managing construction projects; and (5) lack of financial capacity of owner. Furthermore, the issue of corruption and bribery is concerning despite being mid ranked in the survey.

### Recommendations for further research

The following recommendations are proposed with regards to further research: (i) an investigation into the application of risk management techniques in each phase of project life cycle thereby enhancing the applicability in practice of managing construction projects; (ii) investigate typical critical factors in accordance with the

type of organisations, especially private companies, 100% foreign invested enterprise and joint venture with foreign company because these companies are often confronted with many risks. This might have different critical factors rather than companies associated to state; and (iii) identification of risk management strategies for each of specific cases mentioned above.

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# WELCOMING HIGH RELIABILITY ORGANISING IN CONSTRUCTION MANAGEMENT

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To achieve project objectives, construction project managers have to manoeuvre through complex coordination structures. They have to simultaneously deal with limited budgets, tight schedules, demanding stakeholders and a fragmented supply-chain. Despite their extensive coordination efforts, project managers are frequently confronted with unexpected delays that force them to improvise and re-plan. As a consequence, budgets and schedules tend to overrun and project organisations appear out-of-control rather than stable and reliable. To enrich our understanding of these phenomena, we propose using the theoretical lens of High Reliability Organising (HRO). HRO stems from research into high hazard industries, and is relatively new to construction management. It provides five generic guiding principles that help practitioners anticipate and contain unwanted events. Given that the use of HRO beyond high hazard contexts is not universally accepted within the scientific community, we ask whether it is justified to apply the HRO lens to the organisation and coordination of 'mainstream' construction projects. We elaborate on this issue by addressing its main theoretical concepts, its origin and its application beyond the fields of risk and safety. We further explain why reductionist interpretations of HRO concepts unnecessarily limit HRO's research domain. We propose a pragmatic reinterpretation of HRO that provides access to the field of construction management. Finally, we present preliminary results of our study into delays and overruns in inner-city subsurface utility reconstruction projects. Our theoretical and empirical arguments provide a stepping-stone for future HRO research projects in the construction management field.

Keywords: organisation, productivity, project management, reliability, mindfulness.

## INTRODUCTION

Scoping and delivering projects is the core business of the construction industry. Reliably achieving agreed project targets is crucial for the success of clients, construction firms and other stakeholders in the industry. Among these projects, subsurface utility construction projects are very much in the minds and view of the community: they are both exposed and notorious for overrunning schedules and budgets. These projects amount to complicated coordination puzzles that are often constrained by tight budgets and deadlines. Numerous public and private clients, contractors and authorities are involved and have to plan, monitor and align their interrelated activities. However, despite good intentions and a significant time spent on early stage coordination, it seems in practice that project plans are often

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overloaded. Especially in inner-city areas, subsurface utility reconstruction projects generate noise and dust and impede traffic flows, access to locations and the functionality of spaces. Pressures to reduce the burden and hindrance to businesses and people living and working close to such projects are high, limiting the opportunity to include slack in the scheduling. As a result, any unwanted events derail construction schemes and force project managers to re-plan and improvise in an already tightly coupled schedule of activities. Consequentially, budgets and schedules have to be extended, stakeholders become frustrated and the public perceive the industry and its project predictions as unreliable. In studying the phenomena of coordination in these utility projects, we have spent a significant amount of time in the field. We explored how practitioners try to achieve project goals while coping with unwanted events and tight project plans. We also explored whether new ICT instruments contribute to improved alignment and inter-organisational coordination of interrelated construction activities. To structure and analyse our empirical data, we look through the lens of High Reliability Organising (HRO). Pragmatically, this lens seems to be of value as its concepts and principles focus on increasing performance reliability through anticipation and containment of unwanted events.

Unfortunately, when we present our research findings to scientific peers, the discussion often stagnates as we are confronted with debates about the legitimacy of applying the HRO lens. Rather than focusing on the projects and their issues, debates drift into disputes about whether applying the HRO lens is justifiable in the construction management domain. As these debates frequently distract from the presentation of our work, we have decided to challenge this critique and respond to the debate in this paper.

In this positioning paper, we aim to move on from this debate about the legitimacy of using the HRO lens and refocus on the coordination of utility projects. This paper is structured as follows: the first section describes the origin and concepts of HRO. Next, we explain how a reductionist interpretation of the HRO terms and contexts hampers the acknowledgment of the HRO lens's pragmatic value. We then illustrate how HRO principles apply to mainstream organisations. Further, we use the HRO lens to explore coordination of utility projects. The paper concludes by restating our view that a pragmatic reinterpretation of HRO provides a lens through which one can study reliability issues associated with construction projects.

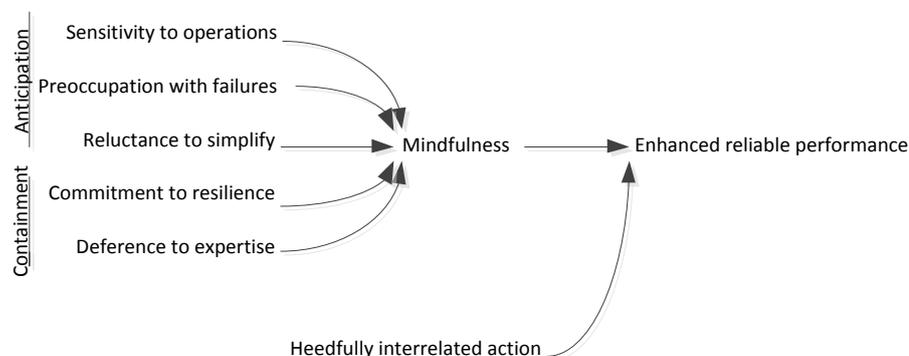
## **HIGH RELIABILITY ORGANISING: ORIGIN AND CONCEPTS**

High Reliability Organising research focuses on how the presence, or lack, of structures, mechanisms and routines within high hazard organisations leads to failures and catastrophes. HRO scholars have developed insights into how practitioners seek to enhance reliable performance, and avoid non-goal actions and non-goal results, by looking at how practitioners cope with potential errors and undesirable events. We first address the theoretical fields upon which HRO builds, and we then define two important HRO concepts: mindfulness and heedful interrelated action. This set of concepts and principles is referred to in this paper as the 'HRO lens'.

The foundations for the development of HRO is Perrow's (1984) Normal Accidents Theory (NAT). NAT was derived through a retrospective analysis of the meltdown disaster at the US Three Mile Island nuclear power plant. Perrow's concept was that organisations could be categorised along two attribute axes: complexities and couplings. He concluded that organisations that have tight couplings and interactive complexities are vulnerable to accidents. Inspired by Perrow's findings, a Berkeley-

based research group (including LaPorte, Rochlin, Schulman and Roberts) became interested in how organisations in high hazard environments perform so exceptionally well – that is virtually error-free. By observing how organisations cope with failures, Roberts (1990) was one of the first scholars to define the characteristics of a Highly Reliable Organisation. Successive studies on, for example, the Challenger Explosion (Roberts and Rousseau 1989), the Mann Gulch forest fire (Weick 1993) and naval aircraft carriers (Weick and Roberts 1993) advanced insights into the reliable performance of similar high hazard organisations and further developed the High Reliability Organising theory.

One commonly used concept drawn from High Reliability Organising is 'mindfulness' (Weick, Sutcliffe et al. 1999; Weick and Sutcliffe 2007). In essence, mindfulness comprises a set of principles that describe how organisations can enhance reliability of their performance. The five principles are divided into two categories: anticipation and containment (see Figure 1). Anticipation focuses on identifying and preventing potential unwanted situations, while containment is about reacting to, and recovering from such situations. Both categories will be further elaborated below.



*Figure 1 - concepts of mindfulness and heedfully interrelated action that lead to enhanced reliable performance (adapted from Weick et al. 1999)*

The first anticipatory principle is 'sensitivity to operations'. Practitioners that follow this principle continually try to make sense of interrelated operational tasks and know how these tasks might be influenced and change over time. The second anticipatory principle is 'preoccupation with failures'. Through this, organisations continuously try to identify potential causes of failures and delays. They try to record and learn from previous faults to better cope should similar events occur in the future. The third aspect is that organisations that anticipate unwanted events have a 'reluctance to simplify' interpretations: they challenge standard assumptions and deliberately try to interpret observations in as much detail as possible. These three anticipatory principles help organisations identify potential failures and create strategies for dealing with them.

Principles related to mindfulness further focus on containing unexpected and unwanted situations. Such events can derail operations, and containment aims to reduce their negative impact. The fourth mindfulness principle, 'commitment to resilience', allows organisations to recover from unexpected situations. Organisations following this principle buffer resources, and create and update failure-recovery plans. In case of an unwanted event, they further change decision-making structures from hierarchical and formal into more flexible informal horizontal structures. The fifth mindfulness principle refers to a 'reliance on expertise' for solving problems.

Organisations that follow this principle favour expert opinions over, for example, commercial pressures.

Another concept central to High Reliability Organisation theory is heedful interrelated action. When interacting in a heedful way, practitioners execute their own tasks but understand how this individual task is influenced by, and contributes to, related actions by others within a system (Weick and Roberts 1993). This increased attention to interdependencies contributes to a more reliable performance.

Although HRO ideas stem from research in high hazard industries, we argue that its concepts can help in understanding reliability in mainstream organisations. As this line is far from universally accepted, the next section describes how the classical HRO research setting complicates the use of the HRO lens other industries.

## **THE HRO LABEL CONFUSES**

This section explains how reductionist interpretations of the terms High Reliability and Organising are obstructive when presenting findings on reliable coordination of subsurface utility reconstruction projects. We offer a critique of the reductionist perspective on HRO, and propose looking through the HRO lens from a pragmatic viewpoint.

People introduced to the principles of HRO often assert that only organisations that can be characterised as 'highly reliable' can use the HRO lens to boost performance<sup>2</sup>. This stance frequently turns our research presentations into a reductionist debate on whether a construction project can be a 'High Reliability Organisation' or not. Bourrier (2011) described classical High Reliability Organisations as performing well while being bounded by a strict no-failure requirement. Reductionists would therefore argue that only error-free organisations can be 'highly reliable'; and the HRO label is strictly reserved for error-free organisations. If this is the case, should an 'HRO' organisation lose its HRO label when an error occurs? Authors with a less rigid view accept that highly reliable organisations can make mistakes and operate in a "nearly error-free fashion" (LaPorte and Consolini 1991). This nuanced interpretation blurs the distinction between highly reliable and not so highly reliable organisations, and enlarges the population of 'HROs'. This then allows a broader range of organisations to adopt the HRO lens.

The term 'organisation' also confuses. Often, the initial interpretation of 'organisation' reflects Morgan's machine metaphor (Morgan 1997 pp.11-31). This then directs the focus towards studying structural and procedural aspects, whereas the HRO lens seems to be more about behaviour and processes than structure. Although HRO scholars have tried to avoid this misunderstanding by using 'organising' rather than 'organisation', this has not ended the debate surrounding the structural characteristics of an HRO.

Finally, does the shifting boundary between HROs and non-HROs diffuse the debate? We think only slightly, and that it makes little practical sense to determine whether organisations are 'real HROs'. The categorisation and classification debate generates only limited insight into the way the concepts that constitute the HRO lens can be

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<sup>2</sup> This is analogous to the idea that the perspectives and concepts of quality control can only be applied to organisations that are already acknowledged for their high quality products.

used. It would seem more productive to abandon the reductionist perspective and concentrate on how the HRO lens can help any organisation enhance its performance.

## **HRO RESEARCH IS UNNECESSARILY CONFINED TO HIGH HAZARD INDUSTRIES AND SAFETY ISSUES**

It is often argued that HRO labels and concepts should be confined to high hazard industries. High hazard industries are strongly linked to safety, and accept high societal and organisational costs, deal with extensive regulation and procedural requirements and are often protected from market forces (Schulman 2011). This situation suggests that having unsafe and risky environments force organisations to follow HRO concepts, which subsequently lead to reliable performance. HRO is thus presumed to be a natural contingent response to a high hazard environment. In less hazardous environments, organisations should not need to afford the investments required to make them reliable. In this line of reasoning, the terms reliable and safe are lumped together and substitute for one another without explanation. This seems to be due to the 'fact' that HROs in high hazard environments are 'reliably safe'. This linguistic contamination of terms obscures the reasoning and the debate. The fact that classical HROs have such a strong focus on safety neither logically implies that reliability should be confined to safety, nor that HROs should be confined to the high hazard domain. The simple fact that hazardous environments encourage certain organisations to use HRO principles does not prohibit organisations in less hazardous environments utilising the HRO lens, maybe to some lesser extent, to become more reliable. We therefore take a pragmatic stance and argue that the term reliability is not confined to safety, and may also refer to other goals set by an organisation.

By replacing the reductionist view with a pragmatic perspective on HRO, research can benefit from productive discussions about processes and principles that enhance the reliability of organisations (see Table 1 for a comparison of the perspectives). Next section provides examples of how other scientific fields borrowed the HRO lens.

*Table 1: comparing the reductionist and pragmatic perspective on HRO*

	Reductionist view	Pragmatic view
Unit of analysis	Structure and context of typical HROs	Processes and principles that enhance reliable performance
Meaning of reliability	Reliability as an absolute goal	Reliability as a process
Function of HRO lens	Distinguishing HROs from non-HROs	Understanding reliability issues and processes that enhance reliably
Main assumptions	Org's are either highly reliable or not HRO concepts do not apply to non-classical HROs	Org's can seek to enhance reliability HRO lens applies to common organisational goals

## **HRO CONCEPTS AND PRINCIPLES OBSERVED IN MAINSTREAM ORGANISATIONS**

Insights from High Reliability Organising are relevant for mainstream organisations because they "provide a window on a distinctive set of processes that foster effectiveness under trying conditions" (Weick, Sutcliffe et al. 1999). Roberts and Bea (2001) suggest the same by stating that "neither the sausage maker, nor the chemical-plant manager is immune from errors that can have far-reaching consequences." These

perspectives do not bother defining and identifying HROs, instead they focus on the underlying reliability-enhancing processes and characteristics (Lekka 2011). This alternative approach to HRO becomes more visible as we see its concepts cross their original boundaries and slowly find their application in mainstream businesses. This section provides several examples of studies that have observed mindfulness and heedful interrelationships taking place outside the domain of high hazard industries.

At the first European ProHRO conference in The Hague (2011), various scholars presented research on reliable processes within regular organisations such as educational institutes, the police, detention centres, theatre and manufacturing. Further, the literature reports on the application of the HRO lens in aviation, oil production and the railway sector (Roberts 2009) and in hospitals (Vogus and Sutcliffe 2007). Closer to construction, one also sees scholars exploring how practitioners can apply principles of mindfulness to support the effective adoption of information technology (Swanson and Ramiller 2004). Further, De Bruijne and Van Eeten (2007) analysed how restructuring the utility sector impacted on the performance reliability of large technical infrastructure. Finally, Mitropoulos and Cupido (2009) looked into the work practices of high and low performing residential framing crews. They found that a guiding principle of 'going a little slower to avoid mistakes' helped crews to finish their work quicker, while also resulting in fewer errors and accidents. All these studies present elements that resemble behaviour that is, explicitly or implicitly, related to the HRO concepts. The next section brings the discussion closer to the construction industry.

## **MINDFUL PRACTICES IN UTILITY CONSTRUCTION PROJECTS**

Here we return to the context outlined in the introduction, our domain of research: the coordination of inner-city subsurface utility reconstruction projects. Our aim is to provide an example of how researchers could use concepts from the HRO lens. We discuss our research efforts and address the typical coordination in utility projects. Finally, some observations made during the study are described and related to the HRO lens, in particular to the concept of mindfulness.

During our study of reliability issues in utility projects, we studied three such reconstruction projects taking place in a mid-sized Dutch city (150,000 inhabitants). In these projects, the municipality, several service providers and (sub)contractors planned and executed a number of tasks related to the reconstruction of cables, pipes, sewers, intersections, squares and road sections in both residential and commercial areas. The overall duration of the projects varied between six and twelve months. In this period, we spent a significant amount of time with practitioners observing planning and execution activities. We attended over thirty multi-stakeholder meetings, joined construction site visits, and had informal dialogues with experienced practitioners. We also interviewed nearly ten practitioners to retrospectively analyse a project that overran its schedule by more than fifty per cent.

Inner-city utility projects are known for their unreliable performance. During these projects, both municipalities and private utility companies, who both own distinct parts of the overall subsurface infrastructure, plan and execute construction work in a shared public space. While the municipality will procure work according to EU regulations, other utility owners commonly each employ their preferred contractors in framework agreements. This diffused ownership and contractor mobilisation, coupled with a limited and shared physical space, complicates the coordination of construction

work. We estimate that, as a consequence of this complexity, delays force the managers of the majority of such projects to abandon initial plans, improvise and re-plan, resulting in projects overshooting both budgets and deadlines. Perhaps surprisingly, most clients and contractors seem able to enumerate the main causes of these delays and overruns. Although this knowledge should help them in anticipating future delays, it seems that practitioners repeatedly overlook or neglect many potential issues. If this is the current situation, how could the HRO lens add to the understanding and managing of this coordination practice? Below, the principles of mindfulness are placed in the context of the just described project practices.

We observed limited 'sensitivity to operational issues' in several construction meetings. During these meetings, many discussions were blocked because of a client's limited knowledge of interrelated operational activities. One reason for this is that subcontracting policies distanced clients from actual construction processes. Further, fragmented ownership of the utility network and ambiguous lines of command impeded clients' awareness of interrelated operational processes. Since no client was formally in command of overall project coordination, they all approached their projects as isolated processes, neglecting the management of interfaces with related construction activities.

With regard to the 'preoccupation with failure' principle, we found that most site supervisors and contractors had a fairly comprehensive view of which unwanted onsite events could occur. Our dialogues with practitioners, for example, showed that they were able to provide detailed examples of events that had held up construction. These were, for example, blind-cutting, detecting potentially hazardous objects and poor weather conditions. Despite their knowledge of such failures, we did not observe work planners taking this into account when developing construction plans.

Further, municipal utility renewal programmes set strict deadlines for the execution of projects, putting pressure on planning and scheduling activities. As a consequence, a lack of time prevented work planners in one of our cases from thoroughly studying existing site conditions. As existing site maps were already of poor quality, the work planners greatly oversimplified conditions and project plans. Additionally, we were told by experienced project managers that they assume ideal and unhampered construction progress almost every time when they make project schedules. Their logic seems to be that: "you never know when hold ups will actually occur". In the end, such simplified plans and schedules do not contain contingencies and are, not surprisingly, waylaid by unexpected problems during the project's execution.

We expected practitioners to follow the 'commitment to resilience' principle when they had structures in place that enabled them to quickly react to unwanted delays in the construction work. This was limitedly possible in practice. For one, we found that project managers hardly had back-up strategies in place. Besides, re-planning and improvisation was inefficient as many work changes needed to be formally approved through time-consuming procurement procedures.

Clients and contractors seem to strongly follow the principle of 'deference to expertise'. The site managers were often unable to explain the formal organisation structure and the positions of the 'partners' on site. They knew, however, who to contact in the event of an issue arising. During unplanned, unexpected situations, contractors therefore try to circumvent formal procedures and directly contact the appropriate manager or supervisor. As an outcome, practitioners informally agree to quickly reschedule small project components or temporarily suspend construction.

Beyond describing the reliability complexities and issues that need to be addressed in utility project coordination practice, our aim is also to better understand how new technologies can enhance reliability in utility project coordination. We elaborate on this idea briefly by hypothesising about how a 4D-CAD scheduling tool could enhance reliability of practice.

Our research shows that 3D- and 4D- CAD construction process visualisations help in confronting the lack of information, avoiding the urge to oversimplify and to ignore potential delays. Practitioners become particularly sensitised to operational interdependencies when designs are integrated on the 3D level, and are pushed towards schedule integration when 4D-CAD approaches are used. 3D design and 4D-clash-detection help practitioners to enhance their awareness of potential errors and failures. Through scenario-based scheduling, the tool also allows practitioners to acquire in-depth knowledge of alternative project schemes, making projects more resilient to unwanted situations.

Pragmatically, the HRO lens provides a valuable structure for making sense of the coordination challenge and the behaviour of the practitioners involved. The lens further supports future policymakers in their efforts to make plans that enhance the reliability of utility projects, and allows researchers to study causalities between new technologies and reliability on these projects.

## CONCLUSIONS

Debates about the legitimacy of applying the HRO lens frequently distract from the diffusion of insights into the complicated dynamics of coordinating subsurface utility construction projects. Rather than discussing the projects and their issues, our presentations turn into reductionist 'either-or' discussions as to whether construction projects are High Reliability Organisations. We argue that this categorical way of defining HROs is irrelevant as it prevents researchers reaching a deeper understanding of utility project coordination. This paper aims to move on from the recurring dispute over the application of HRO theory and concepts in the construction domain. The debate as to whether the utilisation of the HRO perspective is permissible and justified as a lens in Construction Management (CM) research obstructs the wider application of the HRO perspective in the construction domain and in the CM field. Based on our research into the coordination in subsurface utility reconstruction works, and the value we experience in this HRO perspective, we have argued that the CM-application of HRO is permissible. Although some argue that the HRO lens is not applicable to the construction industry, we would point out that this study is not the first to adopt a theoretical lens from another field. Researchers frequently exchange theoretical lenses to understand phenomena in novel ways. For example, other cross-fertilisation has occurred through the adoption of theories from economics, supply-chain management and computer engineering. Despite the fact that these fields were very different to construction, CM researchers successfully adopted theories such as Transaction Costs, LEAN and Systems Engineering. This argument supports the exploration of how the HRO lens can be applied to construction management research.

To try and understand the position taken by those scholars who feel that the HRO perspective cannot be applied in the construction domain, and is therefore irrelevant, we tested the arguments that deem HRO to be impermissible in a construction context. Firstly, we found that the terms High Reliability and Organising seem to confuse the debate. These terms steer the debate towards a reductionist classification issue. Secondly, restricting the HRO ideas to the high hazard environment where it was first

applied is difficult to defend. Many of the key HRO scholars have themselves rejected that stance, and researched HRO in other industries and domains. Further, some valuable research has already been published on HRO in the construction domain. The connection often made between the HRO perspective and safety also seems to be related to linguistic blurring of the terms reliable and safe. HRO is primarily focussed on reducing errors. Since the classical HROs needed to be “reliably safe”, the terms 'reliable' and 'safe' became virtually synonymous. The initially selected domain had safety as its main performance parameter. We argue that organisations in other domains can still opt for error-free performance and reliability in terms of other parameters without compromising HRO principles.

To illustrate the descriptive power of the HRO lens, this paper has also described how its principles apply to mainstream organisations such as hospitals, service providers and framing crews. Additionally, the study shows how the HRO lens can be used to describe the intricacies of coordinating a utility construction project.

In moving the scientific debate in the direction of the HRO lens (involving mindfulness and heedful interrelated actions), we create a breeding ground for the more widespread use of the HRO lens in construction management research. We seek to advance HRO developments by arguing for a more pragmatic interpretation of the HRO lens. The HRO lens has merits for scholars as well as practitioners in construction management.

To move ahead, we urge CM scholars to suppress any reductionist classification impulses, to free the HRO lens from its restriction to a classical (high hazard) HRO environment, to focus on reliability rather than safety and to experiment with the principles of mindful organising and heedful interrelationships to study reliable processes in construction projects.

## **FUTURE RESEARCH EFFORTS**

This study's empirical findings are of a preliminary character. We have not attempted to draw definitive conclusions in presenting the HRO principles, and future research needs to examine construction's HRO lens in more detail. More specifically, it might be that some concepts and principles better fit the construction industry context than others. Research should therefore put further effort into contextualising (i.e. refining, adapting or extending) the HRO lens for the construction domain. This requires researchers to learn more about both well and poorly performing construction projects.

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# INDICATORS OF ENVIRONMENTAL AND PRODUCTIVITY PERFORMANCE FOR BUILDING REFURBISHMENT PROJECTS

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Since the end of the 1990s, much has been written on construction key performance indicators but little on indicators for building refurbishment, although indicators for road and sewage refurbishment are in use. The purpose of this paper is to formulate principles for developing building refurbishment productivity and environmental performance indicators. When starting from traditional productivity measures, also including effects on client productivity, and from environmental sustainability measures, it is necessary to ask why firms rely on performance measures and why they collect certain types of data. Literature in the areas of performance measurement, key performance indicators, sustainability and productivity has been reviewed and applied to a refurbishment context. When developing new indicators for refurbishment projects, it is important to consider practical issues such as resources required to collect data, including both leading and lagging measures, waste management, local, negative disruptions and effects on user satisfaction, consequences of coproduction, changes in input and output qualities and client productivity.

Keywords: performance measurement, key performance indicator, productivity, environmental sustainability, refurbishment.

## INTRODUCTION

Due to the aging building stock in Europe, more attention must be paid to refurbishment of existing buildings. Productivity and environmental performance indicators are developed in various contexts, but seldom with a particular focus on refurbishment. However the nature of refurbishment projects requires new indicators in addition to the earlier, traditional ones for new construction. Issues such as uncertainties in relation to the existing structure, involvement of multiple parties including occupants and a more complex waste handling process make refurbishment differ from other construction activities.

The aim of this paper is to formulate principles for developing building refurbishment productivity and environmental performance indicators. Performance indicators are used at different levels in the construction industry but the focus in this paper is on the project level. Earlier literature in the areas of performance measurement, key performance indicators, productivity and sustainability is reviewed, synthesized and

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applied to the refurbishment context. In general, implications from the performance measurement literature are that practical issues such as resources used to collect data should be recognized and both leading and lagging measures should be included while designing new indicators. Moreover waste appears as a greater challenge in refurbishment projects. Output measurement and especially determination of output qualities are challenges in measuring productivity performance. Local, negative effects of refurbishment processes on user productivity should be recognized in new indicators.

The paper is structured so that the literature is reviewed in three sections, in the order of performance measurement together with key performance indicators, environmental indicators and productivity indicators. Results from these sections are synthesized in a refurbishment context in a following section which formulates principles for developing new indicators. Finally conclusions are drawn in the last section of the paper.

## **METHOD**

This study is based on a literature review in the areas of performance measurement, key performance indicators, sustainability with an environmental focus and productivity. Throughout the review, there is an emphasis on contributions that are relevant in the context of refurbishment processes. Thus, the earlier literature is reviewed, synthesized and then applied to the refurbishment context.

## **PERFORMANCE MEASUREMENT**

Companies measure their performance for a number of obvious reasons including rewards tied to measures, benchmarking to see how they are doing internally and how their competitors do, to develop new company strategies and to evaluate these strategies (Eccles 1991). Instead of developing entirely new performance indicators, there have been attempts to adapt successful benchmarking models from other experienced industries to the construction industry. The nature of construction industry, its projects, participants and methods of execution were the challenges that make such transfers difficult (Lee et al. 2005). Similarly, during the attempts of implementing new performance measurement systems barriers arise for a number of reasons as construction industry is project based and each project is unique, a fairly intense input required to establish a performance measurement system, responsibilities for data collection, processing and analysis are not well defined in the beginning of the project and use of performance measurement system depends on the motivation and capabilities of the managerial team where each project has a different managerial team (Costa et al. 2006).

Although the construction industry is project based, there is a clear link between firms and projects which makes performance measurement more complicated. The project level measures with few indicators clearly do not reflect the performance of an entire firm. Thus El-Mashaleh et al. (2007) emphasize the need for a firm level performance measurement scheme. Vice versa, the firm level policies influence on performance measures at the project level. Additionally, project managers' and executives' perceptions of performance measures vary due to different focuses of these groups (Cox et al. 2003). It would not be unusual to see cases where the link between the firm and the project is weak and project participants disregard a number of important measures for the firm. Hence it should be kept in mind that the results of project

performance measurement might or should be applied at both the project and the firm levels.

A common problem in current performance measurement systems is that they lack preventive measures that can be used during a refurbishment process. While designing a new performance measurement system, both leading and lagging measures should be developed. Lagging measures are the most common measures used in performance measurement systems and they measure outcomes whereas leading measures are preventive and provide information during the projects (Anderson and McAdam 2004). The ideal proportion between leading and lagging measures for refurbishment projects is difficult to estimate, however the need for leading measures is obvious due to the high level of uncertainty concerning the existing structure. Moreover clients or at least building users are negatively influenced by the short term, local effects of refurbishment such as dust and noise (Holm and Bröchner 2000); therefore client satisfaction cannot be measured only in the end of the refurbishment project, something which is often adequate in new construction.

Many attempts to introduce new performance measures fail because both implementation and in use phases of performance measures are disregarded during the design phase. Problems related to in use and on-going management of performance measurement systems are resources required, simplicity, validity and reliability of the indicator, compatibility with other indicators, risks of leaking sensitive company information, and managers that are insufficiently capable and motivated. This can be seen in several studies of benchmarking schemes in other industries (de Bruijn et al. 2004; Francis and Holloway 2007; Maleyeff 2003; Neely et al. 2000). In his performance measurement manifesto, Eccles (1991) mention the importance of top management commitment to ensure continuous evolvement of the performance measurement system.

## **ENVIRONMENTAL INDICATORS**

Environmental assessment tools are used in many industries including construction and they offer a number of obvious benefits. Frequent purposes are to compare, communicate (de Bruijn et al. 2004), help consumers to understand what is environmental and orient them towards buying such products or services (Crawley and Aho, 1999; Schweber, 2013). In the absence of environmental design guidelines, environmental assessment tools implicitly offer guidance. Cole's list (1998) covered most of these benefits though he was able to add other ones: they provide a common and verifiable set of criteria and targets, they gather and organize detailed information on the building and they can be used by building owners to identify priorities for future administration measures.

In the construction industry, environmental assessment tools fail to reflect a number of aspects or do so only partially. Limitations of these tools have been identified in two similar studies. Ding (2008) presents that current environmental assessment methods are dissatisfactory in eight aspects: usability as design guideline, usability for selection of optimum project options, financial aspects, recognizing regional variations, complexity (input), evaluation of qualitative and quantitative data, weighting and measurement scales. Haapio and Viitaniemi's (2008) list of limitations covers user based problems are ignored, reusability of the building products are not considered, a predicted service life is used, ambiguities in utilization of the results and also that economic and social aspects of sustainability are not considered. However both

studies neglect specific challenges of different types of construction activities, such as refurbishment.

Problems related to separation of design and on the other hand implementation and in use phases of indicators are not limited to performance measurement systems. In a recent attempt at monitoring the environmental performance of the Swedish building and real estate management sector with a top-down approach by using national statistics, Toller et al. (2013) developed six indicators. They report difficulties to apply two of the indicators due to unavailability of data, namely use of hazardous chemical products and generation of waste. This shows that implementation and practicality of an indicator must be kept in mind while developing new indicators.

The BREEAM Refurbishment Domestic Buildings is today the only environmental assessment tool that has its focus specifically on the refurbishment process (BREEAM Refurbishment Domestic Buildings 2012). LEED for New Construction & Major Renovations has a longer history but it has little that is specific to refurbishment processes. The Ska rating tool in the UK is another environmental assessment tool which is clearly useful while dealing with fit-out projects; however, its application is limited to offices and retail space. When the BREEAM Refurbishment Domestic Buildings tool handles refurbishment separately from new construction, more attention is paid to the energy section whereas sections such as waste, materials and pollution are given less weight than for new construction. Efficiency is partly included in the tool in the section dealing with refurbishment site waste and efficient use of resources. However since this BREEAM version is the first attempt to evaluate the environmental performance of refurbishment projects, it can be questioned considering fundamentals of sustainability and also relations between the aspects of sustainability and productivity.

Developing indicators for waste from the refurbishment process is challenging. When looking at the fundamentals of sustainability, two common views should be distinguished: the conservationist and preservationist views (Passmore 1980) and waste could be analysed differently according to these two views. The conservationist view draws optimistic conclusions in terms of substitutability of social capital and the main concern is to achieve intergenerational equity. However, in the preservationist view the main concern is nature, where intergenerational equity among human beings is totally disregarded. Hence according to the preservationist view, the aim is to keep the species and wilderness as they are even if they are harmful to human beings. Unlike the conservationist view, conclusions from the preservationist view can be drawn in a refurbishment context, namely that resource use and waste management should be highlighted due to their potential negative influences on nature. Moreover, Toman (1994) identifies three common views of sustainability: neoclassical presentism, neoclassical egalitarianism and ecological organicism. In the ecological organicism view, the focus is on ecological systems and humanity as a whole and natural resources are accepted as limited. The basis of this view is the idea of an ecological system breakdown due to a chain of activities. Again in a refurbishment context, resource use is hardly expected to cause an ecological breakdown whereas waste from the refurbishment process might be different and more threatening due to uncertainty and problems often faced in recycling (Sezer 2012).

Also in another way, refurbishment presents a greater challenge than new construction, because of stakeholders particularly those present in the building during the refurbishment. Taking office refurbishment projects, building user satisfaction is

decreased temporarily due to local disruptions such as noise and dust (Holm and Bröchner 2000) and it is easy to find links between office user dissatisfaction and lower productivity.

Thus local, short term and negative effects of the refurbishment process may create particular challenges while dealing with environmental indicators. Todd and Geissler (1999) note also regional limitations of environmental assessment tools. They claim that regional differences such as having land or water as scarce resources should be reflected in environmental assessment tools. This requires that a tool gives enough flexibility to adapt criteria to local, regional and national differences. In refurbishment projects, local, negative effects have a greater impact than for most new construction and therefore more precise measurement of such effects should be encouraged while designing new environmental indicators.

## **PRODUCTIVITY INDICATORS**

Productivity is the ratio between output and input and it is defined in different ways, as partial or total factor productivity. In the construction industry the use of labour productivity as partial productivity is more common since it demands less data which makes it less costly but also less informative as a measure (Sudit 1995). Moreover labour productivity does not reflect the input quality changes such as due to heterogeneity of the skills of workers (Schreyer 2001). Relying on total factor productivity by including several inputs such as labour and equipment was suggested by Chau and Walker (1988) despite the challenge of data access and representing changes in input qualities.

One of the problems associated with the current productivity indicators is thus that quality changes in inputs and outputs are not covered adequately for construction in general. In refurbishment projects, the difficulties of determining both output and input qualities appear to be even worse. This also implies that existing productivity measures fail to reflect how refurbishment processes affect customer productivity. Having analysed six types of new construction and repair projects, Bröchner and Olofsson (2012) propose a number of non-traditional quality categories in addition to traditional productivity measures. These measures are intended for prioritizing innovation projects and recommended to be applied differently to different types of projects, such as in repairs of plumbing, the useful area of the existing facility might be less relevant and this requires other measurement units. Moreover, as already mentioned, reduced disruption of user activities is often more important in the context of repair projects.

Considering both the short and long term effects of refurbishment brings the potential conflict between productivity (efficiency) and economic sustainability to the surface. While efficiency reflects the short term productivity (productivity during the refurbishment process), economic sustainability refers to long term consequences. Most probably, efficiency will appear to be lower in refurbishment, partly owing to the problems related to output measurement (Sezer 2012).

Client involvement and coproduction is typical of the services sector and can be observed in the production processes of construction, creating further challenges to productivity measurement. Djellal and Gallouj (2013) identify three consequences of coproduction in services: defining the "product" becomes more difficult since the product is always different and tailored to specific needs; assigning the labour and capital input is difficult when measuring productivity, and the quality of the customer

(understood as an input!) strongly influences on the productivity of the service provider. More specifically in refurbishment projects where service characteristics are more obvious compared to other construction activities (Holm 2000), what is hidden by the term "client" appears to be more complicated, because it may include both clients who own the property and end users who may be customers of the client or occupants. Turning back to Djellal and Gallouj (2013), it is evident that client involvement and co-productive nature of refurbishment projects cannot be disregarded while designing productivity indicators.

Once again, design and implementation of performance indicators should not be separated and there are a number of challenges related to current productivity indicators. Nasir et al. (2012) noted several problems in the implementation of the indicators with a focus in infrastructure sector. First of all, using work breakdown and measuring productivity of the each subgroup was difficult. A similar problem appears in refurbishment projects where a predetermined list of activities, suitable for new construction, does not include typical refurbishment activities, nor the unexpected activities that may occur during the refurbishment such as asbestos removal. Second of all, inadequate resources to collect data is a well-known problem in performance measurement. Including many subcategories and assigning subcontractors to different subcategories makes it even more difficult to collect data and aggregate it. Finally, confidentiality concerns related to actual productivity data were reported as the final challenge; however this is more of an organisational issue which is out of the context of this paper.

## **PRINCIPLES FOR DEVELOPING NEW INDICATORS**

As we have found in the literature review, refurbishment projects present different challenges than new construction and other construction activities. Therefore while benchmarking internally (benchmarking among projects), it is doubtful to compare different types of construction projects such as comparing a new construction project with a refurbishment project. Traditionally in the construction industry, performance measurement is done with a predetermined list of activities derived from new construction. Very often the list may not cover specific activities of refurbishment or extra activities may occur during the refurbishment process including asbestos removal, additional demolition work and complicated waste handling. Therefore specific challenges of refurbishment should be recognized while developing new indicators.

While designing new indicators, the implementation and in use process of the indicators cannot be disregarded. One of the major problems reported in current performance measurement systems is resources required to collect data. The problem is practicality of indicators including data collection is sometimes overlooked in the design of the indicators. Practical issues should be recognized in the design of new indicators such as if this type of data can be collected easily. Moreover developing new indicators is a continuous process which requires updates depending on new conditions. Nevertheless, the number of indicators should be reasonably small and they should be kept simple if possible.

In relation to project completion, two types of measures are mentioned in the literature: leading and lagging. It might be excessive to fix an optimal proportion between these two types of measures for refurbishment projects but clearly both are required. During the refurbishment process, leading measures can be used to reflect extra work caused by uncertainties associated with the existing building structure.

Moreover due to local, negative disruptions of refurbishment process, client satisfaction should not be measured only in the end of the process. Therefore, client satisfaction should be a leading measure for refurbishment projects.

Waste from refurbishment processes is clearly different from new construction and more threatening owing to uncertainties associated with existing building structure such as a need for asbestos removal. Therefore the need for precise indicators related to waste management in refurbishment processes is clear.

According to the literature, local and negative disruptions such as dust and noise caused by refurbishment processes have negative influences on users. The relation between local, short term and negative effects of the refurbishment and user satisfaction should be recognized in the new indicators. A problem identified in critical analyses of current environmental assessment tools is regional limitations and in refurbishment projects, local effects are more problematic. This is partly because of consequences for stakeholders, particularly occupants that are involved in the refurbishment projects.

From the productivity measurement perspective, the co-productive nature of refurbishment is challenging. Output is produced together with the client and therefore both input and output qualities are more difficult to measure. Client satisfaction, client productivity and coproduction should be reflected while devising new indicators in relation to productivity.

## CONCLUSIONS

Performance measurement linked to productivity and environmental sustainability is challenging in the construction industry. In order to provide guidance for developing new environmental and productivity indicators for building refurbishment projects, literature in the areas of performance measurement, KPIs, sustainability and productivity has been reviewed here. Refurbishment presents a greater challenge than new construction and in current performance measurement systems, these challenges are overlooked or inadequately met. Clearly, more research is needed to understand different challenges of refurbishment and to improve productivity and sustainability of the refurbishment process. In this paper the need for new productivity and environmental indicators for refurbishment projects is presented together with a number of principles for developing the new indicators. Future research should include testing these principles with a set of indicators applied to the monitoring of actual refurbishment projects.

The design and implementation of a new performance framework should ensure that obstacles in data collection are recognized and simplified indicators to evaluate the productivity and environmental performance are produced. Including both leading and lagging measures is an important task.

Waste should be highlighted as a greater challenge in refurbishment projects and while designing new indicators. Moreover the local negative effects of refurbishment processes such as dust, noise and lack of information exert an influence on user satisfaction, constituting a relation which should then be mirrored in new indicators of refurbishment performance.

Productivity measurement in the construction industry suffers in general from problems in measuring output and input qualities and also from the co-productive nature of construction projects. Clearly, measuring output in refurbishment projects is a greater challenge than for new construction. Users being involved in refurbishment

projects is only one argument for the need for developing different indicators for refurbishment.

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# THE ROLE OF 'GREENING' AND AN ECOSYSTEM APPROACH TO ENHANCING CONSTRUCTION ERGONOMICS

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Ecological engineering principles are being incorporated into the design of buildings and developments through green infrastructure, sustainable designs, green roofs and walls, and water sensitive urban design principles. However, there is a need to go further than this to incorporate ecology as the standard approach in not just design, but all aspects of construction, buildings, spaces, and places to complement the sustainable sites initiative. The objective is to establish the use of ecosystems as the interface between technology and the environment through the implementation of the biophilic design concept and feng shui principles as part of the sustainable sites initiative in construction. An extensive literature survey and critical analysis of existing construction sites constitutes the methodology adopted for the exploratory phase of an extended study. The initial scope of the study is limited to an existing construction site with an established site management approach and procedures. The research originality and value arises from the establishment and integration of ecology and the use of ecosystems in construction ergonomics, and psycho-therapeutic stress management orientation and interventions in an endeavour to enhance the sustainable sites initiative in construction.

Keywords: biophilia, feng shui, ecology, ergonomic, construction performance.

## INTRODUCTION

The special issue on the future of ergonomics: Ergonomics and Sustainability (2008 cited in Stanton and Stammers 2008; Ergonomics 2013) stated that there is a need for ergonomics to be practical beyond just stating the importance and relevance within this area. It should be directly and innovatively applied to strategies involving applications of the existing body of knowledge to the design of interventions and improvements that would bring the construction industry closer to a sustainable future (Hedge 2008; Stanton and Stammer 2008). Such design interventions would include the biophilic design concept and feng shui principle of workplace wellness interventions, which according to current research findings would generate the cost-effective 'biophilic construction site model (BCSM)' drawn from the theory of 'biophilia' (Obiozo 2012; Obiozo and Smallwood 2012; Smallwood and Obiozo 2013).

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Petersen and Holness (2013) report that the Department of Environmental Affairs (DEA) and the South African National Biodiversity Institute (SANBI) are currently working on a project whose goal is to develop and package messages for other sectors of government concerning the relevance of biodiversity and ecosystem services to worker health and wellbeing initiatives. The project is geared towards socio-economic development and support of essential sectors of the economy of South Africa (Petersen and Holness 2013).

The risk of extreme climatic factors in the region presents a problem on account of the resultant increase in the human factor due to work stress, environmental stress and ergonomics of the workplace environment. The proposed intervention explores the substantial human and environmental benefits inherent in the use of ecosystem interventions and biodiversity. The goal is to maintain and harness the natural environmental assets of the workplace environment to the advantage of worker health, wellbeing and performance on the project (Comcare 2010).

The objective of the study advocates for the social organisational responsibility expressed in the practical intent of the organisational management towards sustainable development. This should be directed at an optimal exploration of the value of the natural attribute of the construction workplace environment in order to improve worker health and welfare (Zink 2005, cited in Stanton and Stammers 2008). Cognisance should be taken of the climatic factors and weather variations and how it affects the comfort and performance of the workers (Dul and Ceylan 2011). According to Matlock et al (2001) to improve the human experience the ecological economics of the natural vegetation and the need to preserve and conserve the ecosystem and biodiversity of the locality is also paramount.

The symbiosis and mutual benefit of this strategy would help to prevent the prognosis of the adverse effect of recognised threats to rangeland with regards to human activities such as construction work, mining, agriculture and other ill-advised acts of humankind that tend to disregard the environment and its resources (Matlock et al 2001). The importance of subverting these effects have been anticipated by the climate change models of the South African region presented in the findings of Petersen and Holness (2013).

## **ERGONOMICS, SUSTAINABILITY AND ECOSYSTEM-BASED ADAPTIONS**

### **Ecological Engineering**

Ecological engineering is concerned with the design, monitoring and construction of ecosystems (Matlock et al 2001), which shares similar goals to those of green ergonomics and sustainable sites initiative (Stanton and Stammers 2008; Hedge 2008). Mitsch and Jorgensen (2004) states that the design of sustainable ecosystems intends to integrate human society such as the construction workplace with its natural environment for the benefit of both the occupants and the workplace environment.

### **Ecological systems (Ecosystems), Ergonomics and Sustainability**

Zink, (2003 cited in Stanton and Stammers, 2008) in an invited plenary paper presented at the 15th Triennial Congress of the IEA, Seoul, 2003, argued for the benefits of considering occupational health and safety (OH&S) as a corporate social responsibility. This idea was a novel line of thinking at that time, whose potential was not fully addressed by researchers. According to Stanton and Stammers (2008), Zink

expounded a futuristic scope of corporate social responsibility as the driving force of sustainable development that is in consonance with economic growth and ecological balance. From this standpoint, the concept of sustainable development was presented as a key driver of change in organisational responsibility that regards the wellness and wellbeing of workers as a significant factor of worker health and welfare (Stanton and Stammers 2008).

However, Zink's recognition of opportunities for ergonomics from the sustainability movement has been shown by the number of citations given in research contributions reported in the special issue of ergonomics and sustainability (2008 cited in Stanton and Stammers 2008). The findings show human characteristics, behaviour and performance, and human interactions with technology as vital elements of these aspects. The range of data indicates that a natural synergy exists between these parameters and ergonomics regarding its objective of fully understanding and exploring the outcomes of human-system interactions (Stanton and Stammers 2008). Recent studies present the idea behind the concept of sustainability as an overreaching concern regarding the usage, conservation and preservation of the earth's natural and physical endowment. By all indications, these resources include the sustainability of organisations and the sustainable use of human resources (Stanton and Stammers 2008). In summary, Stanton and Stammers (2008) with significant evidence from the studies observed that a natural link clearly exists between ergonomics and these aspects of sustainable development.

### **The Biophilia Hypothesis**

The initial thought pattern for biophilic design is drawn from the theory of biophilia proposed by Wilson (1984) and anticipated by Fromm (1973, cited in Jones 2002) as a concept that harnesses human attraction to certain habitats, activities and objects in their surroundings with substantial evidence from research findings that cut across all aspects of human spectrum; livelihood and professions. An integral of cognitive human need its application is yet to take its stand in green ergonomics and sustainable sites initiative with which it shares a natural synergy (Jones 2002; Rostykus 2011; EU-OSHA 2012; Dul and Ceylan 2011; Thatcher 2012; Ergonomics and Sustainability 2013). In Kellert and Wilson (1993), the biophilia hypothesis addresses the inherent and cognitive factors of humankind and its innate affiliation to all living organisms (plants, animals, the weather) as psycho-evolutionary and genetic, originating in the savannah regions of the world with its significant benefit of prospect and refuge. Prospect and refuge addresses the ability to look out expectantly from a secure environment like a tree shelter, a cluster of bushes or according to Kellert and Wilson (1993) and Heerwagen (2006) the Forest edge.

### **Greening Construction Sites – Biophilic Construction Site Model (BCSM)**

The BCSM is a psychotherapeutic endeavour involving the implementation of rejuvenative and healthful wellness interventions with a landscape inspired perspective that involves the greening of construction sites regarding the establishment of domains of beneficial contact with nature onsite (Miyake 2003; Bird 2006). An eco-psychology study reviewed and endorsed by experts in Complementary and Alternative Medicine, Education and Psychology as well as Ergonomics investigates the proven benefits of human contact with nature that involves a unique tool enabling participants to purify and transform a primary contamination in mentality that leads to distorted thinking processes which blight human personal, social and environmental relationships (Jones 2002; Corbett and Milton 2011).

It is correlated and collaborates with the feng shui principle of wellness interventions on construction sites which involves the harnessing of the vital life force and energies inherent in an environment perceived to be either positive or negative (Diamond 2004). According to Gerstung and Mehrlase (2000), Diamond (2004), and Bender (2007), feng shui involves the identification of the positive energies in-order to create a natural, harmonious, vibrant, balanced, and life giving environment. A study conducted by Smallwood (2003; 2006) explored the positive attributes and the viability of implementing feng shui principles on a construction site and determined that the need for such an intervention exists in construction. The intervention would lead to the orderly, beneficial and harmonious arrangement of facilities, and introduction of vibrant, pleasant energetic colours drawn from nature such as the choice of a sunny yellow colour for a shading device over a walkway, a healing leaf green shade-net or a painting of nature settings hung in site offices (Diamond 2004; Bender 2007; Miyake 2003).

### **Case Study – BHP Billiton Central Block Construction Project at Wessel’s Mine, Hotazel, Northern Cape Province of RSA.**

The case studies involved three temporary construction sites comprising five construction companies and one permanent construction site of BHP Billiton Wessel’s Manganese Mine at Hotazel Central block project site, Northern Cape Province of the Republic of South Africa. The central block project includes the contract for the construction of a ventilation shaft, electrical sub-station and motor control buildings for the surface and underground mines. Murray and Roberts (M&R) Cementation is contracted to build the ventilation shaft with a four year contract with Synntech Project Management Company. Bashewa Construction has a nine months contract for the installation of the electrical sub-station to power the ventilation fans for the shaft with Olivier Construction on the civil works for the construction of the motor control building. Gear, Mine and Steel Construction was not working on site at the time of the survey.

The research method involved a field survey and exploratory case study on construction sites to determine the effect of greening of construction sites on workers and managements’ health, wellbeing, and performance. The data collection technique included a focus group study, oral and written interviews of workers and management observations, questionnaire survey, and photo elicitations.

### **Description of location – extreme climatic conditions**

The construction sites are located at Hotazel near Kuruman in the arid interior of the semi desert region of the Northern Cape Province of the RSA. The 2013 meteorological and geological data from the BHP Billiton Environment office indicates that the region experiences extreme temperatures in the winter and summer. The geological features include a manganese core and a depth of sand more than 21km from the surface. The summer afternoons are extremely hot, dry and stuffy. The environment is dusty with very little rainfall or precipitation. It has sparse vegetation and is located in a lonely desolate area about a full hour’s drive from the nearest town, Kuruman, at the border between RSA and Botswana. The workers find the stress of commuting to work with the climatic extremities very challenging increasing the job stress factor, which corroborates with findings from (Lingard and Francis 2004; HSE 2007; CIOB 2007; EU-OSHA 2012).

### Key Biophilic design element – Greening of Construction Site Survey

The greening of the construction site was largely restricted to the temporary construction site office premises of the construction companies; the main entrance locations, the general parking lot and central block office premises of the permanent site of BHP Billiton (Photos 5 and 6), and the premises of M&R Cementation temporary staff residences. All four construction firms identified with the green effort according to the peculiarities of each site. Details of key biophilic elements of greening on each site and mode of application are given below:

- a. M&R Cementation began with a totally nature devoid environment and all trees and plants were imported to the site. There was a considerable modification of the existing site. An existing valley and dump yard on the site was refilled with soil originally scraped from the construction site to bring it to the same level with the rest of the site. Total staff strength of M&R Cementation is 204; with 59 at the Vent Shaft construction.

The key biophilic element of greening included a rose garden courtyard fondly referred to as ‘an oasis in the desert’ developed at the entrance location. It featured a large giant water jug fountain, trees and various colours of rose bushes. Soft grass was planted on the entire site office premises. Yellow sun shading devices were used on covered walkways to enhance the rays of the sun with rose bushes planted alongside the walkways and within the courtyards. The planting of grass by the workers in the courtyard extension of their changing room, and the effort to maintain it green with waste water from their shower drains, overcame the lack of water on the site at the time of the survey, and indicates appreciation and support for management’s green efforts (Photos 1, 2 and 3).

- b. Bashewa construction protected the existing Carmel Thorn (*Acacia Erioloba*) trees on the site and enhanced it with shade nets to create two outdoor shelters that are used for site meetings, lunch breaks, and community gatherings as a place of rest, refuge and shelter from the elements. The shelter was also furnished with chairs and tables (Photo 7).

Key biophilic design features: There was no planting or importation of new trees to the site; rather the existing trees were enhanced with shade nets and live Chameleons placed in it; which was a joy to feed by management and workers. It was a beautiful sight, appealed to the senses and had a healing presence. The sounds of the birds chirping in the trees provided a pleasant backdrop to the lunch break retreat when the workers were resting in the shelter after stressful site work. The total staff strength of Bashewa Construction is 10 and details are shown in Photos 7 and 8.

- c. Olivier Construction’s site offices were located on the same premises and also benefited from the efforts of Bashewa’s construction management. Their workers shared the outdoor shelters. This helped to improve communication and interaction between employees of the two firms. Their total staff strength was originally 40, but was reduced to 18 at the time of the survey since the project is near conclusion (Photos 7 and 8).
- d. Synntech Project Management Company had a staff strength of 10 and shared the construction site and premises of M&R with office extensions and gardens created to accommodate them (Photo 2).

A fifth construction company, Gear Mines and Steel had a contrasting construction site environment from the rest with a distinctly nature devoid, arid, and stark environment. The site offices were right in the middle of this hot setting with no effort at all at greening (Photo 4). Everyone passing by this site enroute to Bashewa Construction site or the Vent shaft could visibly feel the ‘physical and psychological heat’ emanating from the site and environment and usually passed a comment to that effect. All spontaneously testified to and disassociate from the construction site with repugnance. The total staff strength is unknown since the employees were not on site at the time of the survey.

Comparative analysis of study – the lack of biophilic design feature (Green element): Gear Mine and Steel Construction Company maintained the currently ‘questionable’ existing pattern of construction companies that have no form of nature on the construction site (Photo 4). It presents an unwelcome association to the other two green construction sites of M&R Cementation and Bashewa Construction.

Photos of all four construction sites are as shown below.



*Photos 1, 2, 3 and 4: M&R Rose garden courtyard with giant water jug fountain; Sunny coloured shade over walkway leading from M&R to Synntech Project Management Offices; contrastingly green grass at M&R workers changing room extension courtyard; the contrasting site of Gear Mine and Steel Construction devoid of beneficial natural green element (source: Field Survey).*



*Photos 5, 6, 7 and 8: BHP Billiton central block office courtyard; Parking lot at BHP Billiton; Outdoor shelter at Bashewa and Olivier Construction site offices premises; and live chameleon on the Carmel Thorn tree at Bashewa Construction site (source: Field Survey).*

## **Results and Analysis of findings**

Organisational effectiveness in construction has necessarily metamorphosed into BCSM or the ‘Greening of Construction Sites’ as an effective tool for cost effective construction risk management and productivity improvement (Miyake 2003; Taylor 2007; Sass 2012; Obiozo, 2012; Obiozo and Smallwood 2012; Smallwood and Obiozo 2013). Of particular importance is that all three firms individually evolved the biophilic design and correlated feng shui principles of wellness intervention on their construction sites without any prior knowledge or information regarding the concepts.

BHP Billiton also encouraged and motivated the greening effort with the yearly tree planting exercise at their Wessel’s Mine Hotazel Manganese construction sites as part

of their environmental protection activity. In fact, the trees at M&R were obtained from the consignment of BHP Billiton freely distributed trees to their contractors. M&R Cementation, however, not only planted and maintained the trees on their site, but also nurtured and fed them with manure and fertiliser so that they survived the harsh weather conditions onsite, unlike so many others planted within the same environment at the same period. The HSE director of M&R Cementation and Bashewa Construction Management in their reports testified to having implemented the green elements on their construction sites from a gut feeling derived from their pleasant experience of landscaped gardens in social and private settings.

It is interesting to note and of particular importance to this research, that the greening of the M&R construction site is the effort and responsibility of the HSE department of the organisation. It is an HSE strategy they highly advocate to and strongly believe in, and many times the HSE Manager would stake personal monies to sustain the green project. According to an M&R HSE Management Survey Report it is an all staff intensive exercise and therefore comes highly recommended from both management and employees to all construction managers by reason of health, safety, environment, performance, and productivity. The 'greening' is always a pleasant surprise and a welcome sight encountered by staff and visitors to the construction sites. The comment of a visitor to the site confirms this: "It is commendable and should be encouraged". The Bashewa Construction Manager also commented that the inspiration to 'green' their construction site was an encouragement from the M&R construction site, especially the beneficial encounter with the rose garden courtyard with giant water jug fountain at the entrance courtyard.

The use of sunny yellow shading devices for the walkways in the M&R site office area enhanced the rays of the sun, creating energising sunny shades; the vibrant dynamic colours of natural blooms of rose flowers added to the pleasant scent is collectively associated with the positive vital life giving energy inherent in the particular construction workplace environment. The vibrant dynamism of the ever changing colours of the live chameleon is appealing and energising and constitutes a welcome diversion from workplace stress and balances the diversity of the ecosystem of the natural workplace environment. Some of the live chameleons were picked from the construction workplace environs which constitute their natural habitat. These factors harmonise and synchronise with the key elements involved in feng shui and the biophilic design concept (Kellert and Wilson 1993; Gerstung and Mehrlase 2000; Bender 2007; Heerwagen 2006). It is apparent that these principles are in harmony with ecosystem adaptation and ecological engineering according to (Matlock et al 2001; Mitsch and Jorgensen 2004). Employee responses confirm it as a beneficial healthy pleasant workplace strategy that promotes worker wellbeing, health, and performance (Stanton and Stammers 2008; Hedge 2008).

### **Discussion from Findings**

The sense of responsibility of the management towards sustaining the physical, economic and social aspects of the workplace environment would fall in the category of ecological engineering geared toward the preservation and conservation of the ecosystem and biodiversity of the workplace of which the human factor is an integral (Matlock et al 2001; Mitsch and Jorgensen 2004). According to Petersen and Holness's (2013) climate change model, the real threat of range shift from climate change necessitates the maintenance of the biodiversity of the particular locality and region in which the worksite is located. This effort has been applied to the advantage

of the employees and the organisation. For instance, the existing trees at Bashewa construction site office premises were retained and maintained not cut down as is usually the case. At the M&R construction site, more trees, rose bushes and grass were planted as dust cover to hold the soil in place against erosion and weathering due to construction and climatic factors.

The waste water from the construction work and the shower drain of the M&R Construction workers was redirected for hydration, watering of plants and keeping the environment cool and pleasant in-order to create a beneficial micro climate that is conducive to work in all seasons.

## CONCLUSIONS

The beneficial application of ecological engineering in the construction workplace has been established by evidence from the research study. It has also presented an identifiable and verifiable data that explores the reality of the proposition contained in the special issue publication on the future of ergonomics: Ergonomics and Sustainability (2008 cited in Stanton and Stammers 2008; Ergonomics 2013). It has established organisational social responsibility as an effective tool towards enhancement of worker health, welfare and performance as proposed and anticipated by Zink (2005, cited in Stanton and Stammers 2008).

The research has also demonstrated the benefit of investing in people and the practicality of ecological engineering in the sustainable development of the construction workplace and mitigation of the psychosocial risk factor of the workplace environment according to the complexity of each project (Heerwagen 2006; CIOB 2007; HSE 2007; EU-OSH 2012). It also serves as an innovative strategy in ergonomics and human factor towards enhanced employee assistance programme (EAP), worker performance and productivity that is nature derived. There is a call for further research and exploration of the various applicable methods of greening the construction workplace to enhance ergonomics and sustainable development, worker health, performance and wellbeing by employing the ecosystem-based adaptation method (Stanton and Stammers 2008; Petersen and Holness, 2013).

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# WEAK MANAGEMENT OF THE PREDICTABILITY OF CONTINGENCY ALLOWANCE IN CONSTRUCTION PROJECTS IN NIGERIA

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Establishing an accurate amount or percentage allowance to cover unpredictable changes in the construction project budget should be a genuine concern of the project team members. Different studies have shown that contingency allowance has neither been adequate nor technically predictable. The study assessed the practice of professionals in the management of contingency and determines the percentage contingency that is predictable on construction projects in Nigeria. In order to achieve the objectives, the sample selected for this study is quantity surveyors in government, institutions and consulting organisations. Data of past projects were collected from 21 organisations and included information of 99 projects of varying sizes and contract type. Analysis of variance, correlation and multiple regression were used to compare groups and for exploring relationships among variables in proposing a model. The proposed model using standard multiple regression predicted 10.10% contingency allowance on consultant's estimate. The study revealed that about 60% of the respondents do not formally manage and report contingency in their organizations alluding to the fact that an intuitive 5% allowance contingency is not only inadequate but also weakens the purpose of contingency allowance.

Keywords: contingency, Nigeria, quantity surveyor, regression model, variation.

## INTRODUCTION

Improving programme efficiency and effectiveness in organizations requires the use of performance measurement in assessing project performances, both in terms of the financial and non-financial aspects. According to Takim, Akintoye and Kelly (2003) performance measurement is the regular collecting and reporting of information about the inputs, efficiency and effectiveness of construction projects. In Nigeria, not much has been reported on the estimating and management of the construction contingency. This is evident in the number of cases of project cost over runs in which relationship between contingency and final construction cost is hardly reported. According to Bent (2005) project managers mostly treat contingency as a 'slush fund'. Importantly, clients and development agencies are becoming more informed about construction project management, the effectiveness of which is of utmost concern and contingency is a key factor of consideration. It has become necessary to simultaneously manage

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company and risk (Turskis, Gajzler and Dziadosz, 2012). It is expected that the quality of a project depends to a large extent on the skills and experience of project team leaders; managerial system and the procedures adopted during the construction process (Takim et al, 2003).

In construction and engineering projects plans and cost estimates are usually drawn to ensure that the work is carried out to the desired quality, within allowed time, and within budget. In a construction project and from the owner's point of view, contingency is the budget that is set aside to cope with uncertainties during construction. Touran (2003) posited that it is common to assign contingency value to both cost and schedule because project uncertainties can affect project schedule as well as cost. Contingency allocation has been the subject of various research and various methods of contingency calculation and allocation have been described in several sources. One of the more common methods of budgeting for contingency is to consider a percent of estimated cost, based on previous experience with similar projects. According to Baccarini (2004) contingencies are often calculated as a percentage addition on the base estimate, typically derived from intuition, past experience and historical data. Any serious changes to this budget that is not catered for by contingency may hamper the progress of work or even lead to abandonment of the project which the client never wishes. Current research efforts are being geared towards achieving effectiveness in planning and management. It is a common practice to add a percentage allowance on the base estimate as contingency, which is mostly not effective. Therefore, the aim of the study is to assess the management of contingency predictability by analyzing the significant difference between contingency sum applied to the construction cost estimate and variations. Also included in the objective is defining contingency and assessing the opinion of quantity surveyors in the management of contingency allowance on projects that they have handled in Nigeria construction industry.

Therefore, an assurance of a reliable and effective construction contingency is essential to client's satisfaction on the estimated final construction cost. Increasing clients' satisfaction is achievable through better project management actions, effectiveness of the team leader, viability and feasibility of procedures and stability of the project environment. Specifically, the study will assist consultant quantity surveyors in their estimating practice which benefits clients to have a reliable cost estimate for their projects.

## **PREVIOUS WORK**

Different authors and researchers including Odeyinka (1987); Ramus and Birchall (1996); Mak, Wong and Picken (1998, 2001); Ashworth (1999); Smith (1999); Harris and McCaffer (2001) consider the assessment of construction risks and its management. Construction contract delivery is a complex undertaking, which is characterised with uncertainties and risk. According to Odeyinka (1987) risk is inherent in any construction project right from inception through its completion. According to Turskis et al (2012) risks that emerge from inability to keep deadlines and remain within the budget are important to all participants of an investment process. Ashworth (1999) posited that risk can be mathematically predicted, whereas uncertainty cannot. The new management paradigm based on process management fosters identification and quantification of risk ( Turskis, Gajzler and Dziadosz, 2012).

## Understanding Contingency Allowance

Patrascu (1988) observed that contingency is probably the most misunderstood misinterpreted and misapplied word in project execution. Contingency can and does mean different things to different people. Ahmad (1992) and Baccarini (2004 & 2005) agreed on this observation and sought for clear understanding of the term contingency. Moselhi (1997) believes that there is no standard definition for contingency. From various authors contingency could generally be defined as a reserve of money allowed above the base estimate amount to reduce the risk of overruns of project objective (Ranasinghe, 1994; PMI, 2004) and allow for changes that experience shows will likely be required (Clark and Lorenzoni, 1985; AACE, 2000) so as to achieve a specific confidence level (AACE, 2000; PMI, 2000) within the scope of the project. In spite of the variations in the definition of contingency in the literature especially the contingency inclusions and exclusions, contingency fund or reserve is not intended to cover changes in scope or schedule, profit, overhead, Acts of God, force majeure situations, earthquakes. This is articulated from various sources (Ahmad, 1992; Moselhi, 1997; AACE, 1992; Ranasinghe, 1994; Chen and Hartman, 2000; Touran, 2003; Baccarini, 2004, 2005; Parsons, 1999; PMI 2004).

Contingencies are crucial to achieving project objectives. According to Yeo (1990) the objectives of the contingency allocation are to ensure that budget set aside for the project is realistic and sufficient enough to contain the risk of unforeseen cost increases. Therefore, any realistic contingency must serve as a basis for decision making concerning financial viability of the variations, and a baseline for their control (Akinsola, 1996).

Moselhi (1997) posited that contingency estimated with intuition and percentage addition ranges from 1 to 5% and rarely exceeds 10%. Parsons (1999) stated the purpose of contingency allowance as to improve the accuracy of cost estimates by compensating for inherent inaccuracies. This is provided in form of contingency allowance. This is expressed as:

$$\text{Total Estimated Cost (TEC)} = \text{Estimated Cost} + \text{Contingency Allowance.}$$

As the project becomes better defined more items are included, the estimated cost grows, and the contingency becomes lower, reflecting the reduced degree of uncertainty at that phase of the project. Ideally, the TEC will remain constant throughout a project.

## Management of contingency fund

At the commencement of the construction phase of a project, most of the risk associated with the contract should result from change order growth, which is to be accounted for by the contingency included in the budget. According to Akinsola (1996) any realistic contingency must serve as a basis for decision-making concerning financial viability of the variations, and a baseline for their control. The problems to be solved at this phase would be how to accurately forecast the final cost of these contracts at any given time (Rowe, 2006). This is the responsibility of the authority that manages the contingency. The peculiar nature of construction projects and its characteristics make exact budget needs impossible to forecast accurately and budget contingencies are critical to meeting project objectives. Ford (2002) found that contingency management practices are not organised by clearly defined procedures compared to many other managerial tasks, such as estimating and scheduling. He further relates contingency management to managerial performance but not directly to

project performance. It is thus, important to assess the skills possessed by would-be project manager in order to hinge the performance of the contingency and the entire project on the managerial performance of the required skills. Odusami (2002) identified decision making as the most critical important skill for project managers. Communication, leadership and motivation, and problem solving were also ranked accordingly with negotiation skill being the least ranked but rated important. A manager that performs well in these skills would mostly perform in managing the contingency fund. Therefore, according to Ford (2002), the effectiveness of contingency management can strongly influence project success and contingency management is an important project management issue. Baccarini (2004) reported that substantial number of cost practitioners and project managers do not formally manage project cost contingency. Most contingency fund would be exhausted before the completion of the project requiring additional fund. This is a problem that managers are to solve. According to Ford (2002) improving contingency management requires the understanding of how managers make decisions on performance. Managers respond to this challenge by simplifying projects, building and applying models, and improving mental models (Ford 2002).

### **DATA COLLECTION**

The research sample selected for this study was guided by typical cases of a population that can provide the requisite data and information among professionals in the construction industry. The primary data for this study were obtained through structured questionnaire administered to experienced professional and practising quantity surveyors in government, institutions and consulting organisations. Most of these organisations have projects across the country hence, are representative of what obtains in the entire population of the study. The secondary data for this study were obtained from records of past projects in the organisations to get cost data variables required for research analysis. A closed-ended method of structured questionnaire was adopted for generating information and data for the study. A three points scale of '1', '0', and '-1' representing 'Yes', 'Not really' and 'No' was also used for the assessment of the attitude of cost experts on the management of contingency during the course of the project and for the assessment of its accuracy after the completion of the project. A data collection schedule which contains 14 variables extracted from the records of completed projects or on-going projects nearing completion. Computer based statistical tools such as Frequency distribution of respondents; Mean Score, Descriptive statistics, Correlation, Regression, and Analysis of Variance ANOVA were used for processing the research data. Inferences drawn from this sample was used to make conclusions.

### **Results and Discussions**

Fifty-three representing seventy-six percent response rate of a total of seventy copies of questionnaire administered to quantity surveyors and or cost expert in three different organisations (government, institutions and consulting) in the construction sector were returned. The sample size comprised government establishment representing 18%, institutional representing 16% and consulting firms representing 66% of the sample size respectively. The sample also sought for the age of the organisations in which 11 representing only 21% of the respondents being less than ten years old and the remaining 79% were between 11 and above 40 years in age. All the respondents are academically qualified with a total of 40 university degree holders representing 65% of the returned questionnaires with 18% having their degree at

Masters Level. Others are Higher National Diploma holders representing 25% of the respondents. Of the 53 respondents surveyed 60% are professionally qualified as member of the Nigerian Institute of Quantity Surveyors four (8%) of which are fellows of the institute indicating that a large percentage of respondents have adequate understanding of the professional practice in the management of contingency among quantity surveyors in Nigeria.

*Assessment of Respondents' practice on Management of Contingency*

Respondents were asked whether contingency is formally managed and or reported throughout the project. Interestingly 40% of the respondents stated that their organisation formally manage and report contingency throughout the project but a larger percentage 60% do not really manage or report contingency on their project. This suggests that there is a significant room for improvement in organisations' approach to construction cost contingency. In discussions, some of the respondents declared that contingency is actually treated as a slush fund. It was also revealed that distinguishing between contingency and additional work is a problem because additional work is being treated as unforeseen work to be accounted for by contingency. Another related question was asked on review of the accuracy of contingency at project completion. The same percentage that manage and report contingency also review the accuracy of contingency at completion. Indicating that only 40% of respondent actually review contingency accuracy 60% do not really do this. Table 1 summarises the results.

*Table 1: Results of Contingency Management and Accuracy of Contingency Review*

	Contingency Management		Review of Accuracy of Contingency	
	Frequency	Percent	Frequency	Percent
No	6	11.3	5	9.4
Not really	26	49.1	27	50.9
Yes	21	39.6	21	39.6
Total	53	100.0	53	100.0

### **Presentation and Analysis of Project Cost Data**

Having established that most construction projects lack adequate management from the opinion of the respondents, it would be appropriate to further assess quantitatively the effectiveness of managing the contingencies allowed on projects. Data were received from 21 organisations and included information relating to 99 projects of varying sizes and contract type. The data obtained were statistically analysed. The first statistical analysis carried out was the use of scatter plot diagram to identify outliers in which four projects were removed from a total of 103 projects which put the total number of projects for analysis to 99. The next step was to check the variability between the projects using analysis of variance ANOVA to detect whether the 99 sample size would not violate the assumption of homogeneity of variance and if the ninety-nine projects are statistically significantly different. The variables used were total variation (including fluctuations) on estimated contract value (i.e. less contingency sum) and the contingency sum. The same analysis was carried out on the percentage of the variation on estimate and percentage of contingency on estimated contract value. A one-way between groups analysis of variance was conducted on the ninety-nine sample projects in which the significant value (Sig.) for Levene's test

indicated that the assumption of homogeneity of variance was not violated and the ANOVA table revealed that there is statistical significant difference between the projects. From the foregoing the accuracy and or effectiveness of contingency in absolute term is the difference between the percentage variations and percentage contingency on the projects. That is, 11.62% - 5.53% which gives 6.09%, a result that is even higher than the percentage contingency. Revealing that contingency sum is less than the total approved variation hence, not effectively managed.

*Estimating Percentage contingencies*

In a related research by Bello and Odusami (2012), it was revealed that the mostly applied percentage contingency is 5% or less and application of contingency of 10 percent or more is rare. A further analysis of construction contingency of 5.53% and average variation of 11.62% of the estimated contract sum indicates that contingency covered only 47.59 percent of approved contract variation and thus, did not cater for 52.41 percent of approved contract variation. The variability of variations (V %) 184%, as measured by coefficient of variation (from standard deviation and Mean), is greater than the variability of construction contingency (C%) which has 86%. This confirmed that contingency sum is less than the total approved variation by 6.09%. One-way ANOVA with post hoc test was carried out to establish if there is a significant difference between contingency and the variations (including fluctuation) to establish the effective management of contingency on project delivery.

A one-way between group analysis of variance was conducted to explore the effectiveness of contingency on variation, as applied to all the 99 projects under study. There was a statistically significant difference at the  $p < 0.01$  in the two variables [F (42, 56)=6.02,  $p=0.01$ ]. The effect size calculated using eta squared was 0.82 which indicated a very large effect. Table 2 shows the summary of the results.

ANOVA

*Table 2: Statistical Difference between Total Variation and Contingency*

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	526208.063	42	12528.763	6.021	.000*
Within Groups	116519.603	56	2080.707		
Total	642727.665	98			

*\*Significant at  $p < 0.05$*

The result of the analysis indicated that contingency allocated is not producing the result that is intended on project delivery hence, contingency applied on projects is not effectively managed.

*Regression Model and Results*

In this section, the predictive ability of the identified project variables is explored so as to develop a model for predicting contingency on construction projects. A simple regression equation for a dependent variable X1 is presented in the form;

$$X1 = \beta_0 + \beta_1X2 + \beta_2X3 + \beta_3X4 \text{ ----- (eqn i)}$$

Where,  $\beta_0$ ,  $\beta_1$ ,  $\beta_2$ ,  $\beta_3$  and  $\beta_4$ , are constants derived from the regression coefficients after the analyses and X2, X3 and X4 are the independent variables corresponding to Consultant estimate, Planned duration and Gross floor area respectively. Standard multiple regression was used to explore the interrelationship among Consultant estimate, planned duration and Gross floor area in predicting the total variation of 99

projects sample. The following equation was developed from the model displayed in Table 3 from which the coefficient of the predictor independent variable was extracted.

From the model equation (i) Substituting, the coefficient we have;

$$X1 = -15.235 + 0.101 X2 + 0.436 X3 + 0.003 X4 \text{ ----- (eqn ii)}$$

X1 =Total Variation on the Project (Future Contingency) X2 =Consultant estimate X3 = Planned duration (weeks) and X4 = Gross floor area. (m2)

Table 3: Extract of Coefficients Table from Standard Multiple Regression

Model		Unstandardized Coefficients		Standardized Coefficients	Sig.	Collinearity Statistics	
		B	Std. Error	Beta		Tolerance	VIF
1	(Constant)	-15.235	14.125		.284		
	Consultant's Estimate	.101	.053	.408	.060	.181	5.537
	Planned Duration	.436	.580	.119	.454	.332	3.011
	Gross Floor Area	2.942E-03	.003	.160	.315	.330	3.027

*Dependent Variable: Total Variation (incl. fluctuation) on Estimate*

#### *Evaluating the Model*

Looking at the model summary Table 4, the R Square reads 0.415 which indicates that the model was able to predict 41.5 per cent of the variance in the variation using these three independent variables. This prediction is quite respectable if other factors that influence the contract variation are included in the model. Also, looking at the significant for the model the consultant estimate is significant at  $p < 0.10$  but other two variables are not. The results of the multiple regressions also report the ANOVA to assess statistical significance. The model is statistically significant at  $p < .005$ .

Table 4: Model Summary from Standard Multiple Regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.644	.415	.390	63.25529943

To conclude on the importance of the model, the coefficient (constant) for consultant estimate is estimated to be 10.10% which is an average contingency acceptable in the construction industry. Moselhi (1997) affirmed a contingency ranging from 12% to 25% as reliable, Aibinu and Jagboro (2002), Omoregie and Radford (2006) had suggested 15-20 percent.

Effectiveness of contingency is not just to calculate the percentage addition but its management. Akinsola (1996) posited that any realistic contingency must be a basis for decision making concerning financial viability of the variations, and a baseline for their control. In aggregate contingency allowance has been effective in accounting for variation or in avoiding cost overrun in 36% of the ninety-nine projects studied in this research. Hogg (2003) reported 23% of the 35 projects that he considered; the conclusion is the same: that there is weakness in the approach to contingency assessment and or allocation. According to Ford (2002), the effectiveness of contingency management can strongly influence project success and contingency

management is an important project management issue. The findings on management of contingency revealed that a larger percentage do not really manage or report contingency on their project. This position was articulated by many authors including Ford (2002); Hogg (2003) Baccarini (2005) and Rowe (2006).

## **CONCLUSIONS**

The definitions of contingency by various authors were studied. A more comprehensive definition of contingency is expressed as a reserve of money allowed above the base estimate amount to reduce the risk of overruns of project objective and allow for changes that experience shows will likely be required so as to achieve a specific confidence level within the scope of the project. Few quantity surveyors formally manage and report and or review contingency throughout the project but a larger percentage do not really manage contingency with review and or reporting contingency on their project. This suggests that there is a significant room for improvement in organisations' approach to construction cost contingency. Some quantity surveyors especially those in government and institutions organisations declared that contingency is actually treated as a slush fund. There was a statistically significant difference at the  $p < 0.01$  in contingency and variation [ $F(42, 56)=6.02$ ,  $p=0.01$ ]. The effect size calculated using eta squared indicated a very large effect which revealed that result of the analysis indicated that contingency allocated is not producing the result that is intended on project delivery hence, contingency applied on projects is not effectively managed. This is the responsibility of the authority that manages the contingency. The effectiveness of contingency management can strongly influence project success. Total project contingency decreases over the life cycle of a project and contingency management is an important project management issue. A larger percentage of cost experts do not really manage or report contingency on their projects. The model presented in this research estimated the coefficient for consultant estimate at 10.10% which is an average contingency acceptable in the construction industry. The model was able to predict 41.5 per cent of the variance in the variation using three independent variables. This prediction is quite respectable using few handy variables- a limitation to the use of the model as it does not include other variables like complexities of projects; project governance; capabilities and capacities of resources, levels of risks and uncertainties; strategic intent of project leaders among other factors that could influence the contract variation.

## **RECOMMENDATION**

The importance of forecasting an accurate and effective construction contingency is sine qua non to client's satisfaction on the estimated final construction cost and hence, the construction contract delivery. Contingency sum should be understood as the fund for the client or project manager's authority hence, there should be no fear to declare how much the quantity surveyor forecast the contract to overrun based on genuine estimate. The notion that whether or not there is enough contingency, variation would arise should be discarded and a more proactive and scientific method of estimating and managing a defendable and reliable contingency that records a reasonable savings at completion of the project should be embraced. Contingency should be formally reported and reviewed in comparison with variation during the construction and at the completion of the project; this would enable the cost expert and managers to capture organisational knowledge that leads to improved practice.

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# CRITICAL ANALYSIS OF RESEARCH ON PROJECT SUCCESS IN CONSTRUCTION MANAGEMENT JOURNALS

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How to deliver project success has become a prominent discourse in both academic and practitioner debates on project management. However, despite years of research, how to improve the likelihood of successfully delivering a project and the criteria for assessing project success still remain unresolved. This study reviews conceptual and empirical research papers on project success relating to project success factors (PSFs) and project success criteria (PSC) published in construction management journals with a view to investigate the link between them and the relative importance of PSFs and PSC. The findings show that the link between many PSFs and PSC remains unexplored with the link only being articulated from a conceptual perspective with less empirical evidence in support of such link. Although relative importance of PSFs and PSC can be analysed from previous studies, there is no evidence that the most important PSFs by mean ranking make a difference to project success in practice or influence PSC across different projects and different stakeholders. These issues present fertile avenue for future research as many project stakeholders continue to grapple with which areas to concentrate limited resources to improve the chance of delivering a successful project.

Keywords: critical analysis, project success criteria, project success factor.

## INTRODUCTION

Project success is a complex concept that changes over time and different for different project stakeholders (Griffith et al 1999). Successfully accomplishing a project requires the effective management of various constrains and therefore measuring project success is a complex task as success can intangible and consensus hardly exists (Chan et al 2002). The success of a project and the influencing factors depend on the nature, the type of activities and the project environment. Therefore, factors affecting success change from project to project (Muller and Turner 2007). The construction industry is complex and dynamic in nature due to uncertainties surrounding rapidly changing technologies, budget constraints, involvement of geographically dispersed virtual teams, changing requirements and impacts of environmental, political and economic changes. Therefore, achieving project success is challenging and both academics and construction practitioners have grappled with the project success dilemma for decades partly because the concept of project success still remains ambiguously defined (Chan et al 2004). As a result, how to improve the likelihood of successfully delivering a project and the criteria for assessing project success remains unresolved. There is a plethora of studies relating to PSFs and PSC.

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Muller and Turner (2007) define PSFs as the elements of a project that can be influenced to increase the likelihood of success and are the independent variables that make success more likely. PSFs are therefore distinct from PSC which are measures by which we can judge the successful outcome of a project. PSC are therefore dependent variables which measure project success. Most previous studies have tried to identify PSFs and PSC but only a few have analysed relative importance of PSFs and PSC or relationship between them. Some of these authors have identified such links conceptually through literature whereas some others have identified positive or negative relationships through qualitative, quantitative or combined empirical studies.

Systematic analysis of papers on a chosen topic published in academic journals helps researchers to explore what have been done by others, current status and future research trends (Tsai and Wen, 2005). On this basis, reviewing literature within the domain of project success enables researchers to gain clear understanding on the subject area and helps understanding unresolved issues. In particular, the link between PSFs and PSC and the relative importance of PSFs and PSC are still inadequately explored. An analysis of the body of knowledge in this regard is therefore worthwhile. Therefore, this paper aims to review conceptual and empirical research papers relating to PSFs and PSC in construction management journals with the hope of providing an account of the body of knowledge and identifying research gaps for future research. The rest of the paper is structured in five sections. The next section defines and differentiates PSFs and PSC. The method used in this review is described thereafter. The fourth section presents the results of this critical review. Findings and their implications are then discussed subsequently outlining future research focus in the last section.

## **PROJECT SUCCESS FACTORS AND SUCCESS CRITERIA**

The term Critical Success Factors (CSFs) is defined as factors predicting success and critical to the delivery of projects (Sanvido et al, 1992). These are a particular class of PSFs and first used in the context of project management by Rockart in 1982 (Sanvido et al 1992). PSFs in general and CSFs in particular depend on the nature and the type of projects; success factors in one project may become failure factors in another as different types of projects require different approaches to manage (Muller and Turner 2007). Different researchers have analysed PSFs in relation to different types of projects and contexts. For example, Li et al (2005) identified 18 potential CSFs for Public-private partnerships (PPP) or Private Finance Initiative (PFI) projects in the UK and investigated their relative importance. The other example was a qualitative and quantitative study of Songer and Molenaar (1997). They identified PSFs and relative importance of such factors for public sector design and build projects through a survey among 88 public sector design and build personnel and structured interviews of federal agency representatives in the United States.

Construction organisations judge success of projects differently depending on their own objectives (Chan et al 2002). Parfitt and Sanvido (1993) have shown that the definition of success often changes from project to project and the traditional definition is the degree to which project goals and expectations are met. PSC are the set of principles or standards by which judgement is made about the success of a project (Lim and Mohamed 1999). Project success is viewed from different individual perspectives and goals which can relate to a variety of elements including technical, financial, education, social and professional issues. PSC vary from project to project depending on project size, participants, scope of services and sophistication of owners.

What is viewed as a measure of success on one project may be perceived as an indication of abject failure on another project (Muller and Turner, 2007). Similar to PSFs, various researchers have identified PSC for different project types or on different project contexts. For example, Griffith et al (1999) identified PSC and their relative importance for capital facility construction projects and developed a project success index. One of the other examples was a study of investigating the relative importance of PSC for projects on the grounds of Human Resource Management (HRM) by Belout (1998)

Although there are number of research on both PSFs and PSC for projects, the concept of the link between them is still remains unclear with no study systematically pulling this body of knowledge together. It emerges the requirement of relating PSFs to PSC identified in both theory and practice (Westerveld, 2003). There were few studies focusing to investigate relationship between PSFs and PSC. For example, Chan and Tam (2000) investigated the link between PSFs and PSC for building projects in Hong Kong context. The other example was investigating the relationship between PSFs and PSC on the aspect of quality performance in construction projects by Jha and Iyer (2006). That study systematically reviewed the conceptual and empirical link between PSFs and PSC as well as the relative importance of PSFs and PSC.

## **THE METHOD**

This study adapted the critical literature review process as employed by Hong et al (2012) and Wiengarten et al (2013) and involves three stages. A comprehensive desktop search was conducted systematically at the first stage searching on the titles, abstracts and keyword fields using two key search engines; Engineering Village (COMPENDEX, GEOBASE and Referex) and ARCOM. Search keywords included: project success, project success factors, project success criteria, critical success factors and influence factors on project delivery, etc. Citations within the relevant papers were also helpful in identifying further relevant papers in a snowball fashion. Only journal papers were included in this study. The contents of selected papers were reviewed in the second stage and non-construction related papers were removed. Then, relative importance rankings of PSFs and PSC, and evidence their links both conceptually and empirically recorded systematically using such evidence as reported parameter estimates for correlation, linear regression and structural equation modelling, etc. Finally, statistical results were computed as shown on tables in the next section. Some papers showed relative importance of PSFs and PSC through direct rankings whereas some have shown relative importance based on rankings of mean values. In order to provide a common basis to compare rankings, all mean rankings were converted to a 5-point scale.

## **RESULTS AND ANALYSES**

180 papers relating to PSFs and PSC were collected during the initial literature search and 173 papers out of this were from construction management journals. Only few construction management journal papers have focused on analysing relative importance of PSFs, PSC and their link. Details are given in Table 1.

*Table 1: Details of papers used in the review*

Purpose	Quantity	% of Construction Journal Papers
No of papers analysing the relative importance of PSFs	33	19.1
No of papers analysing the relative importance of PSC	09	5.2
No of papers analysing the link between PSFs and PSC	13	7.5
No of papers analysing relative importance of PSFs and PSC or relationship between them or any one of above	45	26.0

628 PSFs were identified initially from both empirical and conceptual papers, but it was possible to cluster them into 387 factors after removing redundant items. 345 of these factors were identified from the 33 studies in the first category in Table 1. In order to simplify the analysis, PSFs that occurred at least on five papers were selected. Altogether there were 21 such factors and their relative importance were analysed by calculating their average means. Table 2 shows these results. Similarly, this study could cluster PSC identified through 9 studies in the second category in Table 1 into 9 PSC after removing redundant items. Their relative importance is also analysed by extracting mean values from the 9 studies in the second category in Table 1. Details are shown in Table 3. The final analysis was the link between the 21 PSFs and the 9 PSC using empirical evidence extracted from the 13 papers in the third category in Table 1. Results are represented in Table 4.

*Table2: Relative importance of project success factors*

Project Success Factor	No of Studies	Average Mean	Rank
PSF1 : Effective Project Team Formation	20	3.35	15
PSF2 : Effective Communication	20	3.98	04
PSF3 : Top Management Support	17	3.93	05
PSF4 : Allocation of sufficient resources	16	3.63	09
PSF5 : Clearly defined goals and objectives	15	3.70	08
PSF6 : The level of Technology	12	3.40	14
PSF7 : Financial stability & adequate funding	12	3.76	07
PSF8 : Project Manager's competence	12	4.18	02
PSF9 : Project monitoring and feedback	12	3.47	12
PSF10: Motivation and incentives	09	2.95	20
PSF11: Established budget and monitoring	09	3.44	13
PSF12: Client's consultation and involvement	08	4.40	01
PSF13: Clear and detailed procurement process	08	3.61	10
PSF14: Project Risk Management	08	3.06	19
PSF15: Project Plans and schedules	07	3.30	16
PSF16: Frequent progress meetings	07	3.07	18
PSF17: Commitment to the project	07	4.12	03
PSF18: Well defined Technical specifications	06	3.82	06
PSF19: Political support	05	3.30	16
PSF20: Social support	05	2.80	21
PSF21: Effective quality assurance programme	05	3.54	11

*Sources:* Li et al 2005; Nguyen et al 2004; Yong and Mustaffa 2012; Aksorn and Hadikusumo 2008; Songer and Molenaar 1997; Chua et al 1999; Belassi and Tuckel 1996; Belout and Gauvreau 2004; Chen and Chen 2007; Black et al 2000; Cheng et al 2010; Pinto and Prescott 1988; Li et al 2007; Jha and Iyer 2006; Toor Ogunlana 2009; Cheng and Li 2002; Famakin and Ogunsemi 2012; Shokri-Ghasabeh and Kavousi-Chabok 2009; Phua 2004; Jha and Iyer 2007; Idrus et al 2011; Ahadzie et al 2008; Charlos and Khang 2009; Park 2009; Nitithamyong and Tan 2007; Yu and Kwan 2011; Yu et al

2006; Hwang and Lim 2013; Yang et al 2009; Kog and Loh 2012; Wang et al 2010; Tabish and Jha 2011

*Table 3: Relative importance of project success criteria*

<b>Project Success Criteria</b>	<b>No of Studies</b>	<b>Average Mean</b>	<b>Rank</b>
PSC1 :Budget/Finance/Cost performance	7	2.76	6
PSC2 :Technical performance	5	3.03	5
PSC3 :Schedule performance	4	2.36	8
PSC4 : Stakeholder satisfaction	3	3.76	1
PSC5 : Time performance	3	3.13	4
PSC6 : Customer satisfaction	3	2.39	7
PSC7 : Quality performance	3	2.20	3
PSC8 : User satisfaction	2	1.88	9
PSC9: Productivity / efficiency	2	3.59	2

Sources:

de Wit 1988; Griffith et al 1999; Belout 1998; Songer and Molenaar 1997; Chua et al 1999; Shokri-Ghasabeh and Kavousi-Chabok 2009; Bryde and Robinson 2005; Nitithamyong and Tan 2007; Collins and Baccarint 2004

## DISCUSSION AND IMPLICATIONS

This paper set out to review conceptual and empirical research papers relating to PSFs and PSC in construction management journals with the hope of providing an account of the body of knowledge and identifying research gaps for future research.

The results in Table 1 show that many past studies have been conducted on project success, but significantly less attention has concentrated on investigating the critical issues of relative importance of PSFs (i.e. only 19% of studies) and PSC (i.e. only 5% of studies), and the link between them (i.e. only 8% of studies). PSFs and PSC are therefore much talked about and written about however their relative importance and relationships are hardly backed by empirical evidence as only 26% of studies in construction management journals actually involve empirical examination. The interest appear to be in identifying PSFs and PSC, rather than understanding which are important and in what ways or how PSFs actually influence PSC and to what degree. This focus is limiting in so far as it does not allow key decision makers to decide based on empirical evidence where limited resources should be directed to ensure that projects are delivered successfully and consistently.

The analysis also shows that the most important PSFs and PSC by mean ranking have not necessarily received greater research interest. For example, 'client's consultation and involvement' which is the number 1 ranked PSF, has been examined in only 8 studies whereas the 15th ranked factor, 'effective project team formation', has been examined in 20 studies. Similarly, the first ranked PSC, 'stakeholder satisfaction', attracted only 3 studies whereas the 6th rank factor has been examined in 7 studies. Consequently, evidence of utility and relative importance of these factors across different projects and contexts is limited. Further, there is also no evidence that the most important PSC by mean ranking is used to measure project success by different stakeholders. There are several possible explanations to the pattern of results in this analysis. Most past studies have analysed relative importance of PSFs or PSC conceptually or by concentrating on selected project types or contexts, for example, HRM, or different procurement arrangements. Therefore, computing mean ranking by averaging across studies without controlling for this may have distorted the results.

Table 4 reveals the relationship between PSFs and PSC and as shown, the link is still relatively unexplored as no evidence of studies exploring relationships between many PSFs and PSC were found. This suggests that not only there is less research focus on analysing the links between PSFs and PSC we are also unable to conclude on what influence some PSFs may have on some PSC. The relative lack of focus on exploring empirically the links between most PSFs and PSC in previous studies is curious and represents a huge lacuna in the construction management literature. The findings of this study, albeit limited, provide fertile avenues for future research to build on to move the debate on delivering projects successfully and more reliably as well consistently in the construction industry.

Table4: Link between project success factors and success criteria

	Project Success Criteria								
	√ Conceptual	+ Positive Relationship (Quantitative)				- Negative Relationship (Quantitative)			
	# Positive Relationship (Quantitative + Qualitative)	# Negative Relationship (Quantitative + Qualitative)							
	PSC1	PSC2	PSC3	PSC4	PSC5	PSC6	PSC7	PSC8	PSC9
PSF1	√#		+#	√		√+	√	++++ # -	
PSF2		+	+			+		+++	
PSF3	+		+					+++++ -	
PSF4	√#		#	√		√	√	#+++++	
PSF5									
PSF6						√++			
PSF7									
PSF8	+√		+			√		++++++ ++++++ + - ++++	
PSF9	+	+	++			+		++++	
PSF10									
PSF11									
PSF12	++	+	+ -	+	+	++	+++++		
PSF13	√				√	√		√	
PSF14	#		#		++	#			
PSF15									
PSF16							+++		
PSF17	+		-				++		
PSF18									
PSF19									
PSF20									
PSF21					++		+++		

Source:

de Wit 1988; Belout and Gauvreau 2004; Chan and Tam 2000; Jha and Iyer 2006; Jha and Iyer 2006; Westerveld 2003; Bryde and Robinson 2005; Ahadzie et al 2008; Jha and Misra 2007; Yang et al 2010; Ika et al 2012; Alzahrani and Emsley 2013; Doloi et al 2011

## CONCLUSIONS

This paper has given an overview of project success research in construction management journals relating to specific areas of PSFs and PSC. The study provides an account of the status of studies on the relative importance of PSFs and PSC as well as their relationships. This literature review has shown that construction project success is a broad, contentious and a difficult subject; PSFs and PSC are two related areas of project success; construction organisations judge project success differently depending on their objectives; PSFs depend on the nature and the type of projects; a success factor in one project may become a failure factor in another project. Yet the review highlights the inadequacy of research on understating relative importance of PSFs and PSC, and the link between them remains relatively unexplored. Such links appears more clearly articulated from a conceptual perspective and less so from an empirical perspective as there is no empirical evidence that the most important PSFs by mean ranking make a difference to project success across different projects and contexts and different stakeholders. These issues highlight clear avenues of future research on this subject area.

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# LEARNING FROM MOVIE-SETS COORDINATION

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A comparative study of large, professional movie sets and construction sites revealed that conditions for movie production were far more complex and unpredictable, with sudden surprises, changing facilities and often hundreds of people from independent professional groups to be coordinated from hour to hour at different locations (Egebjerg, 2012). These are the uncertain production conditions that we usually hear of as an excuse for not being able to control construction sites. Yet the study also shows that the movie industry is far better at controlling production time, budget and quality exactly as initially planned (Deloitte, 2010). Part of the explanation for this different performance is a process management system that large movie studios have developed over the years including a digital tool for micro-managing the process in a flexible way to suit the dynamic processes. Both industries live with the reality of obstacles occurring on the ‘critical path’ and the process becoming not as fast as anticipated. So there is a need for a map of alternative ‘short cuts’ to get back on track. Usually this work is managed inside the head of a professional construction manager, but even the best person in the job can become tired from keeping a high level of overview, information and coordination of escalating problem chains. This paper describes the innovative experiment of designing and testing on construction professionals a proto-version of a similar digital tool and system to that used on movie sets for detailed scheduling, coordinating and micro-managing construction processes. The current working name for this digital tool is “Short Cut”, and it is seen as a future supplement to common scheduling tools with application for project parts that are particular sensitive to deadlines or other complexities.

Keywords: coordination, flexibility, micro-scheduling, proactivity, process-manager

## INTRODUCTION:

### Can movies inspire construction?

Movie sets are in many ways similar to construction sites (Egebjerg 2012) in that they involve:

- many different, independent professional groups having to collaborate with new people on the set every day, many of whom they have never met before and will never meet again
- timing is crucial, as is logistics, coordination, communication, etc.
- production facilities change while production moves forward at constantly - changing locations
- unpredictable conditions and everyday deviations from the plans
- fixed production plans have to be followed strictly or the consequences for the overall project will be severe

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It only takes one small mistake to trigger an escalating problem-chain on a construction site, possible leading to loss of money, loss of quality, accidents, conflicts, etc. (ex. Apelgren 2004, Seppänen 2009). This reality is very close to the daily reality of large professional movie sets: Imagine any minor breakdown in the production plans for shooting a car chase through a city, or a sick main actor in a scheduled scene with rented animal trainers, child actors, weather dependencies, hundreds of extras, fitting production into special effects design, lots of permissions signed on a far away location rented only for the day, etc. All in all production breakdowns are just business as usual and has to be as well anticipated as possible in the pre-production phase. Movie set production management faces hundreds of production issues that do not turn out as expected and has only a few minutes for decision making on the spot on shoots easily costing one million dollars per day on a professional studio project. In movie production the unexpected is the norm. That is why movie managers through history have had to teach themselves to be Jedi masters of production management. They developed their own system, today known as the Hollywood studio management system, which is used across the world (ex. Brown 2006, Persse 2008).

At the centre of this management system is a scheduling tool different to all the common scheduling tools we know from construction sites (Gantt, Line of Balance, Last Planner System, Network Diagrams, etc.). It is more similar to a mixture of all these and a common meeting calendar where activities can be easily moved around. The aim of movie set management is to optimise the workflows in dynamic production processes through flexibility when plans are put into reality. The unwritten philosophy behind this system is close to the concepts about realistic, running plans that we also know from LPS and Lean Construction (ex. Ballard and Howell 1994, Koskela and Howell 2002), only these are even more detailed and proactive tools.

This research study has designed and tested a tool for scheduling construction activities inspired from the principles behind the tool to micro-coordinate a movie set.

### **Movie sets are on time and budget while construction sites overrun**

Egebjerg (2012) collected and analysed present industry statistics in Denmark and compared movie with construction performance looking in isolation at production costs, schedules and expected outcome. These figures showed an overall picture of movies performing far better than construction in reaching their plans and goals. In a large survey for the Danish Film Institute, Deloitte (2010) concludes that the movie industry is cost-efficient, finding that it goes 3% under budget in average, and points to the general Production Management System as the main reason for this success. Numerous interviews in Denmark and US with industry professionals confirm this picture (Egebjerg, 2012).

Endless reports about the construction industry in Denmark and abroad point out the poor performance of the industry in not keeping budget, schedules or quality with very random variations (5-30% on budget overruns) (ex. Byggeriets Evaluerings Center 2006-2009, Erhvervs- og Byggestyrelsen 2004-2009, Rambøll 2010, Rigsrevisionen 2009). One official study of time overruns on all construction projects finds an average of 17% on all reported productions in Denmark (Byggeriets Evaluerings Center 2009). Many of these industry analyses point to poor site management as one important factor (and the figures take into account as much as possible the influence of changes in the project during the process).

It is important to remember that these industry statistics are about production phases and are isolated from the overall financing of the projects. Movies tend to keep on budget during production, independent of later sales, which can vary with many times the production budget or end up in a big loss (ex. Bart 1999, Squire 2004). (Movie projects have a very complex market and project financing, but the actual shooting financing is quite simple and isolated from the rest).

There are a number of different factors in movie production culture that should be mentioned: the professional client, the preproduction phase, the micro-scheduling tool, the open partnering process with sub-contractors during preproduction, contracts specifying process services, the ultra-lean micro-management (from minute to minute), the flow-manager (1.AD), the quality service coordinator (the Scriptor), the vertical dialogue, the consensus hierarchy from the producer/director teamwork distributing mutual respect and motivation down the line, the bonuses, credits, royalties etc. (Egebjerg 2012).

The statistics from construction management also disclose this large element of chance in which factors will eventually lead to an overrun, suggesting that typical management systems are very vulnerable to even small coincidences leading to escalating problem chains of accelerating complexity due to today's technologies (Seppänen 2009). Field studies by Egebjerg (2012) showed a significant case study of this element of coincidence leading to severe consequences on a construction site, beginning with a dispute over a 10 centimetre mis-measurement that had to be worked around, leading to more and more mis-coordination between the professional groups, daily ad-hoc changes to the schedule, demotivation and in the end, large overruns on time, quality and budget.

Field studies from movie sets (Bechky 2006, Egebjerg, 2012) showed how their management system catches the unforeseen events again and again within minutes and hours, stepping into immediate action to prevent further damage. They can do so partly because the digital scheduling tool supports minor adjustments and full overview of upcoming challenges to the flow of the production processes, and because the management organisation is constructed so that this information is always up-to-date.

Movie production industry has a secret weapon in the eye of the storm. One actor in the network holds everything together: the time schedule. This actor is non-human, but built inside it lies all the power of previous phases of careful planning, thinking and decisions made by many parties. It is a fluid entity (Latour 1991) that changes from inside the minute it hits production, but without ever changing the outside frames of deadlines and budgets (Egebjerg 2012). It is a flexible, dynamic schedule that everybody refers to during every minute of production; it is always in the pocket of every team member and never out of sight or ear in the walkie-talkies and the megaphone of the process-manager (1.AD). There is a great deal of respect for this digital tool that ties everything together to give a better overview, communication and understanding for one part of the whole, a trust that something is actually able to keep a hold on the chaos.

This is why this Postdoc research continued to study the principles behind this specific movie tool – trying to design a similar tool for micro-coordinating construction sites. The similarity lies not in the software, but in the idea of how a schedule should work with flow.

## **METHOD: SNOOPING BEHIND THE SCENES**

The process of designing the scheduling software was based on knowledge gained from research during PhD studies: ethnographic studies at both movie sets and construction sites, literature studies, courses in movie business and scheduling software plus app. 50 semi-qualitative interviews with all levels of professionals from both industries analysed in an Actor Network Theory perspective. These ethnographic studies of movie productions were focusing on large, professional feature productions to enable better comparative studies with large construction sites. This would mean: a professional client organisation (studio productions rather than independent), no changes in script/plans during process (feature rather than television), and large budgets (\$80-100m (US), large teams (2-300+ employed), independent supplier companies (contracts). Also did the author have personal experience from working several years as a professional in both businesses, movie industry and construction management (Egebjerg 2012).

Designing and field-testing the software has been done in prescription driven design science in close collaboration with future users as an agile development of new management instrument to control site processes (ex. Aken 2004, Holmström, Ketokivi and Hameri 2009, Lukka 2003). Designing version 1.0 has been done in collaboration with several user groups from the Danish construction industry and with IT experts from the field. Field-testing the prototype software in a minor scale has been done in collaboration with a large, Danish contractor (NCC) on an actual site. An easy user-interface has been a major priority of the design, so the idea of the test was to provide the construction site with these easy-read and always updated day-plans, week-plans, resource-plans, supplier-plans etc. for a better overview and communication. Secondly the field-test was able to provide site managers with the easy overviews of potential clashes (location, workspace, resources, logistics, weather bindings, noise issues etc.) and of course potential short cuts to the critical path. All this is done to observe if user-groups will pick up the idea to use the scheduling tool with all of its advantages of proactive coordination, but also to learn about things to improve for a later version 2.0. There has also been testing on usergroups from large North-American contractor companies – site managers and lean managers have demoed the software off-site and responded to it in interviews.

## **RESULTS:**

### **Respecting plans by trusting plans**

Movie management system before the digitalisation would cover full walls with complex post-it plans similar to what lean-construction is doing today in their early phases, only far more detailed (scheduling production flow down to hours and minutes). Besides they are still drawing storyboards to visualise details in the product (scenes and shooting-angles) for easier communication in between the team, and mix this information in to the Work Break Down sheets where needed.

So much effort is put into scheduling the production processes that it makes the final result very durable for later discussions, but also more flexible for adjustments, because all details are written down and at hand. The trust of an intelligent schedule plays a significant role in the respect to the process through the team that is so profound in the culture of movie production. The schedule also plays a role as a social tool during the process – a tool for visual communication about logistics and coordination between many different professional suppliers.

### **Synchronicity needs as much precision as Asynchronicity**

A major difference in the technology of movie making compared to construction is the synchronous production flow around every scene shot giving this ‘one-stringed’ production plan for every Unit at work called the Stripboard (example the brand Movie Magic Scheduling). When coordinating a construction site the focus is on keeping the gangs working asynchronously around the same locations in order not to get in each other’s way. This is why we see tools like LOB and LPS, which ensure that previous work has been done, before new work can begin (Kenley 2004). But this might also be the source of the largest breakdown in construction schedules, while one small delay can make the schedule fall to be just like a ‘decoration on the wall’ and the rest of the coordination left to informal ad-hoc deals and to the social skills of the present PM and his crew, and the project becomes subject to the effects of coincidences (Jensen 2010). But in fact the same kind of precision is required for asynchronicity as for synchronicity – any orchestral conductor will tell you this. And this is why movie making means never letting the schedule out of sight for a whole week, but rather updating progress every minute and making daily reports back to headquarter in a non-controlling way – just as a form of natural maintenance. It is a myth that time is ‘wasted’ on a movie set due to a large stand-by organisation (Egebjerg 2012). The stand-by time is work-time for almost all groups, preparing, checking quality, coordinating logistics etc. Similar to a construction-site where a lot of local communication and coordination takes place, only not as structured and formalized as on the movie-set.

### **Designing software for flexibility**

So one major challenge when designing the software was to get around designing parallel activities resulting in making the tool 100% flexible in both axis directions with parallel strings of activity but without headlines (like ‘location’ or ‘profession’ or the like).

There is only one axis-value: Time. All other information is connected with the activity in the same design-logic as an extended meeting calendar. Thus creating maximum flexibility in the design of the schedule, because activities can be moved around in time – exactly the same they are on real life construction sites every time there is a change in coordination. This design allows room for adding any kind of activity in this schedule during process: a meeting, a delivery, something to be fixed, somebody to look at something, drying time, a social event, a rain-storm passing, client inspection or anything relevant for this specific production and organisation. So one important difference from other digital micro-management tools is, that for the sake of maintaining flexibility all the information on a single activity is collected on the same sheet and not spread all over a Gantt diagram or Line of Balance view (and this holds a lot more relevant information than a network diagram).

Illustration 1: Principle of Movie Scheduling (one flow) vs. ShortCut (multiple flows)

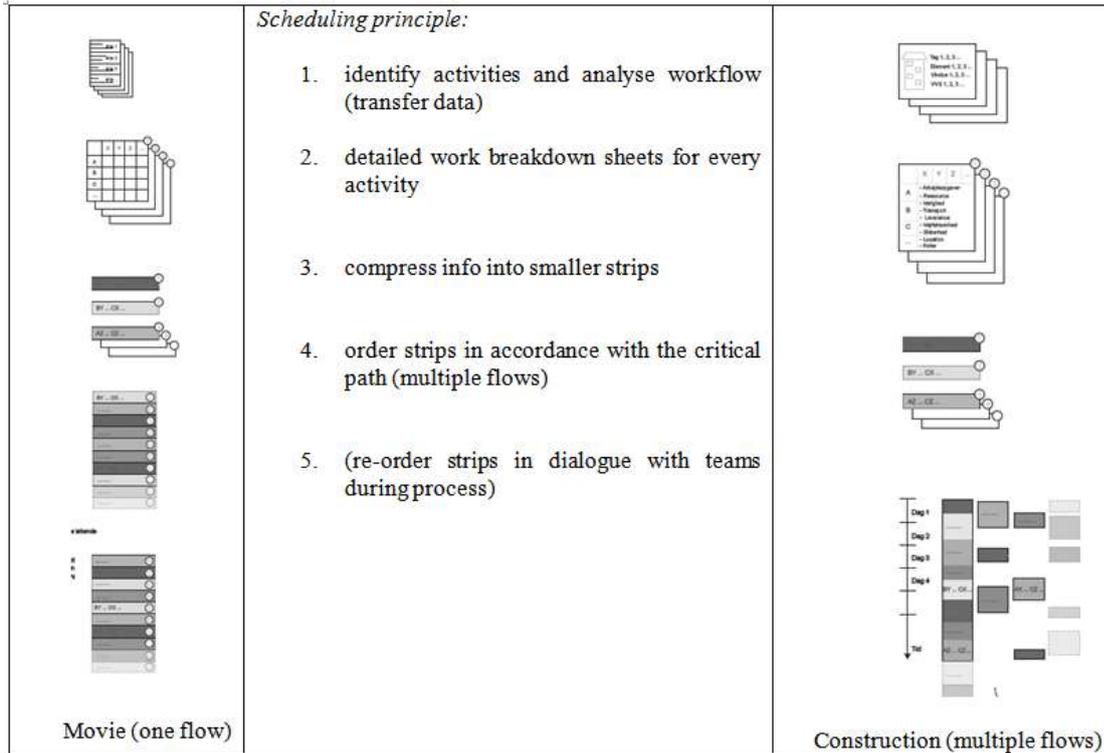
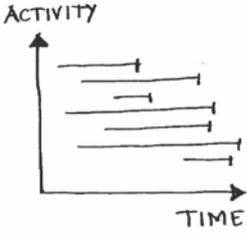
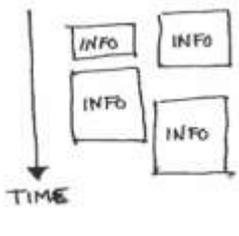


Illustration 2: Principles of coordination, Gantt vs. LOB vs. ShortCut

Deadlines	Speed	Flexibility
		
Gantt	Line of Balance	ShortCut

Here under is a very simplified illustration of the principle of cutting activities into smaller pieces that can more easily be coordinated (opposite to Gantt diagram's long 'black-boxes' of activities).

The level of detailing is an individual choice – It could be hours or weeks, but research recommend activities to be specified in no longer than days (by easy copy-paste). The design of this software aim to be as intuitive as possible for the user with easy drag and drop of activities, easy clicking into work break down sheet, copy-paste or delete of activities, resources and plans. It is possible to apply endless information about any kind of resources, locations, supplies, meetings, controls, links, dependencies etc. There is a search-function to search and highlight among activities for any resource named in the schedule (gang 7, location 27B, crane 2, window 187 etc.) to get a print with all activities highlighted holding this specific parameter. Colours are used as the powerful visual tool for communication that they are: for providing an overview of working locations (and not for useless information of

delayed activities, because everyone knows this already from the calendar view). There is a priority of communicating proactive warnings for weather dependencies, noise and potential clashes for locations and resources.

The theoretical logic of direct benefits from this kind of micro-coordination/-scheduling is in very short: If you have a locked schedule around the critical path, then all delays on that path will be delays for the total project. But if you have a flexible schedule that can adjust to different critical paths, then there will be an option for short cutting the initial critical path – or at least short cutting the delays on that critical path.

*Illustration 3: Simplified extract from schedule after lean start up meeting*



**DISCUSSION:**

**Show it don't tell**

It is important to remember that the different industry statistics between movie and construction are all about the production phases and isolated from the overall economy of the projects. The overall economy of a movie-project including the creative development, marketing and distribution phases is more likely to be compared to the gambling industry due to unpredictable market and competition factors.

The differences on project-level should not make us believe that there is nothing to learn from the movies at production-level. Movie-sets are isolated organizations with their own working culture (Hvenegaard and Matiesen 2005) - much like an isolated entity with translated 'scripts' from the overall movie project (Egebjerg 2012, Law 1999). Inside this closed production entity the different actors can act very powerful on behalf of the fixed roles in the Hollywood management system. The camera-technology dictates the synchronicity, the 1. AD act as a timing-authority even if he is only a freelancer like everyone else, the walkie-talkie becomes an ever-present manager, and the daily time-schedule is the boss of everyone's workflow.

There are a lot of myths around movie sets that are told more as more told as ‘good stories’ by people inside the industry itself, but there is very little actual research on the topic. The PhD study done by Egebjerg (2012) emphasised that the daily, average movie production culture is a long way from the myths about creative chaos, working for free or under poor deals, non-productivity, changing the product-plans (script, budget and schedule) during production, management by fear or any of these other myths that might apply only to certain very artistic productions or young, independent projects. Another myth is that film workers have this personal dedication that will drive them through the processes beyond nature. The findings in the PhD by Egebjerg (2012) was, that the management system is facilitating motivation even on low-status production through a lot of instruments treats and credits, but as much by the system itself creating non-stop dialogue around the detailed schedule strengthening the social bonds on the project.

For future integration and to gain more advantages from the software on construction sites, this research suggests minor adjustments to the site organisation also inspired from movie organisation: A process-coordinator on the site to be responsible for the daily dialogue and adjustments around the schedule plus contract supplements specifying suppliers deliverance of process-service to a central process-coordinator

### **Testing and user feedback**

During the testing at a construction site (app. \$5m project in a three-month construction period) it became clear that the ShortCut system made sense to everybody during the first lean-meeting, since the print could provide an exact digital overview of the foremen’s own, intuitive post-it coordination (pictures below) in a much clearer visual form. Suddenly it was clear for everybody to view the exact duration of processes in a calendar format, plus all the bonus information about clashes, shortage of resources, deliverances or crowded work-areas. Also they could get prints of day-schedules, week-schedules, gang-schedules, delivery-schedules, specific location-schedules etc. and it became more easy to make future adjustments to the first outline from the lean start up meeting.

Response from user groups and professionals in Denmark and US so far is very positive concerning the flexibility of the scheduling with ShortCut and the visual intuitive tool for dialogue around coordination of construction sites.

Response from a number of lean representatives from large contracting firms in San Francisco area has been even more positive to the new idea of site-management, and a couple of them proved serious commitment to the future development of the software saying they could already use it in their daily work. This higher level of interest could perhaps indicate American contractors working more structured already and with more centralised process management than their Danish colleagues.

There has been some initial scepticism around the question of how much time is required to write data into the system. The testing has shown that it is very fast just to transfer existing data to the software (1 day’s work to transfer all data from a \$5m project into a ShortCut schedule). Also there have been thoughts about the challenge for the independencies of the professional groups posed by central steering of process but at the same time agreement of the need for better coordination in complex project situations. It is important to notice that there is no reason for a construction site to become entirely as lean as a movie set. So perhaps just smaller adjustments to the organisation and scheduling tools can provide a significant lift on productivity.

The indications so far from this research are that the software tool itself can stand alone to be implemented in a turn key contracts or with minor adjustments to supplier contracts in other forms of enterprise to support micro-coordination in shorter periods of a project or on certain projects where special precision is required. But perhaps in future construction markets there will be more focus on competitive process management and then be relevant to apply micro-coordination to all kind of projects.

There are still many technical limitations to the prototype version, since the Realdania postdoc funding was only meant to examine the potentials of the tool and it will take more resources to implement all the ideas. There is a big challenge ahead to test a version 2.0 and make it able to integrate with existing software on the market (MS Project, BIM etc.)

## CONCLUSION

### Keep it simple

Movie-sets are in many ways similar to construction-sites with independent professional groups collaborating under changing and unforeseeable production conditions. Yet movie-sets perform far better on productivity than construction-sites do. An important advantage for the movie organisation is the digital scheduling tool that keeps the team coordinated and in trust of the reliability of the daily plans (Egebjerg 2012).

This research has shown that there is a good potential for developing a digital scheduling tool to construction sites in a different design but from similar principles as on movie sets. A prototype-version has been through an early stage test on user-groups from Danish construction industry proving its potential value for productivity through an easy, communicative overview of detailed, flexible coordination very suitable to facilitate lean-processes. The dialogue on the site is facilitated when the design of the schedules is easy to read for everyone and flexible adjusting to reality. Realising there are good reasons to trust a reliable and realistic plan is the first step in paying respect to future plans.

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# TRUST, MISTRUST AND DISTRUST IN ALLIANCING

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Despite the success of many alliancing projects in Australia and New Zealand, there has been an increasingly decline in the use of this procurement method for infrastructure projects by the public sector. Research has found that trust, mistrust and distrust between the Alliance Leadership Team (ALT) and Alliance Management Team (AMT) were the biggest issues that impacted on the effectiveness of the alliance. There is currently a discrepancy in the nomenclature used for trust terminologies, especially the understanding of mistrust and distrust in project relationships which is a gap for research. Current research on alliancing has generally been very positive in the potential for alliancing contracting to facilitate trust within the project however, trust conditions are volatile under different business situations within the gain share and pain share modes, therefore, the criticality of different trust attributes under mishaps especially, is also another gap within research. The Analytical Hierarchy Process (AHP) is used to examine the criticality of different trust attributes from the alliancing participants' surveys. Results demonstrate that only in a gain share mode cognitive-affect based trust is preferred for both the conditions of trust and mistrust. However, in a pain sharing mode, cognitive based trust prevails over cognitive-affect, system and affect based trust for the conditions of both trust and distrust. This research demonstrates that the values of team work and relational bonding only occurs as a lag effect indication of the cost performance of the project and has little effect on governing the attitude and culture of which the people within the construction industry operates, in terms of organizational change. Unless there is a change in the fundamental legal framework of which business is conducted under common law, culture and the continuing simultaneous use of other non-relational procurement systems may determine the eventual behavior of any business transaction.

Keywords: alliancing, analytical hierarchy process, trust, mistrust, distrust

## INTRODUCTION

Despite the success of many alliancing projects in Australia and New Zealand, there has been an increasingly decline in the use of this procurement method for infrastructure projects by the public sector. Research has found that trust, mistrust and distrust between the Alliance Leadership Team (ALT) and Alliance Management Team (AMT) were the biggest issues that impacted on the effectiveness of the alliance (She et al. 2012; Mills et al. 2011). In 2013, the Alliance Association of Australasia (AAA) announced the amalgamation of the Alliancing Association of Australasia (AAA) with Infrastructure Partnerships Australia (IPA) “due to a significant decline in the number of collaborative contracts used particularly in the public sector in Australia” (Alliancing Association of Australasia 2013). With global economics changing at a rapid pace, people become more rational and therefore trust less whilst; at the same time cooperation can be motivated through manifold devices without trust

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(Cook et al. 2005). The principle objective of Alliances is to align team member expectations so that they work together for the benefit of the project however, the eventual amalgamation of AAA as a result of a decline in this procurement use demonstrates that the gain share and pain share commercial arrangement is insufficient for aligning behaviours and values in team work.

Current research on alliancing has generally been very positive in the potential for alliancing contracting to facilitate trust within the project. Walker et al (2002) conducted an empirical case study on the National Museum of Australia to provide a longitudinal view of people's enthusiasm and commitment in project alliancing as opposed to Business as usual (BAU) projects. Results demonstrated the cross-team helped and supported each other to overcome problems rather than reverting to blame-laying and associated administrative effort to document and support arguments for laying blame or deflecting blame. Ibrahim et al (2013) examined fifteen key indicators that have a strong influence towards determining the success of team integration in construction projects and then validated the key indicators on alliancing projects in New Zealand. They found that the top four indicators were free flowing communication, single team focus and objectives, commitment from top management and trust and respect. These indicators infer towards the structure of the alliancing contracting collaborative team; namely the relationship between the ALT and the AMT. Reed and Loosemore (2012) proposed a theoretical model of cultural shock which helps to explain the transition process into alliance projects. However, trust conditions are volatile under different business situations (Lindenberg 2000), within the gain share and pain share modes (She et al. 2012). Therefore, the criticality of different trust attributes under these situations between the ALT and AMT are unknown. This research aims to find the dominant attributes affecting trust, mistrust and distrust within pain share and gain share mode under the mishap situation within alliances. Mishaps can be intentional or unintentional however it occurs commonly in any complex project and it is essential to understand how these trust conditions affect the effectiveness of the relationship between governance and management.

## **THE STORY OF ALLIANCES**

Alliances are complex projects with high uncertainties in risks. However, in an alliance, both the contractual structure and team dynamics are non-adversarial as all the parties forfeit the right to litigate in an event of a dispute (She et al. 2012). In alliancing each alliance member places their profit margin and reward structure "at risk" so the entire alliance entity either benefits together or lose all known as pain share and gain share (Walker et al. 2002). The ALT is in charge of the strategic decision making of the project as well as supporting the AMT team whilst the AMT is in charged with the operation of the project. Both AMT and ALT would have representatives from both the client and contactors' side to facilitate equity, knowledge as well as collaborative spirit in decision making.

In an empirical research by Mills et al. (2011) a range of factors has been identified where AMT and ALT performed above and below expectations. Overall, the respondents were more critical of the performance of the ALT with more than two thirds of respondents believing that the ALT did not perform above expectations. The results highlighted that ALT need to perform not only at strategic levels but also be proactively involved in project issues and providing supportive operational environments to delivery successful project management (Mills et al. 2011). The recent move towards the amalgamation of AAA with IPA as mentioned before clearly

signals a real problem for achieving true alliancing outcomes as perceived among the owners. It is then important to understand the difference between the attributes of trust, mistrust and distrust that exists under pain and gain share modes in order to truly integrate the alliancing philosophy into the principles of relational contracting.

### **Trust, Mistrust and Distrust**

There is currently a discrepancy in the nomenclature used for trust terminologies, especially the understanding of mistrust and distrust in project relationships within the construction industry. This is a gap in research and requires a re-evaluation of current literature. Trust has been defined by different scholars over the years as predictability on human behaviour. For the nature of the construction industry, which is heavily adversarial and calculating, Robinson's (1996) definition is still the most applicable, in that "trust is one's expectations, assumptions, or beliefs about the likelihood that another's future actions will be beneficial, favourable, or at least not detrimental to one's interest." Using the encapsulation interest view of trust, it is trust based on mutual party's belief in encapsulating each other's interests through repetitive interactions and monitoring of behaviour (Cook et al. 2005).

Researchers within the construction domain have often used the term mistrust as the opposite of trust (Wong et al. 2008; Smyth and Thompson 2005). However, it is a misconception to view mistrust as an opposite of trust. Legitimate mistrust is the perceived likelihood that a potential or actual transaction partner's interests are not aligned with one's own interests (Lindenberg 2000). Robinson's (1996) definition of trust above allows legitimate inherent mistrust to co-exist with trust. Mistrust can occur in a positive state of a relationship and may even assist in the building of trust as parties communicate more openly regarding potential issues before the commencement of the partnership.

Distrust, which is the negative state of trust is understood to be the "expectation that others will not act in one's best interests, even engaging in potentially injurious behaviour" (Lewicki et al. 1998) and the "expectation that capable and responsible behaviour from specific individuals will not be forthcoming" (Lewicki et al. 1998). Mistrust allows doubt and hidden agendas but this does not necessarily imply that there is serious malicious suspicion. Mistrust can transform into distrust through miscommunication, misunderstandings and untimely resolution of issues both explicitly and implicitly known to one or both parties.

The attributes of trust have been classified under three main categories; system based trust, cognitive based trust and affect based trust. These categories are briefly discussed below:

**System based trust:** Can also be known as institution-based trust legal systems, conflict management and cooperation, systems regulating education and professional practice were suggested as tools to sharp trust in institutions (Rousseau et al. 1998). The attributes under system based trust include contracts and agreements, communication systems, organizational policy, adopt ADR, reputation, satisfactory terms (Wong et al. 2008).

**Cognition Based trust:** members cognitively evaluates the competence of other project team members with the available information (Morrow et al. 2004). The attributes under cognitive based trust include performance, consistency, competency, problem solving, reliability, experience and integrity (Wong et al. 2008).

She

Affect based trust: this trust is grounded in reciprocal interpersonal care, concern and emotional bonds (McAllister 1995). In affect based trust situations, parties rely on instincts, intuitions and feelings to determine the other party's trustworthiness (Morrow et al. 2004). The attributes under affect based trust include relational bonding, thoughtful, emotional investment, compatibility, long term relations (Wong et al. 2008).

Trust based on communication, information flow, sincerity, fairness and financial are classified under cognitive based trust (Wong et al. 2008) however the action of communication involves cognitive processing but how the message is being received by the receiver is a perception on the receiver's side and can be influenced by instincts, intuitions and feelings to determine the trustworthiness of the message (Lantolf & Thorne 2006), hence, it is logical to reclassify these trust attributes under the category of Cognitive-affect based trust for the purpose of this research. Cognitive-affect based trust is the most important trust for alliancing as it underpins the alliancing philosophy.

By integrating the core concepts of alliance contracting with the fundamental underpinning of trust conditions, it may be possible to understand the complexity of trust in stakeholder relationships and overcome the confusion with trust, mistrust and distrust.

## **RESEARCH METHODS**

Analytical Hierarchy Process (AHP) is used for this study as trust is volatile therefore the relationship between constructs can only be viewed in a probability sense just like AHP was successfully used to determine the factors that may affect the state of market volatility. One of the major advantages of AHP is that it does not always require a statistically significant sample size (Dias and Ioannou 1996). AHP uses pairwise comparisons between quantitative or qualitative criteria to assess the relative importance of each criterion (Saaty 1980). The qualities (or levels) of different attributes are not directly compared. In extreme cases, only one single respondent is sufficient (Saaty 1980) as respondents are not asked to make choices between all criteria and thus are less likely to adopt mental short cuts by concentrating disproportionately on one attribute or level.

In order to identify the important trust attributes that had the most impact on trust, mistrust and distrust under pain share and gain share, a questionnaire was prepared based on the results of interview responses from previous empirical research as well as available literature on trust. By using the analytical hierarchy process (AHP), prioritized numerical scales are generated representing the relative impact of the perceived trust attributes that affected trust, mistrust and distrust within pain and gain share modes under the mishap situation.

### **Measuring the consistency in Judgement**

In the application of AHP, inconsistency in pairwise comparisons may appear as a result of factors such as lack of adequate knowledge, improper conceptualization of hierarchy and even lack of statistically sample size (Saaty, 1980). A consistency ratio is generated for each prioritized scale upon completion of carrying out the pairwise comparison. The consistency ratio is defined as the consistency index for a particular set of judgments divided by the average random index as shown in the equation:

$$CI=(\lambda_{max}-n)/(n-1) \text{ and } CR=CI/RI$$

Where  $\lambda_{\max}$  is maximum eigenvalue,  $n$  is the size of the judgement matrices,  $RI$  is the random index. The values of  $RI$  for different sizes of judgment matrices are found in the existing studies including in Saaty's works (1980). Based on the various numerical studies, Saaty (1980) stated that for the inconsistency to be tolerable, the consistency ratio ( $CR$ ) must be less than or equal to 0.10. If this condition is not fulfilled, a revision of the comparisons is recommended.

*The framework for Data Analysis*

The objective is to find out what trust attributes have the biggest impact on trust, mistrust, and distrust within pain and gain share under the mishap situation therefore the main objectives, trust, mistrust and distrust were placed at the left-most side of the analytical hierarchy as shown in Fig.1. The four criteria are: cognitive-based trust, cognitive-affect based, system based trust and affect based trust. Each criterion was then further subdivided into their relevant sub-criteria which are the trust attributes as shown each figures below.

In this study, the problem involved using AHP at the two levels: (1) estimation of the relative importance of the main criteria, (2) estimation of the relative importance of each sub-criterion on the criteria.

Figure 1 above demonstrates that mistrust can be present under the gain share mode within a mishap situation. Mistrust is any likelihood of misaligned goals, which can still occur in a gain share mode as the final Key Results Area is affected by the perception in the potential gain share between owners and non-owners which do not necessary have an equal risk allocation. Moreover, when using the dispositional view of trust, parties that have low levels of trust as a result of past experiences from non-alliancing projects, would be suspicious under any situation that may arise doubt. Under a mishap situation, it would aggravate personal bias in assessing the situation. However, under a pain share mode, distrust can be present rather than mistrust when using the encapsulated interview view of trust, as there is a high probability that conflict of interest would surface in the process of mitigating cost overrun when making decisions on methods to resolve problems.

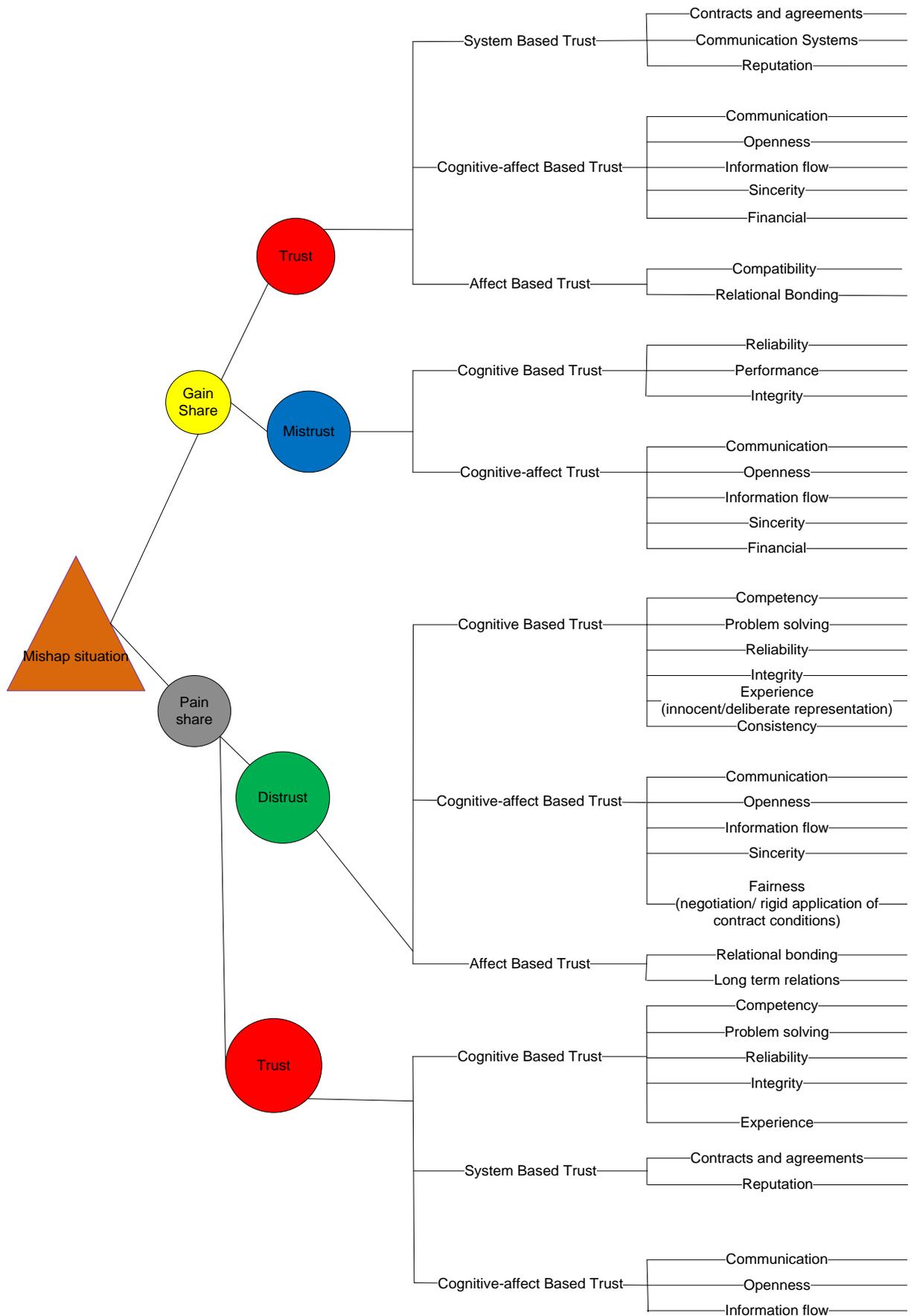


Figure 1: Hierarchy structure of criteria impacting on trust, mistrust and distrust under gain

*share and pain share modes under the mishap situation*

### Data Collection

A total of forty surveys were distributed to a list of alliance participants in Australia and New Zealand and all forty surveys were completed and returned. The target group of respondents was identified mostly by means of personal contacts and the responses were collected after a clear discussion on the questions and target research outcomes. Table 1 shows the profile of respondents.

*Table 1: Summary of Respondents' profile*

Field of Work	(%)	Years of Experience
Alliance General Manager	14	>20+
Design Manager	13	>10+
Construction Manager	13	>15+
Approvals/Consenting Manager	25	>20+
Stakeholder Manager	15	>20+
Client side representative	20	>20+

### Data Analysis

A nine-point scale was used for respondents to compare the trust attributes in pairs. Table 2 below shows the AHP pairwise comparison scale. The responses were programmed and then normalised into an Excel spread sheet for implementation of the AHP process as shown in the next section titled Results and Discussion.

*Table 2: AHP pairwise comparison*

Value rating for Judgements	Linguistic Judgments
1	Elements are equally preferred
3 or (1/3)	One is moderately preferred to the other
5 or (1/5)	One is strongly preferred to the other
7 or (1/7)	One is very strongly preferred to the other
9 or (1/9)	One is absolutely preferred to the other

*Note: 2, 4, 6, 8 are intermediate judgmental values between adjacent scale values*

## RESULTS AND DISCUSSION

The following Tables 3, 4, 5 and 6 demonstrate the final AHP weights of every sub-criterion and criteria under the gain and pain share modes within the mishap situation after the normalisation of all the individual respondents' AHP calculations.

*Table 3: Weightings for Trust within Gain Share under Mishap Situation*

Goal	Criteria	Weighting	Sub-criteria	Weighting
Trust	System based trust	0.22	Contracts and agreements	0.27
			Communication systems	0.43
			Reputation	0.3
	Cognitive-affect based trust	0.55	Communication	0.2
			Openness	0.25
			Information Flow	0.19
			Sincerity	0.24
			Financial	0.12
	Affect based trust	0.23	Compatibility	0.34
			Relational Bonding	0.66

Table 3 above shows that under the gain share mode cognitive-affect based trust has the highest weighting of 0.55 and has the most impact on trust with the sub criterion of openness (with the weighting of 0.25) being the most preferred out of the pairwise comparison. System based trust has the lowest weighting of 0.22 with the sub criterion of contracts and agreements being the least preferred out of the pairwise comparisons. It is interesting to note that even for mistrust as shown below in Table 4, it is still cognitive-affect based trust that has the most impact under gain share.

*Table 4: Weightings for Mistrust under Gain Share within Mishap Situation*

Goal	Criteria	Weighting	Sub-criteria	Weighting
Mistrust	Cognitive based trust	0.45	Reliability	0.26
			Performance	0.27
			Integrity	0.47
	Cognitive-affect based trust	0.55	Communication	0.2
			Openness	0.22
			Information Flow	0.2
			Sincerity	0.28
			Financial	0.1

Table 4 above shows that under the gain share mode cognitive-affect based trust has the highest weighting of 0.55 and has the most impact on mistrust with the sub criterion of sincerity (with the weighting of 0.28) being the most preferred out of the pairwise comparisons. Cognitive based trust has a slightly lower weighting of 0.45 with the sub criterion of integrity being the most preferred out of the pairwise comparison.

Table 3 and Table 4 results demonstrate that under gain share, openness and integrity have the most impact on trust and mistrust respectively and the perception of cognitive-affect based trust overall prevails over system based trust and affect based

trust. However, for pain share it is cognitive based trust that has more impact over system and cognitive-affect trust as shown by Table 5 and 6 below.

*Table 5: Weightings for Distrust within Pain Share under Mishap Situation*

Goal	Criteria	Weighting	Sub-criteria	Weighting
Distrust	Cognitive based trust	0.43	Competency	0.13
			Problem solving	0.34
			Reliability	0.15
	Cognitive-affect based trust	0.36	Integrity	0.19
			Experience	0.07
			Consistency	0.11
			Communication	0.13
			Openness	0.16
			Information Flow	0.15
			Sincerity	0.17
	Affect based trust	0.21	Fairness	0.39
			Relational Bonding	0.46
			Long term relations	0.54

Table 5 above shows that under the pain share mode, cognitive based trust has the highest weighting of 0.43. It has the most impact on distrust with the sub criterion of problem solving (with the weighting of 0.34) being the most preferred out of the pairwise comparisons. Affect based trust has the lowest weighting of 0.21 with the sub criterion of relational bonding being the least preferred (with the weighting of 0.46) out of the pairwise comparison with long term relations which has a weighting of 0.54. It is interesting to note that fairness with the weighting of 0.39, is the most preferred criterion under cognitive-affect based which has a weighting of 0.36 under pain share whilst it was sincerity under gain share for mistrust. This means that the alliancing participants still prefer justice rather than sincerity in a mishap situation, overriding the alliancing spirit of 'no blame' culture.

The distinction between mistrust and distrust is also highlighted by the difference in this preference. Mistrust is any likelihood of misaligned goals which can also occur in gain share as the final Key Results Area is affected by the perception in the potential gain share between the owners and non-owners which do not necessary have an equal risk allocation therefore sincerity is important for the relationship between teams. Distrust is the perception that one party's action will harm the other party and therefore under pain share within a mishap situation, alliancing parties feel that fairness can protect their best interests as it is difficult to determine whether mishaps are intentional or occur purely by professional misjudgement. However, under pain share it is still problem solving which has the most impact for trust like it is for distrust, as shown in Table 6 below.

*Table 6: Weightings for Trust within Pain Share under Mishap Situation*

Goal	Criteria	Weighting	Sub-criteria	Weighting
Trust	Cognitive based trust	0.51	Competency	0.22
			Problem solving	0.37
			Reliability	0.18
			Integrity	0.14
			Experience	0.1
	Cognitive-affect based trust	0.33	Communication	0.3
			Openness	0.5
			Information flow	0.2
	System based trust	0.16	Contracts and agreements	0.37
			Reputation	0.63

Table 6 above shows that under the pain share mode, cognitive based trust has the highest weighting of 0.51. It has the most impact on trust with the sub criterion of problem solving with the weighting of 0.37 being the most preferred out of the pairwise comparisons. System based trust has the lowest weighting of 0.16 with the sub criterion of contracts and agreements being the least preferred with the weighting of 0.37 out of the pairwise comparison with reputation which has a high weighting of 0.63.

It is interesting to note that openness with the weighting of 0.5, is the most preferred criterion under cognitive-affect based, which has a weighting of 0.33 under pain share for trust whilst it was also openness with a weighting of 0.25 under gain share for trust. This means that the alliancing participants perceive openness as the precondition for both pain and gain share performance. The expectation for openness under pain gain is much greater than the expectation for openness under gain share which demonstrates that there are much higher levels of suspicion under pain share than gain share within a mishap situation. This questions whether trust is facilitated through the alignment of goals from the risk allocation of the gain share and pain share commercial arrangement.

## CONCLUSIONS

Trust is volatile under the gain share and pain share risk allocation arrangements in alliances. In a mishap situation, cognitive-affect based trust is only preferred under a gain sharing mode for the conditions of both trust and mistrust but in a pain sharing mode, cognitive based trust mentality prevails over cognitive-affect based trust, system and affect based trust for the conditions of both trust and distrust. This research demonstrates that the values of team work and relational bonding only occurs as a lag effect indication of the Total Output Cost performance and has little effect on governing the inherent attitude and culture of which the people within the construction industry operates. Unless there is a change in the fundamental legal framework of which business is conducted under common law, cultural and the continuing simultaneous use of other non-relational procurement systems will determine the eventual behaviour of any business transaction.

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## QUALITY MANAGEMENT

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# DEFECTS OF NEW-BUILD DWELLINGS CONSTRUCTED TO BUILDING REGULATIONS AND TO THE 'CODE FOR SUSTAINABLE HOMES'

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Defect is an important aspect to address for enhancing quality of homes. However, there is little research into defects of new-build homes in the UK constructed to the 'Code for Sustainable Homes' which has been introduced to the UK building industry since 2007 as an environmental assessment tool. The aim of this paper is to contribute to knowledge of the defect profile of new homes regarding the defect number, type, location, severity and responsible trades. The research was carried out through analysing defect records for 327 homes in the UK constructed to the Code in comparison with to Building Regulations. In total 3209 defects were identified, with the mean average of 9.8 defects per home. Despite some extreme cases 91.4% of the dwellings studied were reported of 20 or less defects each. It is concluded that the defect profile of UK new-build homes since 2007 has improved in number, diversity and severity of defects. Nevertheless, kitchens and bathrooms remained as two most defective areas, with plumbers and painters/decorators being most often tasked for rectifications. With the evidence presented no clear relationship was observed between the defect profile of the homes and their performance standards or build methods adopted.

Keywords: building standard, defect, quality, sustainable home.

## INTRODUCTION

Housing represents a significant part of our society. In the UK, public and private housing together contributes a total value of £3,923 billion or 56% of the nation's wealth (Office for National Statistics 2009). Previous research has estimated that defects cost between 2-6% of the overall build cost during construction (Ball 1987; Hammarlund 1990; van den Beukel 1989), and between 3-5% in post-completion maintenance (Josephson and Hammarlund 1999). Therefore, eliminating defects and maintaining good quality have an important cost benefit for the society. The Callcutt Review (2007:63) advocates that the high demand for housing must not be met with housing to a low standard, 'building to a low standard, where new housing incurs additional cost because defects in design or construction have to be expensively remedied after occupation, is a false economy'.

Although it may be inevitable that defects in a building occur through general wear and tear, defects due to human errors in the construction of a home should be

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mitigated. However, previous research (e.g. Assaf et al. 1996; Harrison 1993; Pheng and Wee 2001) has suggested that most defects identified of new-build homes are actually attributed to human errors in relation to design, specification, workmanship and management, which imposes an urgent need for attention of both research and practice. The UK government announced the 'Code for Sustainable Homes' (CSH) in 2006 to be 'A mark of quality' (DCLG 2006:5), which replaced 'EcoHomes' as the environmental assessment tool for new domestic buildings in the UK. The CSH has since April 2007 been adopted in the UK, as a voluntary scheme but often made required by planning authorities. In such cases, the adoption of the CSH imposes additional performance requirements to Building Regulations that represent a compulsory minimum level of performance standards, and therefore introduces an opportunity but also a challenge to quality control. The number of defects has been regarded as an important indicator of quality of homes (see e.g. Harrison 1993; Auchterlounie 2009). However, despite the previous studies on the types and locations of defects in domestic buildings, most such research was with buildings constructed to Building Regulations, while there is very little research into defects of homes built to the CSH. Also, it remains unclear if the adoption of the CSH has had any impact on the defect profile of new-build homes.

Therefore, the aim of this paper is to contribute to knowledge of defects in new-build dwellings constructed after the CSH was introduced to the UK building industry. Several questions guided this research: 1) What is the defect profile, e.g. number, type and location of defects, of new-build homes constructed to the CSH in comparison with those to Building Regulations only? 2) How severe are such defects? 3) What trades are responsible for rectifying such defects?

## LITERATURE REVIEW

### The concept of defect

Number of defects is a key indicator of quality that has been used in the house building industry (Auchterlounie 2009). Harrison (1993) reported that quality was directly related to the number of defects found in a property. However, there exist many terms similar to 'defect' in the literature of construction management, such as rework (Love 2002), quality deviation (Burati et al. 1992), nonconformance (Abdul-Rahman 1995), quality failure (Barber et al. 2000), non-compliance (Pan and Garmston 2012), fault (Bonshor and Harrison 1982) and snag (Love 2002; Sommerville et al. 2004).

Love (2002:19) defined rework as 'the unnecessary effort of redoing a process or activity that was incorrectly implemented the first time'. Ashford (1992) defined rework as 'the process by which an item is made to conform to the original requirement by completion or correction'. Snagging is referred to by the independent UK body Inspector Homes Ltd as the act of checking a new home for difficulties with the quality of finish and workmanship. Accordingly, Sommerville et al. (2004) regarded snags as the items identified near completion stage of a construction project which require remediation or action. The BRE study (Bonshor and Harrison 1982:1) defines a 'fault' as 'a departure from good practice as established by criteria in the published requirements and recommendations of authoritative bodies. Additionally, for site faults only, a departure from a design requirement'.

With regard to the concept of defect, Josephson and Hammarlund (1999:683) used the definition 'the non-fulfilment of intended usage requirements'. Barrett (2008) defined

defect as 'a lack or absence of something essential to completeness'. The BSI (2004:86) defined defect as 'fault or deviation from the intended condition of a material, assembly or component', where 'fault' is defined as 'inability to function properly' (p.86), and 'deviation' as 'algebraic difference between a size and the corresponding required size' (p.77).

The many terms outlined above are interrelated with each other but different in their scopes and definitions. None is universally accepted. The complexity of the concept of defect is further complicated by the value-laden nature of this concept and indeed also the concept of quality in a broader sense that people's perceptions and expectations can be very diverse, dependant on their roles. In the context of housebuilding, such roles may include policy-makers, builders, occupants and end-users. Nevertheless, defects are commonly categorised as being either patent or latent; a defect is patent if observable, whether or not it is actually observed, while latent defects are hidden and not observable (Barrett 2008). The research reported in this present paper addressed defects in buildings which occupants encountered and reported to the builders and developers of concern.

### **Types and locations of defects of homes**

Defects may be associated with any element of the building. Marshall et al. (2009) identified typical defects that can be found in poorly designed, built and/or managed domestic properties less than 10 years old. Such defects included: cracks in walls especially at natural lines of structural weakness, e.g. windows, doors junctions with extensions and bays; bulging/bowing of walls; rising dampness; uneven ground floor slabs; movement in upper floors; damp penetration of roof; cracking to render; loose/hollow render; condensation; faulty heating, plumbing and electrics; and blockages/leaks to drainage. Marshall et al.'s (2009) list is not exhaustive but provides a useful outline of commonly encountered defects in residential buildings. It has also been recorded that significantly disproportionate numbers of defects occur in the wet areas of buildings. Chew (2005) commented that wet areas account for 10% of a building's gross area but contribute 30-50% of the building's total maintenance cost. Defects associated with the wet areas are often attributed to the constant drying and wetting cycles experienced in rooms like bathrooms and kitchens. Chew (2005) recorded leaks as the most common type of defects in these areas, accounting for 53% of all the defects studied. Johnson and Meiling (2009) studied offsite prefabricated timber modules in Sweden, and recorded defects which included holes and mess on the walls caused by craftsmen, missing linings around doors and windows, and doors in need for adjustment owing to movements in the structure. In Johnson and Meiling's study, 33% of all defects were related to walls and 52% to walls or openings.

### **Previous research on defects of new-build homes in the UK**

Sommerville et al. (2004:256) collated data from over 600 new home inspection surveys and suggested that larger houses contained larger numbers of 'snags', and that in an extreme case, 'A staggering 406 snags were found and recorded within a five-bedroom residential property after the building had been snagged by the builder'. Sommerville and McCosh (2006) further analysed the defects identified in 1696 new homes in the UK, and reported an average number of 59 defects per property. However, there was a considerable variation, with the number of defects per property ranged from 1 to 389 (with the standard deviation of 47) and five properties with over 300 defects reported. This study confirms the positive correlation between 'number of defects' and a number of factors including 'number of bedrooms' and 'size of property'.

However, despite these studies, little research exists into the defects of homes in the UK built after the CSH was adopted in 2007.

## RESEARCH METHODS

The research reported in this paper employed an analytical case study approach to analysing the profile of defects of new-build homes. All data were collected from archived maintenance records of defects of new-build homes. The use of this data collection method enabled the collation of a large amount of detailed data and information in an accurate and time-efficient manner. The same method was used in previous studies of defects (e.g. Chew 2005; Chong and Low 2006; Sommerville and McCosh 2006). Maintenance records of defects of new-build homes may be archived in various types of organisations, including housing associations, housebuilders, responsive and planned maintenance contractors, and new-build contractors. However, many organisations consider their records of defects to be highly confidential, and therefore are reluctant to release the data for research. The data reported in this paper were collected from a national housebuilder in the UK, which operated in both social and private housing markets and supported research and development. The researcher was placed in this organisation for a year, and the good rapport built between the researcher and the organisation facilitated the obtainment of the effective access to data and information for this study.

In total eight projects of the case organisation were selected for the research. The selection of the projects took into account the following considerations in order to address the research questions and to ensure data consistency: 1) full records of defects were available for the project; 2) two types of projects were included, i.e. built and certified to the CSH and to Building Regulations 2006 to allow comparison. The selected projects together consisted of 327 separate dwellings, of which 169 (52%) were designed, constructed and certified to Building Regulations 2006 and 158 (48%) to the CSH Level 3. These dwellings were built using traditional masonry methods (166 dwellings; 51%) and timber frame methods (161 dwellings; 49%) (Table 1).

*Table 1 Research sample of dwellings by number, build method and performance standard*

Project	No. of homes	Build method		Performance standard	
		Timber Frame	Masonry	Part L 2006	CSH Level 3
1	61	61	0	0	61
2	44	44	0	0	44
3	37	0	37	0	37
4	16	0	16	0	16
5	53	16	37	53	0
6	40	40	0	40	0
7	36	0	36	36	0
8	40	0	40	40	0
Total	327 (100%)	161 (49%)	166 (51%)	169 (52%)	158 (48%)

*Masonry denotes traditional masonry method used in the UK, with insulated cavity walls.*

These features enabled the achievement of a like-for-like comparison of the profiles of defects of dwelling groups by 'performance standard' and by 'build method'. The mean total floor area of the dwellings was 87m<sup>2</sup> with the smallest 47m<sup>2</sup> and the largest 169 m<sup>2</sup>. The dwellings studied were built in South Wales (198; 57.7%) and 1018

Southwest England (145; 42.3%) which are associated with an essentially maritime climate, characterised by weather that is often cloudy, wet and windy but mild (Met Office 2011). The dwellings studied consisted of 261 houses (80%) and 66 flats (20%), which align well with the general 80/20 split between houses and flats of new-build homes in England and Wales (see Goodier and Pan 2010).

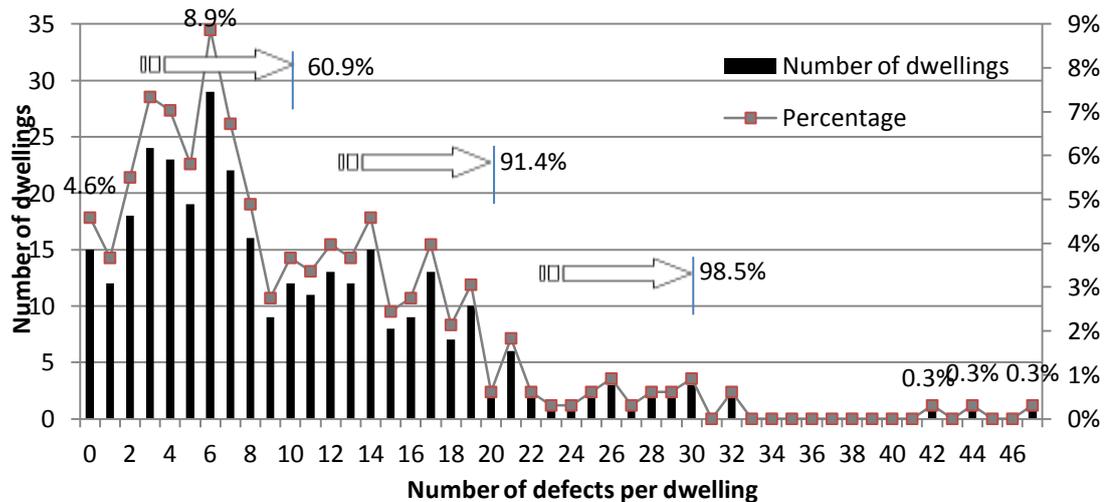
Data were collated using the defects registers kept at the case organisation, and then stored and analysed using Excel Spreadsheet and the IBM SPSS Software. The data analysis reported in this paper was mainly descriptive in nature to provide an overview of the defect profile. All defect descriptions recorded in the defect registers were analysed in order to identify and group the areas and types of defects in the dwellings thoroughly and effectively.

## RESULTS AND ANALYSIS

### Overview of the defects

In total 3209 defects were identified in the defect records for the 327 dwellings studied, with the mean average of 9.8 reported defects per dwelling and the mode average of 6 reported defects per dwelling (8.9%). Fifteen dwellings (4.6%) were reported of no defect, while 3 dwellings were reported of significantly larger numbers of up to 47 defects per dwelling. Almost all (98.5%) dwellings were reported of 30 or less defects each, 91.4% of 20 or less, and 60.9% of 10 or less (Figure 1).

Figure 1 The overall profile of defects (n=3209)

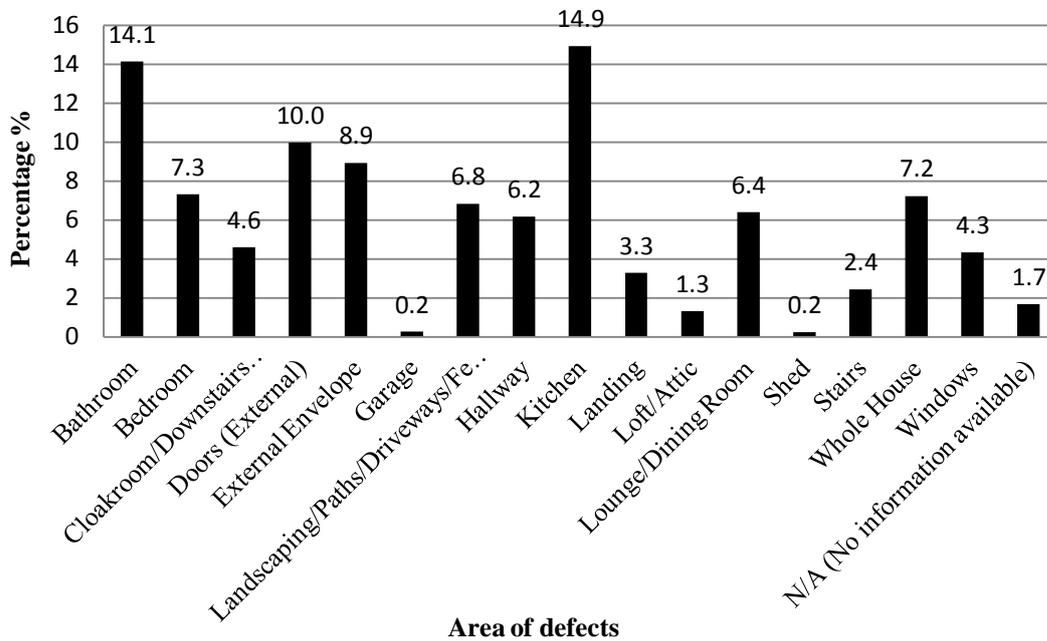


### Area of defects

In total 16 areas of defects were identified, which were: bathroom(s), bedroom(s), cloakroom (downstairs W/C), external doors, external building envelope, garage, garden (landscaping, fencing and driveways/pathways), hallway, kitchen, landing, loft/attic, lounge/dining room, shed/external stores, stairs, whole house (multiple room defects), and windows. All the 3209 defects recorded were distributed unevenly throughout these areas. The two areas with the largest numbers of defects were 'kitchens' (479 defects; 14.9%) and 'bathrooms' (454 defects; 14.1%), followed by 'external doors' (320; 10%), 'building envelope' (287; 8.9%) and 'bedroom' (235; 7.3%). The areas associated with the smallest numbers of defects were 'garages' (8; 0.2%), 'sheds' (7; 0.2%), and 'loft' (42; 1.3%) (Figure 2). A caveat for the areas with the smallest numbers of defects was that not all dwellings were designed with a shed or garage, and that where a shed and/or garage were included, the basic finishes to

these areas reduced the likelihood of defects occurring. The lower level of defects recorded of the loft area might also be attributed to the low level of activity in this area so defects might often go unnoticed for a long period of time.

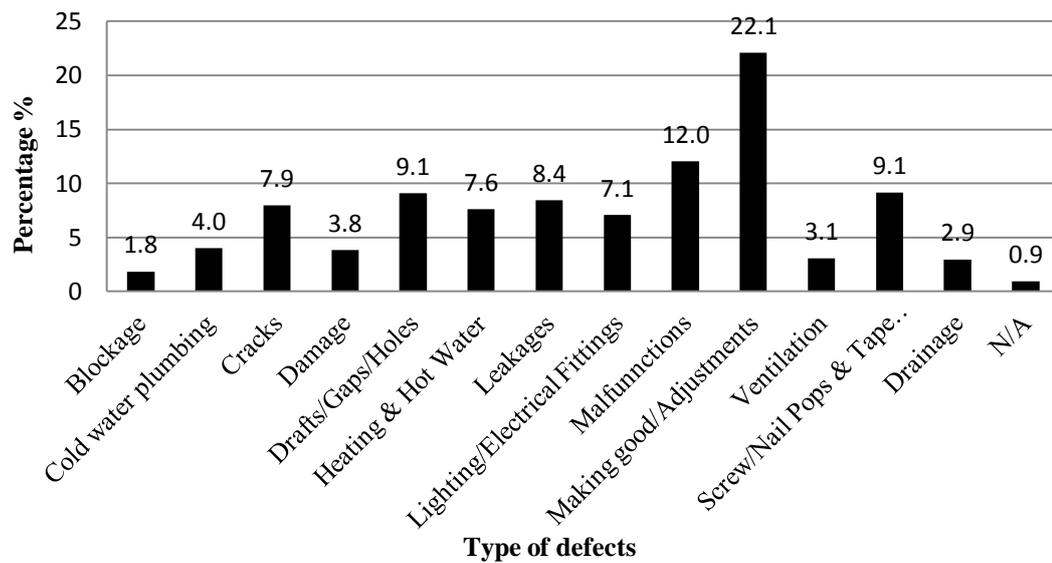
Figure 2 The profile of defects by area (n=3209)



### Type of defects

In total 13 types of defects were identified, which were: blockage(s), cold water system, cracks, damage, draught(s)/gap(s), heating and hot water system, leakage(s), electrical systems, malfunctions (materials and components), making good/minor adjustments, ventilation system, screw/nail pops and tape blows, and drainage. All the 3209 defects recorded were distributed unevenly throughout these types, with the most significant defect type being ‘making good or adjustments to the finished dwelling’ (709 defects; 22.1%), followed by ‘malfunctions’ (386; 12%), ‘screw / nail pops and tape blows’ (293; 9.1%), ‘drafts/gaps/holes’ (291; 9.1%), ‘leakages’ (271; 8.4%), ‘cracks’ (255; 7.9%), etc. (Figure 3).

Figure 3 The profile of defects by type (n=3209)

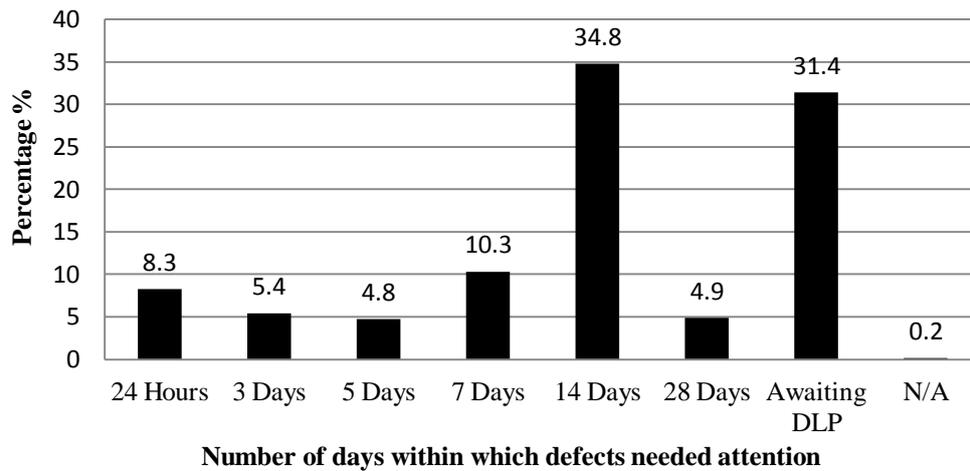


### Severity of defects

In total seven different levels of severity of defects (which denote the levels of urgency measured by the number of days in which the defects needed attention) were identified, namely, 1 day, 3 days, 5 days, 7 days, 14 days, 28 days, and awaiting Defects Liability Period (DLP). The defects that required soonest attention, e.g. within 3 days, represented the most severe ones. The non-critical cosmetic and decorative defects were given longer periods before attention was needed. Awaiting the DLP denotes that a defect needed to be rectified before the end of the DLP. The DLP refers to the period in which the housebuilder was responsible for any defect occurring, and this period normally lasts for 12 months after the housebuilder's handover of the dwelling to the occupant in the UK contracting practice. Towards the end of the DLP a final inspection was conducted and any remaining defects were highlighted and needed to be addressed by the housebuilder before the responsibility for addressing any future defects was fully handed over to and absorbed by the housing association of concern.

Over a third (1116; 34.8%) of the defects studied required attention within '14 days', and nearly a third (1007; 31.4%) fell into the DLP category and were not deemed critical by the occupant, client or customer care team. These two categories were followed by around a tenth (331; 10.3%) of the defects requiring attention within '7 days'. Only 8.3% (266) of the defects studied were deemed most critical requiring attention within 24 hours (Figure 4).

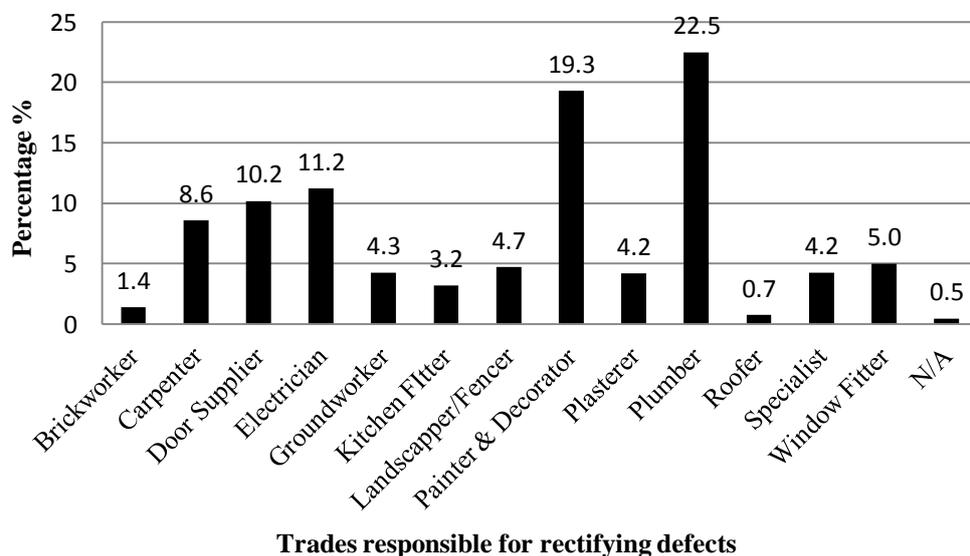
Figure 4 The profile of defects by severity (n=3209)



### Responsibility for rectifying the defects

In total 14 trades and sub-contractors were deemed responsible for rectifying the defects, which were: brickworkers, carpenters, door suppliers, electricians, groundworkers, kitchen fitters, landscapers/fencers, painters & decorators, plasterers, plumbers, roofers, specialists (e.g. ventilation), and window fitters. Over a fifth of all the defects (722; 22.5%) were associated with ‘plumbers’ (which also included heating engineers), followed by 19.3% (620) of the defects associated with ‘painters and decorators’ (Figure 5).

Figure 5 The profile of defects by responsibility for rectification (n=3209)



### Defects and performance standards and build methods

By performance standard, 51% of the 3209 reported defects were associated with the homes designed, built and certified to Building Regulations 2006 (accounting for 52% of the sample dwellings), and 49% of the defects were associated with the homes designed, built and certified to the CSH Level 3 (accounting for the other 48%) (Table 2). The almost same profiles of defects and homes by performance standard suggest a general unclear relationship between the number of defects and the performance

standard adopted for the dwellings studied as a whole. By build method, 51% of the 3209 reported defects studied were associated with the masonry homes (accounting for 51% of the sample dwellings), and 49% of the defects were associated with the timber framed homes (accounting for the other 49%) (Table 2). The same profiles of defects and homes by build method suggest a general unclear relationship between the number of defects and the build method adopted for the dwellings studied as a whole.

*Table 2 The profile of defects by performance standard and build method*

	Timber frame	Masonry	Total
Built to Building Regulations	695 (42%) (44%)	947 (58%) (58%)	1642 (100%) (51%)
Built to CSH Level 3	876 (56%) (56%)	691 (44%) (42%)	1567 (100%) (49%)
Total	1571 (49%) (100%)	1638 (51%) (100%)	3209 (100%) (100%)

## DISCUSSION AND CONCLUSIONS

Previous research has examined the types and locations of defects in domestic buildings. However, much such research in the UK was with the buildings constructed to Building Regulations, while there is little research into defects of homes built to the CSH which has been introduced to the UK building industry since 2007. Also, it remains unclear if the adoption of the CSH has had any impact on the defect profile of new-build homes. In addressing the gaps in knowledge, this paper has examined the profile of defects in new-build dwellings in relation to the defect number, type, location, severity and responsible trades.

The mean average of reported defects per dwelling examined in this paper was 9.8, which was significantly lower than those previously reported, e.g. 59 defects per dwelling reported by Sommerville and Craig (2006). Despite a small number of extreme cases with up to 47 defects per home, 91.4% of the dwellings studied were reported of 20 or less defects each, indicating a much less variety than those reported in the UK building industry in previous years, e.g. 406 recorded defects in one property as reported by Sommerville et al. (2004). Nevertheless, kitchens and bathrooms were found to remain as two most defective areas, in terms of number of defects, of the new-build homes studied. This finding is in line with the result reported by Chew (2005). These areas are subject to the most extreme conditions in a home because they are normally humid, wet and hot and go through prolonged wetting and drying cycles. Also, this finding applied to homes built to Building Regulations as well as to the CSH, which suggests that the raised performance standard had no clear impact on the defect profile of the wet areas.

Plumbers and painters/decorators were identified as the two trades most often tasked for rectifying the reported defects. The finding on plumbers supports the results that most significant areas of defects were identified as the wet areas like kitchens and bathrooms. Many rectification activities for the defects associated with 'painters and decorators' actually resulted from 'making good' following other remedial works, which suggests a significant quality control problem towards the end of the construction period where finishes were applied to the dwelling. Nevertheless, it is worth noting that although these trades and subcontractors were responsible for rectifying the defects, they were not necessarily the parties who caused the defects.

This point of argument is also debated in the literature. For example, Pheng and Wee (2001) pointed to human error as the main cause of defects, while Low and Chong (2004) suggested that defects were more of a design based problem. Atkinson (2003) revealed that 82% of the defects studied were attributed to management, and therefore argued that defects were a management based problem. However, the results suggest no clear relationship between the number of defects and the performance standards adopted, i.e. the CSH Level 3 and Building Regulations 2006, or between the number of defects and the build methods utilised, i.e. timber frame and masonry. Nevertheless, only less than one tenth of the defects studied required attention within 24 hours, the vast majority being much less critical.

Drawing on the discussion together the paper concludes that the defect profile of new-build homes in the UK in recent years has improved from reported in the history, in number, diversity and severity of defects. However, critical defective areas remain as bathrooms and kitchens. From the evidence presented it is unclear if the adoption of the CSH has had any significant impact on the defect profile of new-build homes. Future research could cross analyse the multiple factors that influence building defects, results of which should help achieve an alternative insight into the defect profile of new-build dwellings.

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# ATTAINING ZERO DEFECTS WITHIN THE UK'S BUILDING SCHOOLS FOR THE FUTURE PROGRAMME: STAKEHOLDERS' PERCEPTIONS

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Until its demise in July 2010 The Building Schools for the Future (BSF) programme represented the biggest single UK government investment in school buildings for more than 50 years. One of its key goals was to ensure that pupils learn in high quality 21st-century facilities that are designed or redesigned to allow for educational transformation in historically underperforming schools whose pupils were often enmeshed in deprivation and social exclusion. This represents a major challenge to those involved in the delivery of the new or refurbished schools. This paper explores the extent to which schools completed under the umbrella of BSF lived up to the UK government's ideology of 'value for money' a key parameter of which is the delivery of high quality buildings. Drawing on an embedded case study methodology based around one local authority that completed nine secondary schools under the BSF funding model between 2006 and 2010 the findings portray the many challenges faced by constructors in the pursuit of zero defect construction. Critical to this, the authors argue, is the approach used by stakeholders to define and measure the presence of a 'defect'. Analysis of exploratory interviews undertaken with four key project stakeholders give evidence of the very different views each professional holds of both quality and what constitutes a defect. By highlighting a lack of consensus between industry stakeholders as to what constitutes a 'defect', how that is to be measured and at what point in the project this should be formally recorded, the research findings raise important questions about the construction industry's ability to deliver projects free from defects.

Keywords: building defect, quality, Schools for the Future

## INTRODUCTION

In 2003 the UK government launched the Building Schools for the future (BSF) programme with the aim of renewing all 3,500 English secondary schools over a fifteen year period with an initial estimated public spend of £52 to £55 billion subject to future public spending decisions. The initial plan was to rebuild half the schools, structurally remodel 35% and refurbish the remainder. The scheme's key aspiration was to ensure that pupils learn in high quantity 21st-century facilities, designed or redesigned to allow for 'educational transformation' in historically underperforming

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schools, where pupils are often enmeshed in deprivation and social exclusion. The first schools BSF contract commenced in 2005; however in July 2010 the BSF programme, which represented the biggest single UK government investment in school buildings for more than 50 years, met its demise as austerity measures were introduced.

As part of a wider study, which sought to explore the extent to which schools completed under the umbrella of BSF lived up to the UK government's ideology of 'value for money', a key parameter of which is the delivery of high quality buildings, the research reported in this paper aimed to explore how key project stakeholders' define, manage and importantly, assess quality during the construction phase of a BSF project. Literature relating to construction quality and the use of 'defects' or 'snagging' as a proxy for quality management is explored before the results are reported of semi-structured interviews with key project stakeholders that explore how quality is interpreted, managed and measured. The findings suggest that whilst the 'defect' remains an important measure of success on construction projects, in reality it is merely a gauge of standards of workmanship and the contractor's ability to comply with the base level specification rather than an indicator of quality. Invariably quality is a highly subjective concept that is strongly influenced by the client's overall satisfaction with the finished product. The paper concludes by proposing that further research be undertaken to evaluate how the construction project team can more effectively manage the client's expectations throughout the project life cycle to enhance satisfaction and therefore improve the perceived quality of finished buildings.

## **THE LITERATURE**

### **Theory of Quality**

Following World War II and his ground-breaking work in Japan Deming (1986) in his seminal text 'out of a crisis' produced a fourteen point plan which is considered to be a 'complete philosophy of management', which can be 'applied to small or large organisations in the public, private or service sectors' (Institute for Manufacturing 2009). Deming (1986) suggested that quality can only be defined in terms of customer satisfaction, management is key and quality can be achieved through continuous improvement. Deming differed from Juran (1989), who placed great importance and responsibility on statistical process control, with 'quality through continuous improvement'. Deming (1986) also believed that management is responsible for 94% of quality issues. Deming had a major influence in changing the way Japan controlled quality and told Japan's chief executives that, 'improving quality will reduce expenses while increasing productivity and market share' (Deming, 1986).

Prior to the introduction of quality assurance, quality was predominantly measured by the finished product. Other than Deming only a few quality champions have advanced this theory. Juran (1989), believed to be of significant importance, looked further into quality linking it to value and the end user. Juran further defined quality as the 'fitness for use' and suggested that this could be linked to value management where unnecessary costs and products are removed. Juran's theory brought the development of the quality trilogy: quality planning, quality control and quality improvement as a result of Deming's work and further development of Pareto's principle, that 80% of the problem is caused by 20% of the causes. It is widely acknowledged and understood that the main aim for quality management is to provide customer satisfaction for all stakeholders. Harris and McCaffer (2006) suggest that this can only be achieved if all stakeholders directly contribute to achieving the objectives.

Quality management might be defined as ‘the culture of an organisation committed to customer satisfaction through continuous improvement’ (CIOB 2011). Its principles should be the same for all industries, although quality management is evidently more successful in the car industry than in other industries such as construction, which can be attributed to the early implementation of Deming’s methods. This may be (and the evidence supports this discussion) due to the inherent differences in the nature of the two industries.

### **Quality in Construction**

Latham’s (1994) and Egan’s (1998) seminal reviews of the 1990s collectively challenged UK construction to place a greater focus on the quality of the assets it delivers. The authors collectively suggested improvements in quality would foster improvements in the levels of client satisfaction achieved. Key strategies in the attainment of this ambitious target included Latham’s (1994) assertion that existing tendering procedures required significant transformation throughout the supply chain and Egan’s (1998: 22) call for continuous quality improvements through the targeted reduction and eventual eradication of primary building defects within five years.

Whilst Egan does not advocate the adoption of the ‘defect’ as a singular measure of quality, it is nonetheless important to establish its suitability as an indicator of quality within construction projects. In his review of progress since the Egan report, on behalf of Constructing Excellence, Wolstenholme (2010) acknowledges that industry has achieved its 20% year-on-year target for reducing the number of recorded defects since Egan first set the target in 1998. A critical part of the sectors continuing attainment of this target must be its commitment to identifying the principle causes of construction defects. Yet as Auchterlounie (2009) opines defects have continued to plague construction projects across the full spectrum of projects raising important questions as to their underlying causes. Atkinson (1999) suggests there is a wide spread belief within the construction industry that defects are merely the result of human error and a general lack of work ethic leading to poor workmanship standards. Yet counter to this view, Atkinson (1999) also suggests that the situation is often quite complex, with different active and latent errors interacting and eventually leading to human error and the occurrence of a visible defect (Douglas and Ransom, 2007). Either way it is clearly in the interests of the construction industry to identify and combat the root causes of defects.

Josephson and Hammarlund (1999) attempted to identify these underlying causes in their four-year research study based on the detailed observation of seven Swedish construction projects over a four to six month period. They identified that defects could not be attributed to either a single stakeholder or phase in the project but to the overall motivation of the project’s organisational team. This suggests that improvements in the motivation of the construction team would lead to a reduced occurrence of construction defects. Love et al (1999) used a system dynamics framework to evaluate two Australian projects, from commencement of the construction phase, to the end of the defects liability period; the first was a residential tower block, and the second an industrial warehouse facility. They concluded that a paradigm shift in project management strategy was needed to reduce the occurrence of defects. At the centre of their calls for improvement, was the implementation of a collective, joined-up approach to project management with a single point of information and responsibility. In their ten-project study, consisting of 700 apartments’ in multi-storey buildings, Kim et al (2008) proposed an Information

Communication Technology (ICT) solution for managing defects in large construction projects. They tested and suggested real-time data collection and processing of defects, and the study reported significant efficiency improvements. Hassan et al (2011) reviewed the occurrence of defects across four design and build hospital projects constructed for the Malaysian Department of Health. From their quantitative analysis of secondary defect data together with stakeholder interviews, their analysis of between 1343 and 5483 defects per hospital reaffirmed the earlier findings relating to the breakdowns in the project management. The researchers suggested that the management of project quality should be a continuous process, overseen by an independent third party organisation. Such approaches are already utilised in the UK construction industry but they do not appear to have led to a reduction in the occurrence of construction defects.

The research reviewed so far appears to advocate for a relatively project-focused approach to the causes of defects. Yet another body of evidence has argued the need for a more long term strategy for reducing construction defects, based around the theory of organisational learning. Schön, the leading organisational learning theorist, has argued that people and organizations should be flexible and incorporate their life experiences and lessons learnt throughout their life through a process of double-loop learning, in which the organisation adjusts its operations not only to keep pace with changing market conditions but also to create new and better ways of achieving its business goals (Fulmer 1994). A number of researchers have argued that such an approach would allow organisations proactively to reduce and eventually eliminate defects and improve the quality of their projects (Love et al 2000).

In later research, Love et al (2002) examined the extent to which change management processes or their potential lack within the project management system affected the overall quality levels attained. The research again adopted a case study approach, collecting data through both observation and stakeholder interviews. The research identified that instances of change had a significant impact on the project management, and led inevitably to an increase in the number of observable defects. As a result, the researchers concluded that achieving a reduction in defect occurrences required project managers to learn from and develop mechanisms proactively to anticipate project change, and to deal with its effects when it occurred.

Yet as Lundkvist et al (2010) quantitative survey of forty-one Swedish project and site managers suggested the calls of Love et al (2000) for the adoption of organisational learning strategies as a part of enhanced quality management have been largely ignored. The survey revealed that although the majority of respondents understood the benefits associated with the detailed analysis of defect data from past projects, in practice very few had tried to use it for the purpose of experience feedback and continuous improvement. The majority did little more than correct the defects. However evidence from Laing O'Rourke (2009) and Bovis Lend Lease (Labbad 2010), two of the UK's largest contractors suggests that this lack of reflection or organisational learning may be a symptom of the construction team's eagerness to move on to its next challenge. This is a problem that Peach (2010) believes must be addressed if overall quality is to improve and the industry is to come close to achieving zero defects.

If Auchterlounie (2009) is to be believed, the findings of these studies have thus far failed to identify the principal root causes of construction defects. This raises the question, is achieving zero defects truly a Sisyphean task? Deming (1986), the world

authority on quality, appears to suggest this to be the case, arguing that attempting to remove all defects would be an excessive waste of time and money. Instead, he asserts that clients and manufacturers should establish an acceptable level of defects for a project prior to its commencement. Looking to the literature, Aagaard et al (2010) have developed a theoretical framework based around the economic theory of optimisation for identifying the optimal level of defects. The model suggests that it is possible to identify an acceptable number of defects based on their associated economic cost—fundamentally, the model suggests that any decision to attempt to deliver a zero defect building is principally an economic one. The fewer defects the client is willing to accept, the more the project will cost, whereas the more defects the client can accept the less it will cost. Yet the complexity of construction procurement would appear to suggest that the model is overly simplistic, especially given the excessive use of price based competition (Wolstenholme 2010). In reality, the costs of defects are borne by the contractor, who has little prospect of transferring these back to the client in the form of additional transaction costs. Bovis Lend Lease (Labbad 2010) suggests that, defects can amount to 1.7% of a projects total value. On an £80million project, this would translate to an additional expense of £1.4million wasted on the correction of poor workmanship. However, Fagbenle's (2010) recent large scale quantitative survey of more than eight hundred Nigerian construction firms suggests that these costs and the total number of defects could be reduced significantly if contractors manage their supply chain proactively. Analysis of the questionnaire data revealed a strong positive correlation between the time and quality performance of labour only subcontractors, suggesting that such subcontractors compromised on quality to complete the work in the quickest time possible.

The literature reveals that although defects are costing contractors nearly 2% of the project value to put right Bovis Lend Lease (Labbad 2010), significant progress has not been made against Egan's fifteen year old target of delivering defect free construction. The literature evidences that whilst defects are the result of human error, a highly complex interrelated set of factors lay behind this. Yet the sector's major contractors appear to be dismissive of the academic models that have been developed, suggesting instead that the main reason for the number of defects recorded at handover is simply the low priority assigned by construction management professionals to the rectifying sub-standard work immediately prior to the critical hand over stage of the project. Even so none of the academic or practice led research undertaken to date has explored the possible influence different stakeholders perceptions and understanding of both 'quality' and 'defects' has on the number of defects recorded.

## **RESEARCH APPROACH**

The research reported in this paper sought to explore to what extent key stakeholder's associated with the Building Schools for the Future programme felt it had achieved its principle aim of 'constructing high quality buildings'. In order to achieve this objective, the authors sought to explore (i) how key stakeholders perceived and defined quality (ii) how this definition of quality was communicated and managed during the construction phase of the project and finally (iii) how the quality of the finished scheme had been evaluated, with particular focus on the use of the 'defect' as an aid for measuring quality.

To meet the objectives of the study, a qualitative research approach was adopted with semi-structured interviews used to collect data from key stakeholders. This approach

reflected an interpretivist philosophical position that made use of an inductive research strategy and a qualitative methodology. Creswell (2009) attest that the adoption of a qualitative research approach is considered an effective method when collecting data that occurs in a natural setting as it enables the researcher to develop a level of detail from involvement in practice.

To ensure that data collection was as reliable as possible the interview sample was selected using 'discriminate sampling' which maximises the chances of collecting relevant data from a small sample. In total of seven key stakeholders were identified, all of whom were associated with wave one of a recent £250 million pound BSF secondary school replacement programme completed in North West England between 2006 and 2010. Emails were then sent out to those stakeholders identified outlining the purpose and context of the study before they were finally invited to participate. In total (4) individuals agreed to participate in the study (see Table 1).

Each participant was invited to take part in a 30 - 45 minute face to face interview, held at their offices between January and April 2013. The interviews were transcribed before being thematically analysed using Nvivo qualitative software. Nvivo allows the researcher to arrange the data using a hierarchical tree structure. The central phenomena (quality management) formed the root of the tree, from which sub-categories or nodes were generated based on a theoretical framework developed from the researchers' previous analysis of programme level defect data (Boothman et al 2012). The analysis used open coding to identify the various sub-categories associated with the two central themes.

*Table 1: Interview Participant Profile*

Respondent	Role	Type of organisation
A	Designer	Designer (contractor appointed practice)
B	Construction Manager	Main contractor
C	Project Manager	Special Purpose Vehicle (client)
D	Commercial Manager	Main contractor

## STAKEHOLDERS' PERCEPTIONS OF QUALITY

### Defects: A Proxy for Quality?

The first area explored during the interviews sought to ascertain how stakeholders view and define defects. The interviews revealed a consensus in respect of what a defect is. The interviewees opined that a defect is fundamentally (i) poor quality of workmanship

*“Workmanship below the agreed standard, Construction not to agreed design or specification, Structure or item unfit for purpose, Material or colour not as per agreed specification, damaged items or structure”. (Project Manager)*

*“Screws missing in the hinge or not the same gap around the door” (Construction Manager)*

Or (ii) the contractor's failure to comply with the specification outlined in the contract documentation often resulting from the overeager drive to reduce costs through the application of value engineering.

*“Any fault in the works which does not comply with the output specification and/or deem that particular asset unavailable or not fit for purpose” (Construction Manager)*

*“The component that you are trying to achieve that doesn’t widely meet the standard(s)” (Designer).*

Nevertheless the Designer reluctantly acknowledged that contractor instigated value engineering is often a necessary compromise if the client is to retain control of the overall bottom line cost of the project.

*“Value engineering - you can lose the value of the scheme design and don’t always save that much money, if you try to avoid value engineering you can pay a lot of money on partnership contract” (Designer).*

### **Understanding and Managing of Quality in Construction**

The second area explored during the interviews sought to ascertain the stakeholders’ understanding of quality in construction projects. Once again the data revealed a consensus of opinion on how quality is defined, interpreted and understood. The data suggests that all four respondents demonstrated a sufficient understanding of the concepts of quality. All the project stakeholders agreed that the contract included minimum standards in respect of the design, specification and standard of workmanship. Taken together, these formed the minimum quality standard for the project.

The Construction Manager fully supported the use of a pre-agreed minimum quality standard for the project, and argued that quality was:

*“The acceptable and agreed standard in relation to the design, material, finish and workmanship as per the contract agreement, Quality should not be subjective as a personal level of acceptance can differ” (Construction Manager).*

Yet the designer, whilst having responsibility for the production of quality related documentation including material and workmanship specifications suggested that actual attainment of quality is

*“Incredibly subjective as it's down to the client perspective”. (Designer)*

At the same time, they recognised the contractor’s commercial needs, observing that approaches such as value engineering are often a necessary compromise if cost is to be controlled

*“Value engineering - you can lose the value of the scheme design and don’t always save that much money, if you try to avoid value engineering you can pay a lot of money on partnership contract”. (Designer)*

This would suggest that the clients perception of acceptability often drives the minimum quality standard although how this is defined and measured remains obscure. Yet as the Project Manager attested early promises made by the contractor to secure the contract can often lead to higher quality demands:

*“I believe that the hype of the first phase actually caused more damage than good as expectations were so much higher than the real thing”. (Project Manager)*

In part, this view is supported by the projects commercial manager who agreed quality is a subjective area which is positively correlated to the overall customer experience. As such the commercial manager for the program views quality as a:

*“bit of a compromise sometimes but it's about keeping the relationship going without letting them take the piss” (Commercial Manager).*

Yet the Project Manager highlighted the dangers of such a client orientated approach to quality suggesting that those clients with Rolls Royce expectations would invariably deem the project a failure. Those clients, with lower level expectations would be more likely to see the finished project as a success.

### **Stakeholders' Reflections on Quality**

The final area explored during the interviews revealed contrasting views between all the stakeholders. The Construction Manager clearly felt that the quality management process implemented on the project had achieved a career defining standard, stating:

*“The client acknowledged that they considered the completed project of a good quality and sent a letter to the team thanking all for the finish jobs and effort to complete it early and defect free. Following this I won a silver medal” (Construction Manager).*

Yet although the projects success was internal recognition, other stakeholders did not share this view. Indeed both the Designer and Project Manager strongly contested this view of the project. The Designer suggested, that despite the project's accolades:

*“I don't think they delivered a good quality product” (Designer)*

However the Designer did concede that the project was completed to 'a similar' level of quality to that achieved by comparable organisations confirming

*“The quality of the work was comparable with other contractors of a similar size and skill level” (Designer).*

The client's representative agreed with the Designer in this view. However, he identified three principle factors which he deemed to be fundamental to the low quality achieved. These included (i) design failing, and specifically failings in the communication of important design information; (ii) failings in the selection and procurement of sub contractors, with cost taking precedence over other aspects of past performance; (iii) the contractor failing to deliver against the expectations of the client, which had in part been artificially inflated by the contractor during the bidding phase of the scheme which in turn led to severe time and cost management issues.

## **DISCUSSION OF RESULTS**

Over the last two decades the construction industry has become obsessed with the attainment of quality through the measurement and use of defects as a proxy. In part this ideology stems from Egan's (1998) seminal review of the construction industry which inter alia called for continuous quality improvements through the targeted reduction and eventual eradication of primary building defects within five years. As Wolstenholme (2010) acknowledges, in the long term, this target became interlinked with sector wide key performance indicators and a year on year target for 20% reduction in the number of recorded defects. The exploratory interviews revealed that although they are important, defects are not a substitute for quality, and participants expressed a far wider view of construction quality. Instead they opined that quality is achieved through the management of customer experience. This supports the views already expressed by both Harris and McCaffer (2006) and CIOB (2011) who advise that a commitment to customer satisfaction is fundamental to the quality of delivery.

The stakeholders interviewed instead identified defects to be more likely indicative of poor workmanship by craft operatives. This would support the earlier views articulated by Atkinson (1999) who's research identified a wide belief that defects are merely the result of human error and a general lack of work ethic amongst tradesmen on site. The second major cause of 'defects' on project completion related to non-compliance with component specifications. As Deming (1986) has asserted the establishment of an acceptable level of performance prior to commencement is fundamental to quality management. The interviewees in our study appear to support this view, with all of them agreeing that the specification documents set the principal quality benchmark for construction projects.

## CONCLUSIONS

This paper raises a number of important questions about the use of 'defect' as a performance measurement for quality within the construction sector. The literature identifies poor management practices together with a disregard towards organisational learning as responsible for the adoption of a weak approach to the management of quality within the construction sector. The literature further identifies a number of contributory factors including (i) the lack of personal ownership of quality (ii) procurement driven by price not the wider parameters of value and (iii) construction teams eagerness to move on to the next project. This collectively prevents the sector from attaining the levels of quality that Egan (1998) observed in other industries.

The exploratory interviews suggest that whilst the 'defect' remains an important measure of success for construction projects, it is really only a gauge of standards of workmanship and the contractor's ability to comply with the base level specification. The conversations with stakeholders, suggest however, that quality is a far more subjective concept that is invariably influenced by the clients overall satisfaction with the finished product. If construction quality is to be improved the findings from this research would suggest that further work is needed to evaluate how construction professionals can effectively manage the expectations of their clients from the projects initial inception to its final handover and occupation.

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# ESTABLISHING STATUS OF NIGERIAN BUILDING DESIGN FIRMS BASED ON EUROPEAN CONSTRUCTION INSTITUTE TOTAL QUALITY MANAGEMENT MATRIX

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Total Quality Management (TQM) is based on the philosophy of continuously improving goods and services. This research was aimed at establishing status of Nigerian Building Design Firms by studying the degree to which they were operating under the concept of TQM using European Construction Institute's (ECI) matrix. Firms were grouped under types of design activities and questionnaire survey was used to generate data of the study. The study revealed that the overall average ECI Score of the groups of Nigerian Building Design Firms is 27.4. Thus, according to the ECI the Nigerian Building Design Firms belong to the class 'The start of improvement'. Among the ECI quality factors, 'Training, awareness, education and skill' was recognised to be receiving the least attention from among the firms. It is recommended that the firms should particularly pay attention to this area in order to achieve the requirements and benefits of TQM.

Keywords: total quality management, design firm, quality factor, employee, education.

## INTRODUCTION

Total Quality Management (TQM) previously known as Total Quality Control (TQC) is defined as "a management approach that tries to achieve and sustain long-term organisational success by encouraging employee feedback and participation, satisfying customer needs and expectations, respecting societal values and beliefs and obeying governmental statutes and regulations" (Yamaoka 1994, Harris and McCaffer 2005). According to Ahmed et al (1990), Kumaraswamy and Dissannayaka (2000), Harris and McCaffer (2005) and (Chen, 2008), TQM evolved from quality control and inspection and quality assurance as a result of the change in the concept of quality management system due to the fact that the previous approaches to quality had not provided the necessary change of culture, but instead had diverted energies from customer needs, satisfaction and process improvement to checks and documentation. TQM approach now provides the needed change of culture.

According to Mack and Joshnsten (2004), the concept of TQM comes from the work and leadership of late Dr. Edwards Deming whose formula for company's business success is based on the relationship between improved quality and improved productivity. TQM is based on the philosophy of continuously improving goods and services as reflected in one of the requirements of the International Standard

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Organisation (ISO 9000, 2008). Hitherto, a quality organisation shall continually improve effectiveness of quality of its management system through the use of quality policy, quality objectives and audits results, analysis of data, corrective actions and management review." ISO 9000 (2005) echoed that the aim of continual improvement of quality management system is to increase the probability of enhancing the satisfaction of customers and other interested parties.

TQM intends to improve both process and its product. Kume (1988) figured out that the bases upon which such improvement can be achieved include, knowing or understanding points to be improved, technical possibilities of improvement, establishing cooperative or organisational structures for improvement and implementing education and training needed for the improvement. Moreover, Mack and Joshnsten (2004) opined that the process for continues improvement of quality is generally defined by six broad steps. These are; making suggestions for areas of improvement; breaking down into parts and providing measurement tools; creating solutions to suggestions; implementing and observing the solutions at work; acknowledging the individuals and rewarding their ingenuity and incorporating the solutions on a broad scale.

Yiwei and Eng (2008) observed that the concept and application of TQM have been successfully applied in the manufacturing and service industries, worldwide. However, there has not been widespread application in the construction industry. The authors reported some of the following reasons and observations.

- A survey conducted by Anon (1993) among 300 architectural, engineering and contracting firms indicated that most of the top managers of these firms did not understand or accept TQM. Similarly, most of their employees and sub-contractors neither considered quality nor were they empowered to make improvements.
- Quality achieved by construction firms studied by Shammass-Toma (1996) generally fell below the required standards, despite the fact that all contractors involved had some quality control procedures in operation.
- There existed a barrier caused by traditional or conventional practice which prevents wider implementation and acceptance of TQM the construction industry.

Regarding the last observation or reason, Cheng and Liu (2007) noted that "organisations have different working environments, work attitudes and leadership styles, which influence the implementation of the TQM approach." For that reason, it is essential that organisational culture must be integrated in TQM approach.

TQM approach is generally employable to any type of organisation and any organisation stands to benefit by its adoption. Aggarwal and Rezaee (1996) revealed that many of the most successful organisations that have become global, more cost effective and efficient, and, more focused on customer satisfaction have implemented the TQM concept.

A study conducted by Cheng and Liu (2007) based on TQM principle on the relationship of organisational culture and the implementation of TQM among Hong Kong construction firms established that the ideal culture profile is one which supports a friendly working environment. In such culture, leaders act as advisors to allow smooth operation of the organisation under a long term concern for growth and acquisition of new resources. European Construction Institute (ECI) Matrix was employed for the study.

Regarding design organisations in Nigerian Bamisile (2004) observed their design processes were prevalently complex compounded with other problems such as uncontrollable delays; having to do work on different stages or on different projects at the same time; consulting only few relevant written information or not at all; poor recording of design, making backtracking difficult; and lack of checking drawings and other documents prepared by junior staff before being issued for construction. Based on this Bamisile (2004) asserted that “one could say that the design teams have not yet adopted any quality culture in their contribution to production of buildings in Nigeria”.

The above assertion could be justifiable considering incessant collapse of building structures around Nigeria and the concern for quality of construction projects across the country (Abiodun and Afangadem, 2007). Between 1974 and 2006, 61 cases of buildings collapse were reported across the country (LSPDA 2010). Out of this figure, 13% was directly attributed to faulty designs. Moreover, the report revealed that out of 233 associated cases of lost lives - 53% was traced to incidences due to faulty designs.

However, Kado et al (2010) conducted a study on application of TQM principles by the Design consultancy firms in North-western part of Nigeria. European Construction Institute Matrix was similarly employed for the study. The study indicated that whether by design or coincidence, design consultancy were actually using the aspects of TQM in their operations. A particular firm attained the highest status of 'Recognised TQ Company.' Conversely, the result of the study revealed that, on the overall, the firms recorded a status of 'Realisation of improvement needed.'

Based on the above, this research was aimed at establishing the status of building design firms across Nigeria under the concept of TQM using European Construction Institute's matrix. Development of quality management in a company should be based on a recognised quality culture and its development process (Harris and McCaffer, 2005). ECI approach was adopted as it provides such avenue. The study of this nature becomes imperative because according to Kume (1988), “attempts to achieve better quality without improving design and process will result in increased cost” – not only monetary but also compromise to safety issues and possible fatalities.

## **LITERATURE REVIEW**

### **Quality Management System Frameworks**

Quality management system is the collection of all processes, tools, techniques and subsystems that run simultaneously with production system (service or manufacturing), and the control of the production system's effectiveness, efficiency and productivity (Yasamis et al 2002), Quality management system is responsible for; ensuring that production or service delivery conform to customer requirements, minimizing cost of quality and production of a product or delivery of service to standards. Furthermore, it consists of framework for guiding quality related actions and all employees and a means of assessing how well these actions are carried out.

Cheng and Liu (2007) pointed out that it is relevant to understand the definition of quality in understanding TQM and hitherto defined it as "the standard of a product or service which meets the customers' (reasonable) expectations." Customer satisfaction is the bottom line of businesses as well as TQM.

'Total Quality Management' was broken down and explained by Aggarwal and Razaee (1996) as; 'Total' stands for organisational wide commitment. It indicates that quality is the business of all stakeholders (users, systems personnel and top management).

Everyone should work together to achieve and possibly exceed user's expectations. 'Quality' stands for a characteristic of high grade of excellence; and 'Management' represents the philosophy, leadership, infrastructure and resources which create continuous improvement in the process of system development and enhancements.

According to Cheng and Liu (2007), International Standard Organisation (ISO) officially defined TQM "as a way of managing an organisation which aims at continues participation of and co-operation of all its members in the improvement of quality in order to achieve customers' satisfaction, long-term profitability of the organisation and benefits of its members, in accordance with the requirements of society." An important aspect of TQM is that everyone in an organisation should be involved and committed from top to bottom, because the pursuit of total quality is seen as never-ending journey of continuous improvement. Particularly, commitment, knowledge and involvement were recognised as the fundamental characteristics of TQM (Cheng and Liu, 2007).

Some of the recognised standards containing framework for quality management system include the ISO series, Malcolm Baldrige (MB) standard and BS 5750 of the British Standard Institute (BSI) (Yasamis et al, 2002, Duncan et al, 1990 and Stebbing, 1990). The requirements of the Quality Management Systems covered by the ISO embrace issues relating to Quality Control, Quality Assurance and TQM.

### **Design Quality and Design Organisations**

Tunstall (2000) described design as the selection of facts, requirements or perceptions about the properties or behaviour of individual elements which can be combined into a larger whole. It was further noted that in principle, the elements of building design are the same as elements of any product, and like any other product, materials process, form and appearance are selected and arranged to meet demands and needs of manufacture and use. This suggests that TQM principles can adequately be employed by design organisations. In fact, Harris and McCaffer (2005) stated that the ISO 9000 family standards operate on the assumption that certain factors have influence on the quality of a product or service provided by an organisation. Top on their list among these factors is design.

Design stage is a very vital component of TQM in construction. Abdel-Razek (1998) conducted a survey of 159 construction professionals and academics in Egypt on the relative importance of factors needed to improve construction. The survey revealed that improving design and pre-construction planning was ranked first. Thus, design organisations play a major role in the construction industry. Bubshait et al (1999) buttressed that "they are the media that transfer the requirements of the client to the contractor and ensure that they are met." Furthermore, "they need to provide a high quality of service to ensure that their client's project achieves the best possible standards of cost, time and quality".

Design quality involves the degree to which the features of the facility conform to the client's need. Moreover, Bamisile (2002) mentioned that design quality "is the quality determined by the 'Client's Consultants' on behalf of the client. It is the quality standards required by the contract and described in the appropriate production information issued by the designers to the 'Production Team.'"

Kolawole (1998) identified three categories of factors militating against the achievement of quality in construction; these are 'cheapest cost first' attitude, design and construction. With respect to design Griffith (1990), mentioned that the problems

attributed to design are detailing, legislation, co-ordination, communication, supervision and buildability.” However, this is in no way exhaustive because the ISO 9000 and the Malcolm Baldrige Standards contain 13 and 14 major quality sections respectively relevant to design (Bubshait et al, 1999).

Individuals or parties to construction projects include among others, design consultants, popularly referred to as Architectural/engineering (A/E). In traditional contracting, their responsibilities according to Yasamis et al (2002) include all the tasks performed to determine the functional specifications of the facility, quality assurance and improvement.

In general, Kolawole (1998), stated that “total quality (in construction) can be achieved only if every individual including the client and every organisation is working towards the achievement of consistent project oriented objectives,” and that it "requires appropriate systems".

### **European Construction Institution (ECI) and (ECI) Matrix**

European Construction Institution (ECI) was founded in 1990 to build and champion a culture motivated to raising the performance standards of the construction industry across Europe, (<http://www.loughboroughengineering.com>... 2010). ECI is focused on delivering construction excellence with an aim to improving competitiveness of its members through sharing of knowledge and application of best practice to enable them meet challenges of world-class project delivery in Construction and Engineering Construction (<http://www.eci-online.org/what-is-eci>, 2013).

ECI produced a matrix in 1993 to measure the degree to which a company was operating under total quality management (Harris and McCaffer 2005 and Cheng and Liu, 2007). The matrix contains 12 quality outlined below:

- Commitment and leadership by top management at location.
- Organised process and structure for total quality.
- Necessary business performance.
- Supplier relationship (internal and external).
- Training, awareness, education and skills.
- Relationship with internal and external customer.
- Understanding and satisfaction of employees.
- Communications.
- Teamwork for improvement.
- Independent certification of quality management system.
- Objective measurement and feedback.
- Natural use of total quality tools and techniques.

### **Research Methods**

#### *Data Collection*

Questionnaire survey was used to obtain primary data for the study. The questionnaire composed of two parts. Part one was used to gather data on firms' profiles. Part two contained copy of the adopted ECI matrix as the main instrument used in collecting the major data of the study.

Each of the quality factors in the matrix was accompanied by six statuses describing level of organisations' attainment. The description was self explanatory such that a respondent can easily select a position that best fits his firm's status or attainment

regarding any of the 12 quality factors. The statuses were allocated 0 to 5 points. Only one status had to be selected under each factor. Multiple selections were disqualified.

Architectural, Structural, Mechanical and Electrical and Multi-disciplinary design firms were identified as the groups of firms responsible for building designs in Nigeria. Respondents from these groups of firms were asked to rate their firms' status corresponding to the 12 total quality factors in the matrix as described earlier.

Responses obtained were used to calculate total scores for individual firms, average scores for groups of firms and overall average score for all the firms studied. In each case, individual, group and overall statuses of the Nigerian design firms regarding their efforts towards TQM were established.

#### *Sampling frame and Questionnaire Administration*

To establish sample size for the research, list of registered consultancy firms was obtained from Corporate Affairs Commission (CAC, 2010). The list indicated that there were 6,990 registered consultancy firms across the country. A sample size of 237 design consultancy firms was calculated using 95% confidence level based on approaches and recommendations outlined by Krejcie and Morgan (1970), Cochran (1977), Salkind (1997), Bartlett et al (2001), United Nation Development Programme (2004) and Olanruwaju (2010).

Principles of cluster and stratified random sampling plans were adopted according to Fellows and Liu (2003) and Keller and Warrack (2003). This was due to the diverse nature of the country geographically as well as the grouping of the design firms based on their respective professional undertakings.

Questionnaires were administered to the executive or senior management staff of the design firms. This was necessary due to the nature of data required by the research.

#### *Data Analysis*

Data analyses simply involved calculating the scores of the ECI total quality factors for each responding firm by adding the scores for each firm's status corresponding to each quality factors. This established statuses of individual firms. To arrive at the statuses of each group, simple average was calculated for the firms under each group. Overall average score of the groups was computed to arrive at the overall industry status.

*Table 1: Score and category of status of ECI companies*

Score	Status Category
55-60	A recognised TQ Company
45-54	A world class operation
33-44	Realisation of improvement needed
25-32	The start of improvement
12-24	Need commitment to overcome resistance
0-11	No appreciation of quality.

If an organisation scored a maximum of 5 points on all the 12 factors it would achieve a maximum of 60 points, thus achieving the highest possible status. Interpretation of score obtained by an organisation was based on ECI categorisation presented in table (Harry and McCaffer (2005).

## Research Findings and Discussion

### *Analysis of Administered questionnaires*

106 questionnaires were returned which indicate a return rate of 44.8%. Out of these, 96 (90.6%) were observed to be usable and adequate for analysis based on the assertion of Moser and Kalton (1971) that the result of a survey could be considered as unbiased and significant if the return rate is not lower than 30-40%.

Architectural firms constituted 28.1% of the firms studied, Structural (16.7%, Mechanical and Electrical (10.4%) and Multi-disciplinary design firms (44.8%). Thus, about an average number of the firms were engaged in more than one design activity.

### *ECI Status of Groups of Design Firms*

Table 2 presents the average scores calculated for the four groups of building design firms studied across Nigeria. However, it should be noted that quality factor number 10 (Independent Certification of QMS) was generally scored '0' for all the design firms. This was necessary because Standard Organisation of Nigeria (SON) disclosed that, even though it had officially adopted ISO 9000 series for quality management in Nigeria, certification of design organisations in relation to quality management was yet to commence.

*Table 2: Average ECI scores of the groups of Nigerian building design firms*

Group of firms	Average Score	Status
Architectural	26.4	The start of improvement
Structural	31.3	The start of improvement
Mechanical & Electrical	24.3	Need commitment to overcome resistance
Multi-disciplinary	27.6	The start of improvement
Overall Average	27.4	The start of improvement

From table 2, it can be depicted that the Architectural, Structural and the Multi-disciplinary groups of design firms have recorded average scores within the ECI status with scores between 25-32 points. This placed the groups under the fourth ECI status of 'The Start of improvement'. More effort is needed from them towards attaining the requirements of TQM.

The average score recorded by the Mechanical and Electrical group of building design firms of 24.3 belongs to the fifth ECI category of 12-24 - 'Need commitment to overcome resistance'. This indicated a lack of commitment towards TQM and hence more concerted effort is needed from the group.

The overall average of the groups stood at 27.4. Therefore, the overall efforts of the Nigerian design firms generally belong to the fourth ECI status of 'The start of improvement.'

ECI status of an organisation depends on the contribution of each quality factor. Table 3 provides the average scores calculated for each group of firms in relation to the quality factors. Note that 'ECIF' codes were used to represent quality factors, 'AF' for Architectural firms, 'SF' for Structural, 'MEF' for Mechanical and Electrical and 'MDF' for Multi-disciplinary firms. Overall average scores were represented by 'OAS'.

*Table 3: Average ECI Quality Factors Scores for Groups of Design Firms*

Factor Code	AF	SF	MEF	MDF	OAS
ECI F1	4.3	4.6	2.0	4.1	3.8
ECI F2	3.4	3.8	3.1	3.6	3.5
ECI F3	3.7	3.8	3.1	3.8	3.6
ECI F4	3.9	4.1	3.5	3.9	3.9
ECI F5	3.4	2.8	3.6	3.5	3.3
ECI F6	3.6	3.4	3.1	4.0	3.5
ECI F7	4.1	4.0	3.5	3.7	3.8
ECI F8	3.7	4.0	3.7	4.1	3.9
ECI F9	3.7	3.9	3.7	3.8	3.8
ECI F10	-	-	-	-	-
ECI F11	3.2	3.3	3.5	3.4	3.4
ECI F12	3.1	3.8	3.2	3.6	3.4

From the table, the highest average score of 4.6 was recorded by the Structural group of firms on the first quality factor (ECIF1 - Commitment and leadership by top management at location). This suggested a high level of commitment by the group regarding the quality factor. Conversely, least average score of 2.0 was recorded by the Mechanical and Electrical group, thereby indicating that the group was providing only spasmodic support and encouragement to quality initiative regarding the same quality factor.

Generally, the overall average scores in the last column of the table showed that the highest average scores was 3.9 recorded in both ECIF4 - Supplier relationship and ECIF8 - Communications. Regarding ECIF4's, the score suggested a visible improvement of business performance among the firms, while in case of ECIF8, it suggested that there was an established and widely used communication system among the firms.

Least overall average scores were recorded in ECIF5 - Training, awareness, education and skills (3.3), ECIF11 - Objective measurement and feedback (3.4) and ECIF12 - Natural use of total quality tools and techniques (3.4). The average scores indicated that requirements relating to staff training, awareness, education and skill development were partially implemented by the firms, that there was co-ordinated measurement of objective and analysis of results in place among the firms and that total quality tools and techniques were only used by the firms only when reminded.

## **CONCLUSIONS**

The study revealed that generally, the Nigerian building design firms obtained overall average ECI score of 27.4. This placed the firms in the fourth ECI status of 'The start of improvement.' The highest performance demonstrated by the firms was in the aspects of 'Supplier relationship' and 'Communications.' Their major weaknesses were in the areas of staff training, awareness, education and skills; objective measurement and feedback and natural use of total quality tools and techniques. Generally, findings suggested that a lot of effort is required from among the firms towards achieving the requirements and benefits of Total Quality Management. In particular, it is

recommended that paramount attention must be given to employees' education and training the Nigerian building design firms among other considerations. It is also recommended that SON should earnestly consider commencement of certification of Quality Management Systems of the Nigerian construction organisations as this will improve their status. Furthermore, it should be noted that the success of the Nigerian building design firms in this respect, is strongly associated with commitment of top management as reflected in first ECI quality factor. Cheng and Liu (2007) noted that "TQM is found to be more successful in companies with long term and internal focus in management aspect."

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# WORKMANSHIP AND DEFECTS IN HOUSING IN THE STATE OF VICTORIA, AUSTRALIA

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The incidence of defects and the quality of housing have been the subject of extensive research internationally for decades. In the State of Victoria, Australia, various voluntary schemes have been adopted and discarded by industry-based organisations and government legislation in an attempt to improve the quality of housing. A constant source of debate has been that of acceptable standards of workmanship. In an attempt to provide defined standards for acceptable levels of workmanship, "Guide to standards and tolerances" was first published in 1990. These were purportedly introduced to cover areas not included in the building regulations and the Australian Standards. This paper reviews the evolution of these guides to standards and tolerances in the context of their impact on the incidence of defects and the quality of housing in Victoria. An extensive survey of building inspection reports over a period of two decades and two Acts of Parliament enacted specifically for the purpose of improving the quality of housing found that the incidence of defects increased significantly. The increase in the incidence of defects is analysed relative to these guides becoming more comprehensive. The findings indicate that the increase in the incidence of workmanship defects is not attributed to the level of comprehensiveness of the guides but attributed to other reasons. These include large increase in volume of work, skill shortages and better informed consumers in respect of the building process and their rights.

Keywords: housing, building defect, workmanship, tolerance.

## INTRODUCTION

The presence and incidence of defects in new house construction is associated with the level of quality in new housing. Defects in construction have been the focus of research for a number of decades. Examples of earlier international research into defects include Freeman (1974), Porteous (1985), and Reason (1990). More recent examples are Wardhna and Hadipriona (2003), Craig (2008) and Macarulla et al (2013).

In Victoria, research into housing defects has been limited but includes Robinson (1987), Georgiou et al. (1999, 2000) and Cross (2003). The focus of this paper is to report on the Victorian attempts at reducing the incidence of defects and improving the quality of housing. The paper reports on historical voluntary and legislated schemes intended to improve the quality of new housing and resulting in the introduction of the Guide to Standards and Tolerances. The use of these guides is evaluated through an extensive survey of 1401 home inspection reports over a period of two decades and two Acts of Parliament enacted specifically for the purpose of improving the quality of new housing. Because of page limitations and the complexity

of the topic, this paper does not fully analyse the guides and discuss other reasons for the increase of the incidence of defects which are the focus of further research.

### **Problem Statement**

Until recently building specifications in Victoria used terms such as, "in a workmanlike manner" and "in a tradesman like manner". The problem has been one of quantifying acceptable standards. With the ever increasing use of lawyers in building disputes, there was a need to develop a better definition of acceptable standards of workmanship. Hence, the introduction of the guide and the on-going refinements to them. However, it is asserted that the introduction of the Guide to Standards and Tolerances have not necessarily helped to improve the quality of housing in Victoria. This paper reviews the Guides to Standards and Tolerances to determine whether their increased comprehensiveness has resulted in an increase in the incidence of defects. The research is a 'building block' on previous work (Georgiou et al, 1999) yet importantly provides the scope for it to be used in future research in the quest for improving house quality.

### **Recent attempts at improving quality**

The first structured formal scheme for housing quality improvement was introduced in Victoria by the Master Builders Association of Victoria (MBAV) *Certified Homes Scheme* with revised specifications distinct from other housing constructed in Victoria. The Certified Homes Scheme was a voluntary scheme available to consumers. That is, a consumer could ask an MBAV member to construct their house to the 'Certified Home Scheme' standard. Key elements of the scheme were as follows:

- A register of all houses built under the scheme was kept by the MBAV
- Cost of registration was £12.10.0 (\$25.00) per house (1961 figures)
- The guarantee was by the builder to the house purchaser
- Scope of the guarantee was for structural defects only
- Period of guarantee was for two years from date of practical completion
- Builders were required to observe the minimum standards of material and workmanship as described in the MBAV specification

The scheme required 400 homes per year to be viable. By 1967, 1,112 were registered for an average of less than 200 houses per year. Hence, the scheme was discontinued in July 1967. Some of the reasons for the Scheme's lack of support were:

- Excessive administration costs
- Advent of standard specifications by long-term lending authorities (the Banks) eliminating need for the scheme.

In the absence of demand by consumers, builders did not see the need to continue the schemes, as it did not add to their business.

The failure of the Certified Home Scheme highlighted the fact that greater consumer awareness was required when building a house and that some form of government legislation would be required to assist and protect consumers. Even as the Certified Homes Scheme was in operation, the case for some form of government legislation continued to be promoted as the industry's preferred method of raising the standard of housing quality. The Victorian Government eventually introduced legislation in the form of the Local Government (House Builders Liability) Act 1973.

### **House Builders Liability Act 1973**

This Act required builders to be members of an industry association for houses to be registered. Builders were only required to fulfil the membership criteria of the chosen industry association - the Master Builders Association or the Housing Industry Association (HIA). As well as being members of an industry association (MBAV or HIA), builders had to be approved by a guarantor fund. The HIA formed the House Builders Association Ltd (HBAV) and the MBAV formed the Master Builders Housing Fund Ltd as the two guarantor funds.

Under the new Act, builders were required to provide a guarantee for a period of six years. The first year covered major and minor defects, and thereafter only major defects. Also refer to Georgiou et al., 2000. An important difference between the two associations was that the HIA marketed their scheme as straight out insurance. Although documented evidence of this was not found, anecdotal confirmation of the practice was repeated by a number of people - including former employees of the Housing Builders Association Ltd. The perception created by this strategy was that once a house was completed it became the insurance company's responsibility. The MBAV maintained that the builder was always responsible for the quality of the house constructed. The fund would only meet its guarantee obligations in the event of default by the builder. This attitude was probably due to their experience with insurance companies involved with the Certified Homes Scheme.

Technical standards under the Act relied on the Uniform Building Regulations (UBR) as prescribed under the Local Government Act 1958. The UBR were prescriptive in composition. Both associations used their own standard contracts, which would in the future, cause anger and frustration to consumers. It should be noted that Australia switched to performance based regulations in 1990 in the form of the Building Code of Australia.

Consumer dissatisfaction continued to grow due to poor workmanship, contractual matters and dispute resolution mechanisms perceived as favouring builders. Differing standards of workmanship were apparent not only from builder to builder, but also by builders varying their standards from their own display homes (Ministry of Consumer Affairs, 1977). By 1983, the growing number of complaints meant changes needed to be made. The government asked a committee to review the House Builder's Liability Act 1973. The review committee comprised members from the Ministry of Consumer Affairs, industry bodies, and community and consumer representatives. In 1984 the Act was amended and the two industry funds were merged to form a non-profit company called the Housing Guarantee Fund Limited (HGF).

The HGF became the sole guarantor of new housing in Victoria. Its source of income would be derived from annual membership fees paid by builders and registration fees paid for each house registered with the fund for guarantee purposes. In this way, the fund was expected to accumulate sufficient funds to fulfil its obligations under the Act. As the two industry associations did not control the fund, the HGF would be able to view the housing industry as a whole. This was demonstrated in the 1996 annual report when it reported that for the twelve years after the Act came into operation, there were 250,000 houses constructed which were covered by a guarantee. These houses generated 12,754 written complaints or 5% of the total houses registered. Despite this significant milestone, dissatisfaction amongst some consumers continued and coupled with a natural evolutionary process, amendments continued to be made leading to the introduction of the *House Contracts Guarantee Act 1987*.

## **House Contracts Guarantee Act 1987**

Despite amalgamating the MBHF and HBAL in 1984 into the HGF an undercurrent of dissatisfaction remained. As consumer awareness and sophistication grew so did the inadequacies of the Local Government (House Builders Liability) Act 1973.

Transferring responsibility for the HGF from the Ministry of Local Government to the Ministry of Consumer Affairs in 1985 did not achieve the desired results. New tighter legislation was required. This came in the form of the House Contracts Guarantee Act 1987 which became operational on 1st May, 1988.

It should be noted the two industry associations were concerned at what they believe to be a substantial tilt in favour of consumers. Some of the main features of the new Act were:

- Provide a seven year guarantee from the date of contract of Building Approval (whichever was earlier).
- Contracts would be required to stipulate financial arrangements such as deposits and progress payment schedules.
- Variations to the contract had to be in writing, signed and dated by both parties.

If the variations procedure was not followed it was possible that builders would not be able to recover costs for variations.

Provisions of the new Act would continue to be administered by the Housing Guarantee Fund Ltd (HGF). The HGF was a private non-profit company, which derived its income from annual registration fees by builders and a registration fee for every house constructed. The number of directors of the company was seven, four of whom were nominated by the HIA and MBAV, the other three by the Minister for Consumer Affairs. Consumer advocates believed this slanted proportional representation as evidence that the HGF was biased towards builders. Regardless, the voice of consumers was growing stronger and now had a unified voice and began making submissions to various forums.

One of the main reasons for consumer dissatisfaction was disputes about poor quality, workmanship and defects resulted in delays and costs. The HGF attempted to address the above issue by introducing in 1990, standards and tolerances guidelines and revising them in 1992. In addition, the HGF raised the standards that builders had to meet to be approved by the HGF. Regardless, consumers and politicians deemed the standards criteria were inadequate and continued to push for changes. This drive for change led to the dissolving of the HGF, introduction of the Building Act 1993 and private certification.

## **Builder Registration**

Introduction of the Building Act 1993 required builders not only to be registered, but other building practitioners had to be registered as well. It also saw the process of building approvals process being privatised.

Charged with administering the Act was the newly formed *Building Control Commission* (BCC) known today as simply the Building Commission. The structure of the BCC comprised five boards:

- Building Advisory Council
- Building Regulations Advisory Committee
- Building Practitioners Board (responsible for registration of practitioners)

- Building Appeals Board
- Dispute Resolution

The operational aspect of the BCC will not be covered here as it is outside the scope of this paper. In addition to the 1993 Act, the *Domestic Building Contracts Tribunal Act 1995* (DBCTA) was also introduced and replaced the House Contracts Guarantee Act 1987. It should be noted that the quest for builder registration as a means of improving housing quality has a long history in Victoria. As long ago as 1945, the MBAV presented the government with a Draft Bill for builder registration (Keast, 1994). In addition to registration was the introduction and continued expansion of the *Guide to Standards and Tolerances* in an attempt to define acceptable workmanship standards. It is debatable whether their introduction achieved the aims expected of them. It should be noted that the DBCTA 1995 is still in force in Victoria as at 2013, but some changes are likely in the future.

## THE STUDY

To derive data from the 1401 Home Inspection Reports prepared by Registered Architects, a coding classification system was developed. The coding system comprised 36 building envelope elements and 12 defect type categories. The building elements were grouped into the trades that performed that work. The objectiveness of the coding system was tested and verified by experts (Georgiou, 2010). The 770 houses built under House Contracts Guarantee Act 1987, recorded 1766 defects for an average of 2.29 defects per house. The 631 houses built by registered builders under the DBCTA 1995 recorded 2130 defects for an average of 3.38 defects per house.

Interestingly, Craig (2008) found houses constructed in the United Kingdom (UK) under the regime of the National House Building Council (NHBC) averaged 3.2 defects per house. One measure of the quality of a newly constructed house may be the absence of defects. In this study, 29% of the 770 HCGA house sample did not record any defects. Whereas, the 631 DBCTA house sample recorded a lower 22.2% of defect free houses. See Table 1.

*Table 1 Key descriptive statistics for the sample*

Category	No. of houses in sample	No. of defects in sample	No. of defect free houses	% of defect free houses
DBCTA houses (registered builders)	631	2130	140	22.2
HCGA houses (HGF approved builders)	770	1766	223	29.0
Total	1401	3896	363	25.9

Of the twelve defect type categories, the workmanship category recorded the largest increase. It jumped from 43.6% of the defects for the HCGA sample to 75.3% for the DCTA sample. This represents a significant increase of almost 73%. See Table 2.

*Table 2 Summary of proportion of defect types for both cases*

Defect type	Registered builders (BBCTA 1995)		HGF Approved builders (HCGA 1987)	
	Number	Percentage (%)	Number	Percentage (%)
Cracking	129	6.1	157	8.9
Damp	49	2.3	121	6.7
Drainage	25	1.2	75	4.3
External leaks	34	1.6	65	3.7
Incomplete	70	3.3	333	18.9
Internal leaks	54	2.5	23	1.3
Miscellaneous	0	0.0	9	0.5
Regulations	58	2.7	76	4.3
Structural adequacy	25	1.2	23	1.3
Water hammer	25	1.2	66	3.7
Window sill gap	58	2.7	48	2.7
Workmanship	1603	75.3	770	43.6
Total	2130	100.0	1766	100.0

The carpentry trade recorded a consistently high proportion of defects across both Acts. See Table 3. As carpenters are perceived as having a crucial input in the building process of a house, the required level of workmanship is reviewed as laid out in the guides.

*Table 3 Distribution of defects by trade*

Trade	No of HCGA defects	% of Defects	No of DBCTA defects	% of Defects
Site Works	107	6.1	75	3.5
Bricklayer	258	14.6	212	10.0
Carpenter	402	22.8	590	27.7
Electrician	42	2.4	63	3.0
Finishes	174	9.9	186	8.7
Plasterer	178	10.1	196	9.2
Plumber	455	25.8	581	27.3
Miscellaneous	150	8.5	227	10.6
Total	1,766	100.0	2130	100.0

## DISCUSSION:

### Standards and tolerances

It is worth repeating that the guides to standards and tolerances were introduced because of disagreement between experts on what constituted a defect and the severity of the defect. The guides were established to set parameters to aid resolution of

disputes. The guides were upgraded periodically because lawyers would vary interpretations and experts would go looking for, and locate defects to initiate a dispute. Whether the upgrading of the guides to become more comprehensive contributed to the increase in reporting of defects will be discussed later in this paper. It should be noted that the guides commenced in 1990 as a four page document, increased to seven pages in 1996, twenty-four pages in 2002 and the current 2007 version jumped to fifty-six pages. For this research, houses constructed up to and including 2004 were considered to match the eight and a half year period covered by the House Contracts Guarantee Act. Accordingly, for the period of this research, houses constructed by builders approved by the Housing Guarantee Fund (HCGA), the 1990 and 1992 Guides applied. For houses built after mid-1996 by registered builders (DBCTA), the 1996, 1999 and 2002 Guides applied.

An important feature of the Guides was purportedly that they have been covering areas not included in the Building Code of Australia (BCA) and Australian Standards. However, the more recent amendments refer to the BCA and Australian Standards. They are not intended to be a definitive standard for all situations, rather they are minimum standards.

Clearly there has been more than a doubling in the increase of defects in the DBCTA houses. Table 4 reproduces the exact wording in the guides applicable to the period of this research (1990 and 2002) including upgrades. It can be seen from Table 4 that the changes from 1990 to 2002 are not that onerous to account for such a significant increase to the incidence of defects. It is probable that some increase may have resulted from the refinement of the Guide. However this may be offset by the fact that jambs and doors are pre hung complete with latches and striker plates. Thus the skill required to hang doors has been reduced and in theory so should the risk of poor workmanship. The situation is similar for the other trades. Due to the space constraints for this paper, the other trades will not be covered here.

Other factors that may have contributed to higher incidence of defects include the large increase in the volume of work between the two periods without a corresponding increase in the labour force. That is, obvious skill shortages. For the period of the HCGA an average of 29,500 houses were constructed annually (ABS, 2010) and for the first part of the DBCTA an average of 40,213 houses were constructed (ABS, 2010), an increase of 10,713 or 36.3%. Unfortunately, the Australian Bureau of Statistics (ABS) construction labour force figures are all inclusive and housing figures are not segregated. There is a widespread anecdotal belief that more needs to be done to increase the housing labour force and more importantly the skill level. Consequently, education and training should be seen as an integral part of the attack on defective workmanship. The above are the focus of further research being carried out.

1990	2002
Doors	Doors
<p>Door handles and latches Door handles and latches will operate as intended by the manufacturer.</p> <p>Doors and door frames Unless specified in the contract, or where an increased clearance is required for:</p> <ul style="list-style-type: none"> <li>-removable toilet doors;</li> <li>- return air ventilation for ducted heating or air-conditioning units; or</li> <li>- inlet ventilation to rooms where the only ventilation is provided by ventilated skylights</li> </ul> <p>a maximum gap of 3mm will be allowed between the top and sides of the door and the door frame and a maximum gap of 20mm between the bottom of the door and the finished floor.</p> <p>Doors and windows which bind or jam as a result of the builder's work, will be considered major defects for contracts signed prior to May 1988. For contracts signed on or after 1 May 1988, doors and windows which bind or jam, as a result of the builder's work, may be considered defects providing the claim meets the time and dollar limits of the Act.</p> <p>Warpage of internal doors will not exceed 6mm over the door's length.</p>	<p>6.1 Door Handles and Latches Door handles and latches installed shall be fit for purpose and will operate as intended by the manufacturer. Defects occurring in the first three months of completion shall be the responsibility of the builder. Thereafter defects occurring will only be considered the builder's liability if the actions of the building have contributed to the defect.</p> <p>6.2 Doors and Door Frames This clause only applied to the 3 months maintenance period as specified under the contract.</p> <p>6.2.1 Internal Doors Unless specified in the contract, or where an increased clearance is required for:</p> <ul style="list-style-type: none"> <li>removable toilet doors;</li> <li>return air ventilation for ducted heating or air-conditioning units;</li> <li>inlet ventilation to room where the only ventilation is provided by ventilated skylights and or/exhausts fans;</li> <li>between double swing doors and French doors.</li> </ul> <p>Within the first three months an even gap to the sides and top of individual doors shall be consistent throughout to within 1mm and shall be not less than 2mm or exceed 5mm wide and a maximum gap of 20mm between the bottom of the door and the top of any finished floor covering unless otherwise specified.</p> <p>6.2.2 External Doors External doors shall be appropriate for their intended purpose and shall be installed in accordance with the manufacturer's recommendations.</p> <p>6.2.3 General Tolerances for twisting and bending in the first three months are as listed below.</p> <ol style="list-style-type: none"> <li>1. Twist. Twist in a door shall not exceed 5mm.</li> <li>2. Bending. Bending in a door shall not exceed the following: <ul style="list-style-type: none"> <li>(a) In the height of the door: <ul style="list-style-type: none"> <li>(i) up to and including 2150mm high – 4mm, or</li> <li>(ii) over 2150mm and up to and including 2400mm high – 6mm.</li> </ul> </li> <li>(b) In the width of the doors up to and including 1020mm wide – 2mm.</li> </ul> </li> </ol> <p>Doors which bind or jam, as a result of the builder's work, shall be considered defects.</p>
Fixing	Internal Fixing
<p>Gaps between mouldings, and between mouldings and other fixtures which exceed 1 mm and appear within the first 12 months will be considered defects. After the first 12 months a gap of more than 2mm is a defect.</p>	<p>Only gaps between mouldings, and between mouldings and other fixtures which exceed 1mm within the first 12 months will be considered defects.</p>

*Table 4 Proportion of defects in carpentry fixing category*

## CONCLUSIONS

It cannot be stated categorically that the increasing comprehensiveness of the *Guide to Standards and Tolerances* has been a major contributor to the increase in the incidence of defects. Although it cannot be discounted that the greater level of detail provided in a manner that could be better understood by consumers may have had some impact. Other factors may also have contributed. These include the greater volume of work and ensuing skill shortages referred to above. In addition, inspections under the new private certification system may not be as rigorous as they were previously when local authority inspectors performed that function. Another factor may have been greater consumer awareness resulting from education programs by the Ministry of Consumer Affairs (now the Ministry of Fair Trading). An area that needs to be examined is that of education and training. At present, the Building Commission conducts technical inspections in response to consumer complaints. The data gained from the Building Commission inspections should be made available to educators and training providers to highlight areas needing greater emphasis. It is suggested that one measure by itself will not necessarily reduce the incidence of defects but rather a more cooperative holistic approach of all industry participants to change the culture from one of minimum standards to one of desirable standards.

The above may be used as a building block for future research into the quest for improved quality of new housing.

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## **RESEARCH METHODS AND NEW PERSPECTIVES**

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# A 'ZOMBIE' EXISTENCE: EXPLORING ULRICH BECK'S ZOMBIE CATEGORIES AND CONSTRUCTION MANAGEMENT RESEARCH

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Many construction management researchers continue to be preoccupied with narrowly advancing the corporate causes of productivity and profitability, with relative neglect for the implications of recent developments in the global economy. In this article, Ulrich Beck's idea of 'zombie categories' and his theory of reflexive modernity is drawn upon to critically discuss how these render traditional studies of organisational performance limited. Zombies are the living dead. Like zombies, these are social concepts that are dead and yet kept alive in their use by scholars to describe the growing fiction of traditional social institutions. Through a reflection of two cases - a doctoral research project on construction labour productivity and an ongoing study on servitization of construction - it is argued that one needs to move away from the current complacency in using, and becoming used to, familiar categories in construction management research to question their consequences. The promulgation of 'zombie categories' associated with organisational performance in construction might serve only to create the problems that many desire to solve in the first place.

Keywords: post-structuralism, reflexive modernity, research method, zombie category.

## INTRODUCTION

The purpose of this article is to provide a fresh critical reflection on the categorisations that we, as a community of construction management researchers, have become somewhat accustomed to. In part, the motivation of this article emanated from an email reply posted by a Portuguese academic on the Co-operative Network Building Researchers (CNBR) in December 2012, in response to an earlier posting regarding the measurement of student satisfaction. The Portuguese colleague wrote:

*"In 2010, at the CIB General Assembly held during the CIB 2010 World Congress in UK, I raised the following question: How can we call this CIB World Congress 'Building a Better World' without having a single paper addressing the huge unemployment rate, in 2010, in the European construction Industry. I added that no discussion was held addressing how to put people/companies back to work when construction industry was badly hit by the 2008 financial crisis."*

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This posting questioned whether exchanges over the conditions and consequences of measuring student satisfaction implied the avoidance by the academic community to tackle the tougher, societal challenges that are confronting young people today. Indeed, recent statistics indicate a sharp rise in youth unemployment in the Eurozone. For example, Spain - which saw her ongoing recession developed, in part, out of disproportionate growth in the property market in the 1990s - recently reported an unemployment rate among young people of over 55%, making her the second worst state after Greece in the European Community in terms of youth unemployment (see Eurostat, 2013). And so, perhaps the difficult questions that the Portuguese academic raised to the global community of building researchers appear reasonable. Yet, his posting was not entirely accurate; there were, in fact, two sessions at the CIB 2010 World Congress dedicated to discussing how the industry could address the global economic crisis. Even if these sessions downplayed the significance of the need to tackle unemployment, I certainly recall presenting an article at this World Congress on the representation of migrant construction workers amidst deteriorating working conditions in the UK following the recent recession.

Admittedly, in the organisation of conferences, there lie a number of problems in the classification of articles and presentations into identifiable sessions. For instance, just how do we categorise a heterogeneous range of contributions into a number of neatly-ordered subjects and sessions that make sense to participants? My article on migrant worker representation was, rather curiously, placed within a track on "Construction Economics" and juxtaposed alongside contributions on economic incentivisation of infrastructure projects. Then, there is the logistical challenge of organising the programme; with the numerous carving up of plenary and concurrent sessions, there is bound to be the possibility that participants might inadvertently miss out on certain articles and presentations of interest simply because of the scheduling of the sessions. The posting by the Portuguese academic might suggest this to be the case.

Yet, this somewhat trivial event of an email exchange over the CNBR network does trigger the question as to how we, as researchers, use (and become used to engaging with) the categories for representing, describing and explaining our observations. The categorising and order of things is certainly not a new problem (see e.g. Foucault, 1970; Bergson, 1988, and; Styhre, 2004); and in the study of academic conferences, categorisations are often a consequence of a process of contestation and legitimation, negotiation and struggles of hierarchical power across and within academic disciplines (see e.g. Räisänen, 1999; Blumen and Bar-Gal, 2006, and; Gross and Fleming, 2011). The email extract above certainly suggests some form of power relations at play through the categorisation of subjects presented at the conference. So, for example, why is the study of the consequences of the recession on employment seemingly marginalised? Why do the discursive practices at the CIB 2010 World Congress appear to be void of the discussion of practices to help tackle youth unemployment?

In this article, I shall endeavour to reflect on the idea of categories used in construction management research. I seek to explore two interrelated questions here; why do some categories endure and what are the consequences of such persistence? Specifically, I argue that research in the field of construction management is dominated by a performative agenda, and that (social) categories are inscribed within a production paradigm. I draw on the work of German sociologist, Ulrich Beck, to claim that these categories are no longer relevant, or at least less relevant, in a world that is shifting (or has shifted) to a consumption paradigm. In Beck's terms, these categories are known as 'zombie categories', categories that are perpetuated (kept

alive) to describe social phenomenon that are apparently 'dead' (see Beck and Beck-Gernsheim, 2001). I apply Ulrich Beck's notion of 'zombie categories' and his theory of reflexive modernity to reflect on two cases - a doctoral study on construction labour productivity and another on servitization of construction - to explore the consequences of persisting with such categories. Through these reflections, I shall argue that the promulgation of the production-based categories serve not only to reinforce the problems that are being investigated, but also play a crucial part in creating the problems that the research sought to tackle in the first place.

## **CONSTRUCTING CONSTRUCTION PERFORMANCE: WHAT CAN ULRICH BECK TEACH US?**

Organisational performance, as a theme, has been immensely popular in the field of construction management research. Take, for instance, the twelve issues of *Construction Management and Economics* published in 2012. A majority of the sixty-five articles published that year had, at their core, the object of trying to improve the performance of construction organisations through a range of well-established constructs, including critical success factors, project governance, productivity, knowledge sharing, information and communication technologies (ICTs) and sustainability and resource efficiency. A number of scholars were also keen to address age-old problems of corruption, delays and health and safety. Indeed, one gets the impression that the industry, or rather the scholars studying the affairs of the industry, continues to tackle business-as-usual problems of improving organisational performance. And this is, as the Portuguese academic suggested, done at the possible expense of tackling more tricky societal challenges that have emerged more recently. Remarkably, only two articles could be identified, in a special issue on human resource management (volume 30, issue 7), to have dealt with worker issues in the context of the unfolding economic downturn (Thörnqvist and Woolfson, 2012, and; Gall, 2012).

The enduring category of improving 'performance' found in construction management research has, nevertheless, attracted scrutiny from a fair number of critical authors. Green (2011), for instance, talks of the rhetoric of industry reform and argued that performance improvements are rarely brought about through rational, technical means; change is, rather, situated within a wider historical and institutional context where performance is socially negotiated. Of course, criticisms of the (still) prevailing positivistic traditions of construction management research was first brought to the fore by Seymour and Rooke (1995), who asserted that many of the so-called conventional problems confronting the industry cannot simply be addressed rationally:

*"The objectives of practitioners, for example, quality, efficiency, productivity or profits, cannot be taken to be self-evident by the researcher. An essential purpose of research is to establish what participants in the situation under study, managers, engineers or steelfixers, mean by these terms and what values and beliefs underlie such meanings. Researcher may well share some of the understandings of some of the participants, but it is imperative that they suspend their own understandings (Seymour and Rooke, 1995: 522)."*

This extract, taken from their seminal paper, highlights a number of performance categories - i.e. quality, efficiency, productivity, profitability - that still attract many loyal followers in the construction management research community. Of course, what Seymour and Rooke (1995) started was to challenge the dominance of the positivist paradigm in shaping the research questions about construction management. And this

has certainly resulted in a greater degree of methodological pluralism in the field (see Dainty, 2008). Yet, the point of departure in this article is to recognise that things have perhaps moved on from the battles fought between the duality of objectivity and subjectivity, of essentialism (rationalism) and existentialism (lived-in experiences and contexts). The attention of this article is placed, instead, on disturbing the complacency in the formulation and use of categories in our research. Put another way, just why are these established categories of performance necessarily established? And what are the consequences?

Indeed, any categorising is fraught with the difficulties associated with the incompleteness of language and representation. Foucault certainly recognised the longstanding challenge of finding a 'label' for categorising descriptions of reality, of "seeing what, in the rather confused wealth of representation, can be analysed, recognized by all, and thus given a name that everyone will be able to understand (1970: 134)." Similarly, Bergson (1988:125), cited in Styhre (2004), argued that "every language, whether elaborated or crude, leaves many more things to be understood than it is able to express."

Thus, those who reject the idea that the categories of representation can be taken-for-granted, like Seymour and Rooke (1995) in our field, often treat knowledge about our problems as socially constructed (see also e.g. Berger and Luckmann, 1967, and; Latour and Woolgar, 1979). Categories of our knowledge about the world are constantly in flux, shifting within an array of power relationships, and defined only as "the field of coordination and subordination of statements in which concepts appear, and are defined, applied and transformed [...] by the possibilities of use and appropriation offered by discourse (Foucault, 1972: 182-3)."

In a post-structural, post-modern world, it is the diversity of interpretive capacities that matter, which in turn could yield fresh insights into the world around us. Therefore, the stresses on 'being' taken-for-granted categories have given way to a growing acknowledgement that society is constantly organising, ever 'becoming' in the moving present (see Tsoukas and Chia, 2002). However, just what are we becoming? This is certainly a question that has prompted Ulrich Beck, a German sociologist, to rethink about modernity, and whose work will be briefly sketched out in the remainder of this section.

### **Ulrich Beck's 'Zombie Categories' and Theory of Reflexive Modernity**

Ulrich Beck is a German sociologist who currently holds Professorships at the University of Munich and the London School of Economics and Political Science. He is perhaps most famous for coining the term 'Risk Society', and for his critique of the politics of globalisation. It is not the intention here to go into too much depth on Beck's ideas, but to outline two main concepts - 'zombie categories' and reflexive modernity - that are relevant to the discussion on 'categories'.

As a post-structural theorist, Ulrich Beck does not subscribe to positivist sociology on the one hand, and is not content with the degree of relativism associated with post-modern scholarship on the other. One of his longstanding interests lies in critiquing the idea of the nation state in light of a reawakening of the idea of cosmopolitanism. For example, he noted how calculating and attributing responsibility for environmental emissions along the lines of national, territorial boundaries was bizarre even though the supposed dangers of climate change were meant to strike the planet on a global scale demanding an inter-national and inter-governmental response (see Beck, 1992; 2009). Thus, for Beck, the notion of the nation state can be said to have

become a 'zombie category', one that is increasingly impotent (dead) but kept alive in political discourse. Yet, at the same time, Beck is uncomfortable with the shifting possibilities, the ever 'becoming', of post-modern thought. He prompted the question as to what modernity is to become:

*"Just as modernization dissolved the structure of feudal society in the nineteenth century and produced the industrial society, modernization today is dissolving industrial society and another modernity is coming into being (Beck, 1992: 10)."*

In his seminal work on 'Risk Society' and a later piece on individualization, he set the groundwork for what was to become his contribution to a 'reflexive sociology'. This bears deep implications for the discussion on 'categories'. There are two key points that are worth explaining here. First, he argued that society is becoming more individualized, not in terms of the ways people relate themselves to the collective notion of society, but that they have a more heightened sense of awareness of their selves to the notion of the collective (Beck and Beck-Gernsheim, 2001; see also Latour, 2003). In this sense, his idea of a reflexive modernity is one that calls into question the production and reproduction of knowledge between the lay and the experts (and the increasingly-blurred boundary between the two). Thus, much like the argument put forward by Seymour and Rooke (1995) on the relationship between the researcher and the 'practitioner' subjects, reflexive modernity presents opportunities for both the lay and experts to reflect on the terms used to describe the realities of the world around them.

Indeed, Beck would argue that, in many cases, the lay people were probably much more knowledgeable (aware) about what was going on around them than the experts (including policy-makers and academics) charged with responding to challenges faced by society. It is here that one needs to become concerned with 'zombie categories', categories that no longer apply to the world but are continuously perpetuated. Beck uses social class as an example to illustrate how class is constituted by a number of social categories that have become zombified:

*"Until now sociologists have written textbooks and done research on the class structure of Britain, France, the United States, Germany and so on. But if you look at how a class-based sociology defines class categories, you find that it depends upon what is going on in families, in households. Empirical definitions of class identity are founded on categories of household, defined by either a male (head) of the household, or, at least, the leading person of a household. But what is a 'household' nowadays, economically, socially, geographically, under conditions of living-apart-together, normal divorce, remarriage and transnational life forms (Beck, 2002: 24)?"*

Indeed, as Beck and Lau (2005) stressed, "categorical boundaries become less clear and their rationalization more difficult, so it becomes increasingly necessary to decide on one or several new ways of drawing boundaries (p. 527)." It is no wonder why scholars are often seduced into finding 'new models' of representation; the recent excitement over the latest Social Class Survey in Britain (Savage et al., 2013) - drawing in a participant count of over 161,000 respondents and over 6.9 million hits on the BBC website - illustrate both the ongoing quest to redefine categorical boundaries whilst perpetuating interest in an old concept however defined.

Being able to reduce categorical boundaries and delineate between standards and deviance is certainly one of the hallmarks of positivism. This brings us to another of Beck's substantive point about the risk society and reflexive modernity. Accordingly, individuals, and by extension society, have developed a heightened awareness of the

risks around them. However, the prevailing approach has often been one that sets out to assess and mitigate against calculable components of risk. Certainly in the field of construction management research, the approach of hazard identification and calculation of risk(s) probabilities and priorities have become somewhat routinised in textbooks, if not practice. Yet, Beck argues that it is perhaps this very approach of systematising the management of risks - he calls it the anticipation and staging of risks - that, in the end, create the catastrophe that the risk management was initially intended to avoid. Indeed, it the incalculable threats that would "add up to an unknown residual risk which becomes the industrial endowment for everyone everywhere (Beck, 1992: 29)."

Beck uses several contemporary examples to illustrate this idea. Two of my favourites include the state of unemployment and the financial crisis. So, the concern with the high rates of unemployment globally is, according to Beck, somewhat misdirected on to the problems of lack of work and the attributes of the workless. Rather, Beck (2009) posited that current levels of unemployment is a problem created because modernity had created the idea (and ideal) of full employment. Relatedly, it is not that individual financial institutions were clueless about the risks of their investments, but that collectively, the financial system designed to provide safeguards against failures ended up over-protecting the system with institutions indemnifying one another (e.g. through credit default options) that ultimately led to the meltdown. Thus, Beck strongly asserted,

*"The established rules for allocating responsibility - causality and blame - are breaking down [...] the old routines of decision, control and production (in law, science, administration, industry and politics) cause the material destruction of nature and its symbolic normalization (Beck, 2009: 91)."*

## **A TALE OF TWO STUDIES**

So, how does the preceding discussion apply to construction management research? I shall attempt to apply the two points raised here - the idea of the 'zombie category' and how our 'modern' ways of thinking have created 'catastrophes' of their own - by reflecting on two doctoral research projects on labour productivity and servitization of construction respectively.

### **Where is labour in labour productivity?**

The first study relates to my own doctoral research project on labour productivity in the construction industry. I had initially wanted to investigate the effects of training investment on labour productivity levels. As I started reading around the subject, I found an overwhelming volume of previous scholarship forensically identifying the factors influencing labour productivity. My moment of epiphany came when I started my fieldwork; the mismatch between what I was observing in practice and what the research articles were telling me could not be starker. Above all, the construction companies that I was collaborating with - mainly large organisations - did not collect and analyse intelligence on productivity levels, let alone delineate the factors influencing productivity. Productivity in practice, it would seem to me, was no longer a matter of concern!

I then set out on a new course, eventually producing a thesis that explored differentiated interpretations between managers and workers of their perceptions of labour productivity in construction (see e.g. Chan and Kaka, 2007). But, has 'productivity' now become zombified? On reflection, my observation of the

irrelevance of labour productivity to these large construction companies was probably an accurate one. The large companies I was dealing with, at that time, no longer employ labour on their sites. Instead, degrees of specialisation and extended layers of sub-contracting have given rise to the growth of non-standard forms of employment, such as agency workers and labour-only-subcontractors (see e.g. Forde and Mackenzie, 2007). Thus, the concept of productivity is no longer a meaningful one, used but no longer usable because these companies no longer produce. Rather, the large companies I was dealing with were managing the production process involving these extended layers of sub-contracting agents. Put another way, the companies I was observing had become consumers of production and so this demands new ways of thinking about performance.

Indeed, a recent study undertaken in the Canadian construction industry goes to show just how the production-based category of productivity has now become a zombie category. Here, the researchers identified a need to find alternative approaches to labour productivity, and concluded their investigation by reconceptualising the performance agenda in terms of the maturity of organisational capabilities (in itself another tiresome prescription):

*"The major implication of this study is that researchers and policy makers are now provided with an alternative to labor productivity and competitiveness as a means of assessing the current state of the construction industry (Willis and Rankin, 2012: 399)."*

By shifting the category from productivity to the maturity of organisational capabilities, the emphasis moves away from a strictly production paradigm towards a focus on the management (and consumption) of production. So, productivity from a production perspective can be said to become zombified. But what has this got to do with reflexive modernity? Arguably, modernity was symbolised in the systematic ways of thinking about (the factors of) productivity, embodied in the wealth of articles I was reading at the outset. It is likely that such systematic ways of thinking about productive versus non-productive aspects of work help sanctioned the ever extending layers of supply relationships that we have come to characterise the construction industry today (see e.g. Chan and Marchington, 2012). Thus, thinking about the drivers and constraints of the productive capacity of construction labour (conventionally owned by a definable employer) has given rise to the management of calculable risks involved in managing labour. This, in turn, led to companies making the gradual transition away from a production-based paradigm to a consumption-based paradigm, thereby dropping labour altogether.

### **The often-overlooked 'hyphen' in Product-Service systems**

If productivity was an old concept that I tried to resurrect in my doctoral study, a more contemporary phenomenon related to the servitization of the construction industry (see e.g. Dainty, 2007, and; Leiringer and Bröchner, 2010). The story goes that the context of public-private-partnerships has given rise to the need for thinking about the whole life cycle of built environment assets created by the construction industry. This in turn calls for novel ways of thinking about moving away from a product-centred offering towards a greater service orientation in construction. Here again, Johnstone et al. (2008) noted a wealth of literature providing recipes for systematising the transition towards a service-oriented way of working.

Much of the literature on servitization of the construction industry recognises two principal forms of business logic, i.e. product-dominant versus service-dominant

logic. In this ever-expansive literature base, there is often a suggestion that one needed to move towards a service-dominant logic in order to stay competitive in the marketplace, and that this required getting closer to the 'customer'. Indeed, the construction management literature has, over the last few decades, seen more nuanced treatment of who the construction 'client' might be and the implications for theory and practice (see e.g. Boyd and Chinyio, 2006, and; Thomson, 2011).

However, there remains constant tension between the two logics - product and service - in moving towards greater servitization of construction. Consider the following quote from an Operations Director interviewed in the study done by Leiringer and colleagues (2009), illustrating how the dilemma associated with moving from a product-dominant to a service-dominant logic often exists.

*"I think it's important that we maintain our identity and we don't diversify to purely a service provider type of organization. I think it's important that we recruit good civil engineers who want to build and construct things and improve things (p. 277)."*

This quote provides an indication that the move towards greater service orientation can be risky. In making the transition from a product-dominant to service-dominant mode of working, there is a sense that the Operations Director in question was clearly marking out the discrete categories of 'product' and 'service' types of organisation, emphasising in his mind the established category of 'building' things. Besides, what would be left of a construction company if it were to stop constructing? And so, comfort is sought in the 'production' paradigm as the argument is made against moving towards "purely a service provider" as this risk losing a sense of identity.

Arguably, the demarcation between 'product' and 'service' is a false dichotomy. Surely, we have always been producing things in order to service the needs of people. Thus, the importance of getting close to and servicing the customer cannot be such a recent phenomenon that has attracted research attention only over the last few decades! So, what purpose do categories such as 'product' and 'service' provide? Are these categories simply zombified too? Perhaps part of the problem, as discussed in the preceding section on productivity, is the idea that some construction companies have moved from being a producer to becoming an orchestrator and consumer of production. So, the current emphasis on servitization of the construction industry can be seen as a consequence of companies and industries being carved up into identifiable categories of 'product' and 'service' type organisations (e.g. through standard industry codes) that promulgates the need to conceptualise their integration.

The case has been made for 'integration' as a new space for subsuming product-based and service-based offerings (see e.g. Leiringer et al., 2009, and; Leiringer and Bröchner, 2010). Thus, what may appear rather insignificantly as a hyphen between 'product' and 'service' in product-service systems is not so innocent after all. On the one hand, the hyphen signifies prospects of joining up and making the transition between the two categories of production and consumption. On the other hand, it symbolises the divisiveness between production and consumption logics, forcing practitioners like the Operations Director in Leiringer's et al. (2009) to take sides.

## **CONCLUSIONS**

In this article, the problems associated with the formulation and use of categories for describing our research phenomena and the wider world around us have been reflected upon. Specifically, Ulrich Beck's ideas of 'zombie categories' and reflexive modernity have been used to argue how complacency in the use of production-based categories

led to the stickiness of the (organisational) performance agenda in the field. Thus, this article contributes by extending beyond the object-subject duality ignited by Seymour and Rooke in the mid-1990s, by exploring the question as to what the often taken-for-granted and, as I have argued, 'zombified' categories do to reinforce the rhetorical discourses in our field. More critically, I have suggested that the pursuit of more elaboration on these production-based categories can potentially create the 'catastrophes' we have so often been eager to avert. Thus, knowing more about productivity might just make us less concerned about being productive, as companies move away from production to becoming consumers of production. Similarly, the call to integrate between 'product' and 'service' modes of working is a possible implication of the modern pursuit of specialisation. The question that remains unanswered is just why such zombified, production-based categories continue to endure in our field. Exploring this deeper would require a further reflection on the political and institutional dynamics of construction management research.

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# APPLICATION OF THE PRINCIPAL-AGENT THEORY TO CONSTRUCTION MANAGEMENT: LITERATURE REVIEW

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There is a growing literature concerning the application of the principal-agent theory to construction management. As this literature review demonstrates, it has received particular attention in the first decade of the third millennium. The theory focuses on information asymmetry, in which one of the two parties is better informed than the other, and in which they do not share the same interests. Opportunistic behaviour can be expected in such relationships. The concept of asymmetric information is of great value to modern economic theory, and it is thus likely to play a major role in the study of construction management. This review focuses on keywords, which are essential in literature search that precedes all research activities. The results of this literature review pinpoint the key issues associated with the principal-agent theory in the leading journals in construction management to date. As is shown in the paper, contracts and risk management are uppermost in the literature surveyed. Together, these two subjects fit very well in the principal-agent framework. This review will provide the basis for future research in construction management and related fields.

Keywords: principal-agent theory, information asymmetry, project management, risk, communication.

## INTRODUCTION

In recent years, the principal-agent theory has been receiving a growing attention in various applied fields, including construction management. The purpose of this paper is to assess this development by reviewing the literature in the field in terms of keywords listed by authors. As the theory concerns information asymmetry, in which one of the parties is better informed than the other, and in which parties do not share the same interests, it is likely to have a growing influence on construction management, where project parties bring together a wide variety of both expertise and interests to the task at hand. Focusing on the leading journals in the field, this review investigates the connection between the principal-agent theory and areas of its application with deeper historical roots in the construction management field.

The first step in the literature review presented here is based on Bröchner and Björk (2008), who have investigated journal choice by leading construction management authors around the world. They have argued that there are seven leading journals in the field, which will be introduced in the next section. To identify the papers to be

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reviewed here, the online archives of these journals have been searched using "principal-agent" as the keyword. These words are most often followed by the word "theory", but words "problem" and "model" can also be found in the literature. Hereafter, only the word "theory" will be used.

The principal-agent theory offers a useful representation of project management as applied to construction and other fields in which project management plays an important role. George Akerlof, Michael Spence, and Joseph Stiglitz shared a Nobel prize in economics in 2001 for their work on information asymmetry conducted in the 1970s. It provides one of the best known applications of information asymmetry in economics, which is the situation in which one of the two parties is better informed than the other, and in which they do not share the same interests (e.g., Jensen, 2000). In accordance with the principal-agent theory, the following types of information asymmetry apply for project parties: hidden characteristics, hidden information, and hidden intention. These three types of information asymmetry respectively generate the following risks: adverse selection, moral hazard, and hold-up (Jäger, 2008). Different interests of principals and agents postulated by the theory have also been investigated from the vantage point of morality or ethics (e.g., Quinn & Jones, 1995).

In project management, the focus has initially been on the relationship between the project owner and the project manager engaged for a particular project (e.g., Turner & Müller, 2004; Müller & Turner, 2005). However, it has also been extended to other agents engaged in construction, such as contractors, sub-contractors, designers, consultants, and so forth. In the simplest situation, the principal is called the project owner and the agent is called the contractor. Both are guided by self-interest, as well. According to the theory, opportunistic behaviour can be expected from both, but much of the literature is concerned with the contractor's opportunistic behaviour. However, the relationship becomes increasingly complex as the number of project parties grows. It can be assumed throughout that agents will attempt to maximize their benefits even when that may involve a higher damage to the principal (Schieg, 2008).

Previous research has shown that project managers play a crucial role in construction projects, and especially in the construction phase, when they are more important to project success than the project owner and the contractor (Ceric, 2012a,b,c,d). Either collusion or conflict between project managers against the interests of the project owner and contractor can have detrimental effect on project completion within time, budget, and quality desired. In a brief overview, Ceric (2012a: 523) classified the literature relating to the principal-agent theory in terms of the three risks generated by information asymmetry, namely adverse selection, moral hazard, and hold-up. However, it should be noted that the classification in question was not limited to the seven journals investigated in this paper; rather, it was considerably broader in scope. As will be shown below, only two of the above asymmetries appear among the keywords in papers investigated here, and each appears only once.

The remainder of this paper comes in three sections. The literature review methodology employed will be considered first. The key findings of the literature review will be presented next. By way of conclusion, limitations of this study and pointers for future research in this area will be considered. It is to be hoped that construction management research will be enriched by this review.

## METHODOLOGY

The research presented here has followed three distinct steps. The journals to be investigated were selected first. Due to space limitations, the focus was on the top journals in the field of construction management. The journals selected were searched for "principal-agent" as the main keyword in the second step to identify the relevant papers. Finally, the associated keywords in these papers were identified and analysed in the third step. These keywords have deeper roots in the construction management literature than the main keyword. Their identification and investigation is the main contribution of this review. Keywords have become essential in the literature search, which nowadays guides the academic community in any field of research.

Again, this literature review is based on Bröchner and Björk (2008). Their research focused on the preferences of the authors contributing to the construction management field. They followed the most cited authors, whose preferences they furthermore investigated by means of an opinion survey. In the process, they identified 45 journals in the field, from which they identified the seven leading ones. Together with their publishers, the seven leading journals in construction management identified by Bröchner and Björk (2008: 742) are shown in Table 1. For purposes of this literature review, each of their online archives was subsequently searched for the keyword "principal-agent". The results will be presented in the next section.

*Table 1: Top construction management journals by authors (Bröchner & Björk, 2008)*

Journal	Acronym	Publisher
Automation in Construction	AIC	Elsevier
Building Research and Information	BRI	Taylor & Francis
Construction Innovation	CI	Emerald
Construction Management and Economics	CME	Taylor & Francis
Engineering, Construction and Architectural Management	ECAM	Emerald
International Journal of Project Management	IJPM	Elsevier
Journal of Construction Engineering and Management	JCEM	ASCE

It should be noted that the archives of the journals go back to different years. In this case, JCEM archive goes back to 1930, BRI to 1973, CME and IJPM to 1983, AIC to 1992, ECAM to 1994, and CI to 2001. Therefore, the present review is slightly biased toward the journals with farther-reaching archives. As will be shown below, however, the bulk of the literature cited falls within the last decade. Therefore, the historical reach of the archives does not appear to be of great relevance in this particular case.

The main contribution of this review is in the analysis of the associated keywords, many of which have considerable history in the construction management literature. Namely, the papers identified in the leading journals in the field have subsequently been probed by analysing the associated keywords listed in papers found. Their incidence pinpoints the areas to which the principal-agent theory has been applied to date, and in which it is likely to play the most prominent role at this stage. As will be shown in the next section, some of them have deep roots in the field.

## KEY FINDINGS

The incidence of the keyword "principal-agent" in the seven journals selected for this review is shown in Table 2. All together, 55 papers containing the main keyword have been found. According to the search, however, it appears in only two paper titles, three abstracts, and no more than five lists of keywords, which are essential in literature search. The leading journal in terms of the keyword is IJPM with 30 papers, followed by CEM with ten, JCEM with six, ECAM with five, and BRI and CI with two each. However, no papers containing the keyword have been found in AIC, which is included here on account of the argument provided by Bröchner and Björk (2008). That journal will thus be excluded from further investigation in this review.

*Table 2: Incidence of the keyword "principal-agent" in selected journals*

Keyword / Journal	AIC	BRI	CI	CME	ECAM	IJPM	JCEM
Papers	0	2	2	10	5	30	6
Titles	0	0	0	0	0	2	0
Abstracts	0	0	0	1	0	2	0
Keywords	0	1	0	1	0	3	0

The 55 papers cited in the seven top construction management journals are presented in Table 3. Most of the papers appeared in print in the 2000s, and especially between 2005 and 2012. The peak was in 2012, when 13 papers bearing the keyword "principal-agent" appeared in print. The previous peak year was in 2009 with eight papers. This shows that the research in question is by and large recent. However, it should be noted that the first papers in this series appeared in the early 1990s. In particular, Ward et al. (1991) and Ward and Chapman (1991) lead the pack.

*Table 3: Papers cited*

Acronym	Papers cited
AIC	None
BRI	Lützkendorf & Speer (2005), Ürge-Vorsatz et al. (2007)
CI	Davidson (2009), Vennström & Eriksson (2010)
CME	Boukendour (2007), Bowen et al. (2007), Ward & Chapman (2008), Yung & Lai (2008), Hossain (2009), Tuuli et al. (2010), Sha (2011), Bowen et al. (2012), Ling & Tran (2012), Rose & Manley (2012)
ECAM	Hsieh & Forster (2006), Eriksson & Laan (2007), Badenfelt (2008), Bemelmans et al. (2012), Hughes et al. (2012)
IJPM	Ward et al. (1991), Ward & Chapman (1991), Williams (1993), Ogunlana (1996), Farrell (2003), Turner & Müller (2003), Müller & Turner (2005), Yu et al. (2005), Jensen et al. (2006), Koch & Buser (2006), Smyth & Morris (2007), Turner et al. (2008), Hossain (2009), Hossain & Wu (2009), Huang & Chang (2009), Pinto et al. (2009), Corvellec & Macheridis (2010), Hölzle (2010), Mahaney & Lederer (2010), Müller & Turner (2010), Bakker et al. (2011), Kapsali (2011), Koppenjan et al. (2011), Braun et al. (2012), Chang (2012), Eriksson (2012), Flyvbjerg (2012), Hsu et al. (2012), Ika et al. (2012), Bond-Barnarda et al. (2013)
JCEM	Cheah et al. (2004), Ho (2006), Puddicombe (2009), Zhang (2009), Hosseinian & Carmichael (2012), Xiang et al. (2012)

This paper attempts a classification of keywords in selected papers so as to determine the connection between the "principal-agent" keyword and the associated keywords. In the 55 papers identified there are 276 keywords, or about five of them per paper. A large number of identical keywords are shared by several papers. Due to space limitations, only the most important among them are presented here. For instance, keywords such as "construction" and "construction industry", as well as "construction management" and "project management", are excluded from further analysis. General keywords, such as "environment" and "sustainability", and indefinite keywords, such as "control" and "flexibility", are also excluded. Similarly, names of countries and organizations, such as the World Bank, are excluded, as are technical terms, such as "Monte Carlo method" and "regression analysis". In addition, the main keyword "principal-agent" is excluded here since the five papers in which it explicitly occurs are already presented in Table 2. The 21 remaining keywords, which appear in 64 instances, are presented in Table 4. It should be noted that there are 24 such instances in IJPM, 15 in CME, 12 in JCEM, eight in ECAM, three in BRI, and two in CI.

*Table 4: Incidence of associated keywords in selected journals excluding AIC*

Keywords / Journal	BRI	CI	CME	ECAM	IJPM	JCEM
Adverse selection	1					
Communication			1		3	
Contracts			3	1	2	2
Corruption			2			
Financial management						2
Hold-up					1	
Incentives				1	1	
Information asymmetry	1					1
Information systems	1					1
Opportunism			1			
Partnership				2		2
Procurement		1		1	1	1
Professional ethics			1			
Risk management			1	1	4	2
Social networks			2		2	
Strategic planning						1
Supply chain management		1		1	2	
Temporary organizations					2	
Transaction costs			2		2	
Trust				1	1	
Uncertainty			2		3	

As can be seen from Table 4, the most important keywords associated with the principal-agent theory are "contracts" and "risk management", which appear in eight papers each. They are followed by keyword "uncertainty" with five instances. Finally, keywords "communication", "partnership", "procurement", "social networks",

"supply chain management" and "transaction costs" are just behind, as they appear in four papers each. Predictably, combinations of these keywords occasionally appear in the same papers. The connection between "contracts", "risk management" and "uncertainty" is worth noting in this connection, as risks can sometimes be identified only in broad terms, thus precluding precise assessment. In turn, this means that contracts between the principal and agents cannot be formulated in precise terms, either. This is very much in line with the principal-agent theory, as well.

The "transaction costs" keyword is worth exploring briefly. In particular, this involves the connection between the principal-agent theory and transaction cost theory. Elinor Ostrom and Oliver Williamson shared a Nobel prize in 2009 for their work on economic governance performed in the 1970s and 1980s. Their contributions focus on hierarchical structures such as firms and other institutions that play a role outside markets proper. Transaction cost theory has evolved into New Institutional Economic (NIE) in recent years. The principal-agent theory also plays an important part in this wider theoretical framework. Its place within NIE is worth exploring in the future, but such an analysis falls outside the scope of this paper.

Returning to the results of this review, they show that the principal-agent theory has had only a superficial impact upon construction management research published to date. The keyword "principal-agent" thus appears in the body or references of a large number of papers, but it rarely appears in titles, abstracts, or lists of keywords, which are of great importance in literature search. In other words, it is typically mentioned only in passing. Therefore, much remains to be done in the future to bring opportunistic behaviour in general into the mainstream of construction management research, let alone in its focus. This will be further discussed in the conclusions.

Opportunistic behaviour covers a wide range of phenomena, but corruption can be found among its extreme forms. According to Bowen et al. (2007: 631), unethical conduct associated with this term includes "collusion, bribery, negligence, fraud, dishonesty and unfair practices". As Bowen et al. (2012: 885) maintain, "corruption is a pervasive stain on the construction industry in many countries". And they add: "South Africa is no exception". But only these two among the 55 papers reviewed here deal with corruption, and in South Africa only. Given the widespread reputation of construction, a much larger number would thus be expected in the literature.

Concerning agent opportunism, Sharma (1997: 775) offers a useful enumeration of the restraints on such behaviour: self control, client control (principal), bureaucratic control (contracts), and community control. The second and the third constraint are dominant in the extant literature in construction management. However, the research community in this field also has a role to play in restraining opportunistic behaviour. The better it is understood, the less scope will it have for further development. Therefore, this is a useful pointer for future research in construction management. It itself is a form of community restraint on agent opportunism in construction.

## **CONCLUSIONS**

As this literature review shows, the main interest of researchers in construction management associated with the principal-agent theory is a combination of contracts and risk management to limit the principal's exposure. This has been shown by analysing keywords that appear in papers containing the "principal-agent" keyword. The associated keywords provide a clear picture of the focus of recent research. The review presented here needs to be extended in a number of related ways.

To begin with, this literature review should be extended to a wider selection of journals in the field. Over the years, many new journals have appeared, and they are gradually assuming ever greater importance. At this stage, there are around 50 of them. Although the seven journals selected for investigation in this paper are purportedly the very best, the whole field needs to be understood more thoroughly. The literature review presented in this paper offers only the first albeit essential step in this endeavour. It is to be hoped that are steps are soon to follow, however.

Also, the overlap between the principal-agent theory and transaction cost theory within the framework of NIE would be worth exploring in the future. A wider literature review connecting the two theoretical frameworks would be helpful in pointing out both the overlaps and substantial differences between the two in the context of construction management. In particular, such a review would need to focus on the difference between markets and firms, as well as other institutions involved.

Finally, future research should also investigate the widespread reputation of construction for a wide range of opportunistic behaviour, from collusion to more severe forms of corruption and graft. So far, the construction management research has apparently eschewed this important area of research, which is at the focus of the principal-agent theory. It is to be hoped that this review will provide an impetus for such research in the future. That would make it well worth the effort.

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# MAKING SENSE OF INNOVATION IN THE UK CONSTRUCTION SECTOR

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The existing literature on innovation in the construction sector is often oriented towards positivist and quantitative approaches. Research has tended to focus on the means by which innovation can be determined or measured by variables or linear progression of stages. Variable-based approaches are assumed to be the only legitimate basis for theory development and practical explanation. Whilst these approaches may provide indications of averages across large samples, they often ignore multiple perceptions, contexts and time completely or compress them into variables. These approaches have been challenged by other researchers who consider innovation as a narrative mobilised by organisational actors, emphasising multiple perceptions and situational contexts that unfold over time. Building upon and extending this work, the paper explores and explains how identities of construction sector practitioners and contextual circumstances shape the ways in which their narratives of innovation are mobilised. The empirical research of the paper draws from thirty semi-structured interviews with UK construction sector practitioners. Interviewees were engaged with Constructing Excellence and, in some sense, constructed their identities as innovation champions. Different storylines were shared by the interviewees, often taking different perspectives and viewpoints. Applications of Building Information Modelling (BIM) have often been described as innovations. Throughout the course of the interviews, it was evident that enactments of innovations by construction sector practitioners were shaped by their identities and experiences. Grounded in identity construction, a sensemaking perspective is applied as a theoretical lens for explaining how identities of the interviewees and situational contexts shaped the ways in which their narratives were mobilised. The paper discusses the narratives of innovation in the context of project lifecycle. It addresses the research implications and suggests some future research directions.

Keywords: context, enactment, identity, narrative, sensemaking.

## INTRODUCTION

Since the 1990s the UK government has commissioned a series of reports on innovation and performance improvement in the UK construction sector. The Egan (1998), the Wolstenholme (2009) government reports claimed to promote an innovation agenda in the construction sector. These reports have inspired many construction sector practitioners to drive the innovation agenda in their organisations. The overriding tendency is to promote innovation as one of the driving forces of growth of firms, industries and economies. Innovation is often viewed as one of the

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organisational values that can help to retain competitiveness. The innovation agenda aims to engage each stakeholder's responsibility through collaboration across the boundaries in order to receive legitimacy. Innovation is promoted as an essential part of stakeholders' mindsets, attitudes and behaviour.

Construction firms repeatedly promote generic improvement solutions like collaboration, integration, continuous learning and innovation in order to improve performance and become more innovative. These persuasive principles tend to be deterministic in nature: they are sourced from manufacturing and other sectors and are promoted as generic solutions that are applicable to the construction sector. The underlying assumption is that they remain meaningful once they are removed from the context. However, little consideration is given to differences in situational contexts and storylines mobilised by different organisational actors at different points in time.

The purpose of this paper, therefore, is to explain and understand narratives of innovation mobilised by construction sector practitioners. In order to achieve the aim and place the research within the landscape of construction management, the specific objectives of the research are:

- To explain and emphasise the construction-specific context in relation to narratives of innovation mobilised by practitioners.
- To critically review the construction-specific literature on innovation.
- To explain how identities of construction sector practitioners and situational contexts shape narratives of innovation they mobilise.

## **TOWARDS A CONTEXTUAL UNDERSTANDING OF INNOVATION**

The prevailing view on innovation in the construction-specific literature is rooted in positivist and quantitative approaches (e.g. Blause and Manley 2004, Koskela and Vrijhoef 2001), where the emphasis is being placed on influence of definitive variables at different points in time. Whilst these approaches may provide indications of averages across large samples, they often ignore situational contexts and individual perspectives completely or compress them into variables. An alternative "processual" perspective views innovation as an ongoing process shaped by organisational actors and situational contexts (e.g. Hartmann 2006, Sexton and Barrett 2003, Winch 2006), rather than acontextual, apercceptual, objective characteristic that can be determined or measured. The advocates of the more or less processual perspective emphasise the importance of contexts, multiple perceptions and time (e.g. Bresnen and Marshall 2001, Fernie et al 2006). This represents a shift towards a dynamic understanding of innovation, sensitive to individual perspectives and ongoing circumstances.

Recognition of the heterogeneous nature of social processes, multiple perceptions and situational contexts are claimed to be important when conducting any research on the subject. This perspective resonates with a processual (postmodernist) orientation in the management and organisation studies (e.g. Chia 1995, Pettigrew et al 2001).

It is frequently contended in the construction-specific literature that narratives of innovation mobilised by organisational actors cannot be understood in isolation from the situational contexts (e.g. Harty 2005, Larsen 2011, Leiringer and Cardellino 2008). It is argued that construction has some specific characteristics which make it distinctive from other sectors. Harty (2005), for example, identified five features to understand the construction contexts into which innovations are introduced: the collaboration upon which construction work is based, project-based nature, the

importance of communication and inter-organisational relations, and the way power is distributed. It is frequently argued in the construction-specific literature that narratives of innovation mobilised by practitioners are shaped by their interpretation, actions and embedded experience (e.g. Harty 2008, Salter and Gann 2003). It is, therefore, important to understand narratives of innovation mobilised by construction sector practitioners contextually.

Critiquing the behavioural decision-making school of research and addressing limitations of the sensemaking school of research, Winch and Maytorena (2009) articulated that some managers perform better than others in identical situations due to the differences in ways in which they solve the problem. It is argued that so-called "social sensemaking" is more appropriate for conditions of uncertainty and ambiguity, whilst "behavioural sensemaking" is more suitable for conditions of risk. Utilising a contextual, practice perspective and incorporating ideas on interpretation proposed by a sensemaking theory, Gluch (2009) used the actors' own narratives to demonstrate how their roles and identities are shaped in construction. Of particular note, it has been demonstrated that narratives mobilised by practitioners are shaped by their roles and identities, and this is an ongoing process that change over time. Utilising a sensemaking perspective, Green (2011) and Green et al (2005) contend that concepts like supply chain management, partnering and innovation cannot be understood in isolation from the broader dynamics of change in the construction sector. From this perspective, narratives may be directed towards the dominant story which may be implausible for practitioners who mobilise them and even unthinkable. However, it is contended that new generation of managers has an opportunity to re-narrate their journeys, and not necessarily repeat the past. Building upon and extending this work, the paper explains how identities of construction sector practitioners and their embedded experiences shape narratives of innovation they mobilise. Grounded in identity construction, a sensemaking framework may offer a more reasonable explanation of the narratives of innovation mobilised by construction sector practitioners shaped by their identities and situational contexts that unfold over time.

## **METHODOLOGY**

Thirty semi-structured interviews with UK construction sector practitioners were conducted between the period of November 2012 and February 2013. The interviewees were directly engaged with Constructing Excellence that is claimed to be the UK construction sector's single organisation for driving the innovation agenda. The Constructing Excellence movement is drawn from all parts of the sector (e.g. stakeholders, clients, users) and is committed to a UK sector-wide approach to improvement through collaborative work. Amongst the important values in the agenda are collaborative working, integration, continuous learning, improvement and innovation.

Construction practitioners engaged with Constructing Excellence have, in some sense, constructed their identities as innovation champions. From time to time they attend events and discuss innovation. Notably, they often play multiple roles: practitioners were actively engaged with Constructing Excellence and promoted the innovation agenda in their organisations. The interviewees were sourced from a variety of the firms: both SMEs or large, main or specialist contractors, consultancies or clients. Of particular note, storylines mobilised by the interviewees were personal perspectives and viewpoints.

## **NARRATIVES OF INNOVATION MOBILISED BY INTERVIEWEES**

### **Meaning of innovation**

A variety of perspectives on definition of innovation expressed by the interviewees was evident. Throughout the course of the interviews, a number of themes and sub-themes have emerged. The majority of interviewees associated innovation with novelty, emphasis that not all organisational changes are recognised as innovations. Novelty was often described as one of the key distinguishing characteristics of innovation. This was articulated especially clearly by a chief executive from a consultancy firm:

*"New idea, a new way of working, a new way of doing something that improves a project, the process, the working life of all the people who work in it and helps the customer, the end-user for better value for their money. Something new, something different".*

From the above quotations it is evident that a chief executive from a consultancy firm provided a more conventional definition that views innovation as a "thing" or an objective entity. Notably, there seems to be inconsistencies within the mobilised narratives. For example, in the above quotation the interviewee defined innovation as a new "thing" or "something". Whilst it seems to be some kind of a material entity or objectivity in there (e.g. new idea, something), at the same time the interviewee pointed towards a processual understanding of innovation (e.g. new ways of working, new way of doing). It is also notable that novelty was consistently repeated across different contexts (e.g. ideas, concepts, ways of working, project, process) in relation to innovation. The contexts represented novelty within narratives of innovation mobilised by most interviewees.

Those interviewees who associated innovation with novelty contended that in the construction sector it is difficult to create something new. They explained that most construction innovations are not new: although innovations in the sector may be perceived as new by people, they tend to utilise existing systems or processes applied to different contexts. For example, a proprietor from an architecture, planning and management services firm provided an explanation of this misalignment:

*"The reality is it is not completely novel. It tends to kind of want to adopt the existing system because the existing system has got 75% of method tighten up into it. It is rarely when you get total newness. But I do not think that is a definition of innovation. Innovation is about thinking your ways of a solution, not trying to find a new solution, and not trying to find a new problem solving".*

In contrast to the narrative mobilised by the chief executive, a proprietor had a much broader view on innovation as thinking of business opportunities. The focus was placed upon individual thinking and viewpoints, emphasising that it is perceptions of novelty that really matter, rather than any absolute definition. Embracement of novelty in relation to innovation was also considered from a slightly different perspective. For example, a project manager from a cost and project management consultancy emphasised that novelty implies risk and uncertainty:

*"I think a sort of novelty element applies to those who is using innovation, other than relating to some kind of absolute measurable whether something new or not. Risk is a*

*core part to approach innovation. At the end introducing novelty is risky and uncertain".*

From the above quotations it is evident that a project manager did not subscribe to any labels, but considered innovation in the context of risk and uncertainty. Another perspective on innovation was described in terms of associated benefits, efficiency and effectiveness. A significant percentage of the interviewees defined innovation in relation to improvements in the business of a company or even the sector as a whole. They claimed that recognition of organisational activities as innovations should be based on values or benefits for the business. For example, a head of business development and marketing from a specialist contractor firm emphasised the importance of improvements across different contexts:

*"A system, a process, a product, a ways of approaching an issue that improves the way that a company or an industry goes about its business".*

It is evident from the above quotation that a head of business development and marketing had a broader view on innovation as thinking of improvements in the business and sector as a whole. Notably, there seems to be misalignments and self-doubts within the mobilised narratives. For example, in the above quotation innovation is viewed from a broader perspective (e.g. system, a process), whilst indicating an objective entity (e.g. product, issue).

A few interviewees viewed innovation as an ongoing process, rather than a material entity or "thing". Narratives of innovation mobilised by the interviewees were often suggestive of an organisational activity that evolves over time. Process of innovation appeared to be fraught with ongoing, changing activities and circumstances. Of particular note, the interviewees used verbal nouns (e.g. approaching, working) over nouns, emphasising dynamism of the innovation process. This tendency was articulated especially clearly by a procurement operation manager from a public sector client firm who contended that innovation is a process that unfolds over time:

*"Moving something from where it was to somewhere that is a better place than it was, and you go through a process to work out how you do that".*

From the above quotations it is evident that a procurement operation manager employed a logistical metaphor of shifting from one point in time into another. This indicates some interesting insights into how the identities of the interviewees and their experiences shaped the way in which they mobilised narratives of innovation.

### **Ontological and epistemological assertions**

Narratives of innovation mobilised by the interviewees were often reflective of the rhetoric of a positivist storyline. However, it should not be confused with being rooted into a positivist paradigm. The interviewees often suggested a necessity of measurements of innovation. For example, a commercial director from a highway maintenance, bridge and road design council articulated a positivist storyline:

*"Every time we came up with these ideas we had to do a business plan to measure the effectiveness of it, the cost of it, did the trial work and then to work out the benefits of it because it was financial reward for partners, depending who came up with an idea".*

Positivist storyline reflected and reinforced assertions about an objective nature of innovation. In some sense, products were emphasised over activities, continuity over novelty, entities over processes, and determination over flux. Limited attention has

been placed upon any reference to multiple perceptions by individuals and of situational contexts.

The narratives mobilised by the interviewees were often reflective of the rhetoric of a postmodernist storyline, but it should not be confused with being rooted into this rhetoric. Novelty was often emphasised over traditions, processes over entities, perceptions over determinism. The interviewees frequently used verbs over nouns in order to explain dynamism and complexity of ongoing social processes. The narratives shifted beyond the object-subject duality, emphasising power relations, construction and re-construction of identities over time. For example, a planning manager from a consultancy, maintenance and construction firm articulated especially clearly a postmodernist storyline:

*"I think it was the case of being innovative in the sense you want to do things better and differently: borrowing other peoples' ideas, tricking them, modifying them, putting them into your own organisation. But you are doing it in a progressive way and you need a lot of support to do it".*

Notably, narratives mobilised by the interviewees have demonstrated inconsistencies and misalignments: a mixture of positivist and postmodernist storylines, even through the course of single interviews. As was evident in the previous section, whilst some interviewees defined innovation as some kind of a material entity or "thing", they often pointed towards a "processual" understanding of innovation. One possible explanation of inconsistencies and misalignments is to look through a lens of identity construction. Theories that view identity as socially constructed frequently argue that people may represent different combinations of ontological and epistemological assertions about the nature of organisational phenomena (e.g. Alvesson 2010, Sveningsson and Alvesson 2003). From this perspective, narratives of innovation are multiple and may change over time as circumstances unfold – going one step further – the process unfolds through snapshots of entities at different points in time. A person may mobilise multiple identities and have multiple roles. Thus, one should not expect that the interviewees would display deeply-rooted ontological and epistemological assertions.

### **Examples of the innovation projects described**

The innovation projects described by the interviewees represented a variety of contrasting perspectives. Applications of Building Information Modelling (BIM) were often described as innovations or as being innovative. For example, a supply chain manager from a client construction firm described 3D modelling for rail as being innovative. A business improvement manager from a water division, on the other hand, described the first application of BIM in water sector as innovative. This tendency was reinforced by a head of BIM from a construction firm. He described engagement every stakeholder in the process of using BIM as innovation:

The issue with BIM at the moment is producing a lot of geometric data and information. This is coming from consultants, trades, suppliers – a lot of different sources. The government aims to deliver asset management set of information. Senior managers looked at the current process and identified a gap: there is no quality assurance at all to actually guarantee whether it will improve the consultants, geometrically correct and the right information. They researched the market and identified one technology product that was brought in from another country. But rather than just bringing to the company's use, they are encouraging consultants to

engage with the process. The idea is to actually bring everybody into this process, aiming to validate the information moving forward as a business.

It is evident that the first two examples of applications of BIM to different contexts, in some sense, are more tangible (e.g. software, technology). They presumed some sort of a material entity in there. However, the last example of BIM, in some sense, has both tangible (e.g. technology product) and intangible elements (e.g. a process, engaging everyone). This project was framed tacitly and compellingly as another aspect of the innovation – a social process, a sort of “living entity”. The emphasis was placed on verbs over nouns, explaining dynamism and complexity of processes.

Notably, the interviewees situated in particular contexts (e.g. rail, water divisions and developing infrastructure respectively) which shaped the narratives of innovation they mobilise. From this perspective, there is a meaningful connection between the narratives mobilised by the interviewees and the situational contexts. The interviewees reacted and shaped the environments they experiences - they were part of particular contexts. From this perspective, contexts are not fixed or detached from the individuals, their perceptions and actions. Rather people react to situational contexts through their interpretations and actions, whilst their perceptions and actions shape the contexts.

### **Contextual understanding of innovation in construction**

Many interviewees recognised that construction-specific characteristics shaped their perceptions on innovation. A project manager from a general consultancy firm articulated especially clearly that situational contexts shape perceptions on innovation:

*"There are big market, economic issues for construction. Because it is low margin business, it is a project-based business. For all kind of reasons it is difficult to transfer learning from project to project. Construction people tend to reinvent from project to project. There is a lack of continuity. Cycle of construction is discontinuous because it is project-based. On the other hand, construction provides a very kind of positive environment for innovation. Projects are unique, there are unique problems to solve that goes on quite regularly in construction. Some people do not see it as innovation: new designs. It does not innovate so much in terms of developing new products, but it does innovate quite extensively at the day to day problems because of its uniqueness".*

The above quotation clearly emphasised that innovation cannot be understood without a reference to situational contexts. It was contended that construction has specific contextual characteristics that are unique from other areas and other sectors. The nature of the construction sector was described as discontinuous and project-based. Learning from project to project was emphasised to be difficult because of their temporal nature. One the other hand, the uniqueness of construction projects was claimed to regularly require innovative solutions. Sensitivity to contexts was considered to be important by many interviewees, drawing attention to the situated nature and individual perceptions of the contexts. The interviewees pointed out towards a need to understand innovation within the construction-specific landscape.

From this perspective, context is by no means a static entity because it concerns highly dynamic, ongoing circumstances and multiple perceptions. The interviewees made sense of uncertain, ongoing circumstances in ways that responded to their own needs and expectations. They searched for meanings and interpretations whenever situations were perceived to be different from their expectations. This was articulated

especially clearly by a strategic business manager from a software engineering firm who argued that:

*"I think perceptions of this are definitely changing over the time. The first projects we hated because it is different. They found it very frustrating because it is not the same. But ultimately once they got use to that and they are doing it regularly, it becomes the standard practice, rather than the innovative practice. That makes a start, it becomes a second nature".*

Notably, the preceding quotation pointed towards ongoing processes of struggling, contradictions and uncertainty (e.g. frustrating, changing). One explanation of differences in making sense of innovation is that the interviewees' interpretations are shaped by multiple, individually and contextually-specific, assertions. Clearly, positivist, reductionist perspective is unable to provide a reasonable explanation of emergent contradictions, misalignments and dynamism of self-identities.

Understanding of identity as unstable, ambiguous and sometimes contradictory process provides a more reasonable and convincing explanation of the ways in which the interviewees made sense of innovation. This resonates with those construction management researchers who argue that identities of construction sector practitioners and situational contexts shape their storylines, and can change over time (e.g. Gluch 2009, Green et al 2005, Raja et al 2010, Winch and Maytorena 2009).

Although not necessarily considered under a processual (postmodernist) perspective label, a sensemaking theoretical lens explains how identities and situational contexts shape narratives mobilised by practitioners, and how they unfold over time (e.g. Weick 1995, Weick et al 2005). Sensemaking deals with search for meaning in situations of uncertainty, answering a question "the same or different?" When the situation is perceived as different the efforts are made to construct plausible senses of what is happening in order to enable projects to continue and become legitimised. A sensemaking is claimed to be a significant process that explains how the interviewees' own perceptions and target audience shape how they interpret situations and their actions. Far from being a material entity that can be determined by variables, innovation is, perhaps, more reasonably and convincingly understood as an ongoing process of making sense.

## **CONCLUSIONS**

One certain conclusion that arose from the empirical data was that different interviewees mobilised narratives of innovation in different ways, grounded in their identity construction and situational contexts. The narratives of innovation mobilised by the interviewees often revealed ongoing inconsistencies, misalignments and conflicts: a mixture of the rhetoric of positivist, social constructionist and postmodernist storylines was often evident, even through the course of single interviews. It has been contended that construction sector practitioners made sense of innovation through the narratives they build upon. Their interpretations were prone to multiple ontological and epistemological assertions that are individually and contextually specific.

Theories that view identity as socially constructed process have provided a more persuasive explanation of inconsistencies and misalignments, than is available using other approaches that view identity as a fixed or monolithic social entity. Grounded in identity construction, a sensemaking theoretical lens provides a much more reasonable and convincing explanation of how identities of the interviewees and their embodied

experiences shape the narratives they mobilised. The empirical fieldwork clearly demonstrated inability to understand the narratives of innovation shared by construction sector practitioners in any absolute sense from positivist, reductionist perspectives. It has been contended that there is no innovation conceptualisation that exists independently of the narratives that practitioners mobilise in order to understand and enact innovation.

The current research makes a contribution to the construction-specific literature by applying a sensemaking theoretical framework to understand how identities of construction sector practitioners and their experiences shaped their views on innovation. The results of the current research were not based on solitary or limited number of individuals, but were developed through an iterative and rigorous procedure that made use of complexity of the data collected. It is suggested that because sensemaking takes place in everyday interactions, it may be relevant in project lifecycle. Project lifecycle involves various stakeholders engaging in their own and target audience making sense processes. However, it is necessary to recognise that sensemaking processes may differ fundamentally amongst different people in different contexts and at different points in time.

### **Future research directions**

Future research into explaining how identities and situational contexts shape narratives of innovation mobilised by construction practitioners through a lens of a sensemaking perspective may supplement it with more macro approaches. The framework could be expanded upon sensegiving, power relations and institutionalisation. For example, how certain judgements about innovations appear constrained or enabled by formative contexts, organisational rules, laws and regulations. Future research may also investigate the role of Constructing Excellence context in which sensemaking occurs and institutionalisation of the sensemaking decisions. This would provide an explanation of how social, organisational and broader institutional contexts shape narratives of innovation. This may involve a reference to inter-subjectivity (e.g. social, collective processes), generic (e.g. shared understanding, common interests, organisational identity) and extra-subjectivity (e.g. organisational culture, institutionalisation). A more longitudinal research may provide deeper insights into how narratives of innovations mobilised by practitioners unfold over time in other contexts. Future research may utilize different theories (e.g. activity theory, actor-network theory) that could lead to new discoveries of various interconnections and combinations of social theories in, perhaps, a more comprehensive framework.

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# TIME KEEPS ON SLIPPIN', SLIPPIN', SLIPPIN' INTO THE FUTURE: BIM, IMAGING AND TIME ON CONSTRUCTION SIGHTS

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Digital visualisation is central capability of Building Information Modelling (BIM) and proponents of BIM claim that BIM will change everything. For example, the International Alliance for Interoperability initiative now known as BuildingSMART defines BIM as, “a digital representation of physical and functional characteristics of a building.” In current BIM research BIM is linked to Lean Construction, Augmented Reality (AR), project and trade scheduling, safety management, progress measurement on sites, design visualisation and even architectural education. As the BIM industry has arisen, numerous and in some ways glamorous, case study images are published and promoted as examples of successful BIM implementation. Representations of BIM as evident in diagrams, flow charts, conceptual drawings, user screenshots and representations of computer drawn BIM 3D and 4D models abound in BIM research. For these reasons these digital images and simulations emerging from BIM research literature deserve being examined — as representations of BIM theory or practice — to see what they suggest about the current methodological developments in BIM research. In order to understand the modes of BIM representation employed in BIM research an analysis is developed which counters current BIM research with broader research methodologies in Construction Management and the French philosopher Gilles Deleuze’s concepts of the cinema. In addition a comparative analysis of these representations in the research literature is made with images gained from a real construction site. This approach reveals how concepts of time are inscribed into BIM research and how these differ from reality. It will be concluded that the use of non-linear and topological concepts of time on construction sites is relevant to future BIM research. This is particularly the case when virtual BIM models are seen as simple linear and sequential constructions over time.

Keywords BIM, design, computer visualisation, research methodology

## INTRODUCTION

*Time keeps on slippin', slippin', slippin' Into the future Time keeps on slippin', slippin', slippin' Into the future I want to fly like an eagle To the sea Fly like an eagle Let my spirit carry me I want to fly like an eagle Till I'm free Fly through the revolution*

The lyrics of the Steve Miller band’s song 'Fly like an Eagle' (1976) serve as a useful introduction to the concepts of time that emerge from the representations, diagrams and simulations associated with an analysis of current Building Information Modelling (BIM) research. In these representations time is linear and easily progresses into a future where BIM enables seamless collaboration across a range of different construction workflows. The predominant viewpoint presented in the various

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diagrams and images that litter BIM research papers is often that of an eagle, or angel, freed of all earthly constraints and propelled towards a future BIM revolution. But unlike the critical theorist Walter Benjamin's discussion of Paul Klee's iconic image of an angel, looking back on the wreckage of progress, these seductive images of BIM appear to suggest that every technical innovation succeeds and that technology need not have a social-technical dimension (Chrostowska 2012).

In theory, BIM project models paired with collaboration tools offer a number of significant improvements and benefits over traditional design, delivery and supply chain processes. Proponents of BIM claim that the BIM will change everything. In current BIM research BIM is linked to Lean Construction, Augmented Reality (AR), project and trade scheduling, safety management, progress measurement on sites, design visualisation and even architectural education. The linking of 3D CAD models to project time schedules to enable what is termed four dimensional or 4D BIM is claimed as the next frontier for BIM (Sacks et al. 2010). BIM is primarily a visualisation tool and 4D BIM allows construction and project events to be visualized over time. Given the claims that BIM is a new mode of visualisation which can directly embody and simulate real-time itself, it is worth focusing on how time is conceived of and embedded in representations of BIM in the research literature. These various representations in the literature include strategic and operational diagrams, flowcharts, screenshot images and stills of digital animations. The objective in analysing these images and the concepts of time they suggest is to map the methodological extent of BIM research. In other words, the digital images and simulations, emerging from this snapshot of BIM research literature deserve being examined — as representations of BIM theory or practice — to see what they suggest about current methodological developments in BIM research. Whilst this analysis is limited to published BIM research it sets the scene for how we might consider the plethora of images regarding BIM that now also exist in the public domain.

Concepts of digital visualisation are central to definitions of what BIM is. A report sponsored by the Australian Institute of Architects (AIA) on BIM collects together a number of these definitions. For example, the International Alliance for Interoperability initiative now known as BuildingSMART defines BIM as, “a digital representation of physical and functional characteristics of a building”(Consult, AIA 2012). Australia's 'National Guidelines for Digital Modelling' developed by the CRC for Construction Innovation define BIM as being a “three-dimensional representation of a building based on objects which also includes “information in the model or the properties about the objects beyond graphical representation” (Consult, AIA 2012). However, it is difficult to know in this latter definition what is meant by the word 'object' and how objects go beyond graphical representation. Does this refer to a physical object, a 3D visualisation or a class of software code? The USA NBIMS - National Building Information Model Standard Project appears to bring these aspects of BIM together by defining BIM as “a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition.” (Consult, AIA 2012).

With the above definitions in mind this survey of research includes published research in, but not limited to, Automation in Construction, Construction Management and Economics, Journal of Construction Engineering and Management and the International Journal of Architectural Computing. As a point of reference the concepts underpinning BIM research and 4D BIM are compared to real time activities on an

actual building site as captured through time-lapse photography. Given that BIM simulations are intended to represent a reality that is supposed to mimic real construction a comparative analysis of the representations gained from a real construction site is worthwhile. This leads to a discussion and analysis which counters current BIM research with broader research methodologies in Construction Management and the French philosopher Gilles Deleuze's concepts of the cinema. This approach is not meant to lead to an overly philosophical or arcane discussion about the essential nature of time and duration in BIM. On the contrary, this points to the problematic nature of current BIM development in relation to actual design and construction and suggests the need to look at BIM innovation in a different light; by proposing the potential of new methodologies for BIM research in the field of Construction Management.

### **BIM in Recent Construction Research**

As the BIM industry has arisen as numerous, and in some ways glamorous, case study images are published and promoted as examples of successful BIM implementation. Riese (2011) highlights screenshots of various tasks related to the model for the One Island East project in Hong Kong. The colours employed are seductive and this is a key feature in numerous BIM screenshots. A shimmering green is contrasted with yellows for services and purple. The viewpoint is from a point looking above or below and is positioned to emphasise the overlapping of different systems and suggests a layered complexity constituted by the juxtaposition of many different small scale construction elements. With these images as support Reise (2011) claims that BIM can improve workflows through clash detection and coordination, better two dimensional drawing extraction, automated quantity take-offs, supply chain integration and Facilities Management integration. Rowlinson et. al. (2010) examine two BIM implementation case studies. They argue that the opportunities of traditional 2D design is outmoded by BIM practice. They contend that BIM implementation will mean that effort, and hence time, in the construction lifecycle will shift from being centered on the construction phase to being centered on the design phase; BIM means that more decisions will need to be made earlier in the design and construction process. They publish two BIM diagrams. One figure depicts a low viewpoint of a BIM model with all the layers switched on while the other shows a user interface highlighting the capabilities of BIM in relation to clash detection. They claim that BIM has now progressed beyond 3D representations to encompass 4D representations (Rowlinson et al, 2010)

### **BIM visualisation and design**

One of the key areas in which representational and visualisation issues come into play is in the area of design. Iterative hand drawing or sketching is central to design practice. But, Ambrose (2012) argues that BIM represents a new mode of visualisation that will overwhelm traditional conventions and working tools of abstract design thinking such as the "traditional conventions of communication; plan, section, elevation". In this view, BIM is a radically new tool for abstract design thought because of its "ability to virtually simulate the building construction and architectural assemblage" and "is perhaps the most important transformation and architectural production in the last several hundred years". Ambrose proclaims that "Every other discipline that has adapted simulation as its primary model of design and fabrication has benefited from increased efficiency and economy. Simulation is the destination of contemporary digital design" (2012). He illustrates this argument with three figures

from BIM models. Paradoxically, each one is not dissimilar to traditional axonometric or isometric orthographic projections. Nevertheless, each one shows how BIM can replicate abstract design thinking by showing both separately and in combination different building elements.

Lean Construction has also emerged as a domain where BIM's visualisation potential has been identified, and researchers have argued for a natural fit between these two paradigms. Sacks et. al., (2010) propose that a "synergy exists" between BIM and Lean Construction and explore this conjunction of synergies through a comparative matrix comparing BIM "functionalities" with lean "construction principles" and then identifying constructive "interactions." In identifying the common theoretical fundamentals of each paradigm, the result is the improvement of construction processes "beyond the degree to which it might be improved by application of either of these paradigms independently" (Sacks et al. 2010). This conceptual alignment between BIM and Lean Construction is further elaborated in a CIRIA guide which argues that Integrated Project Delivery (IPD) is where Lean Construction and BIM reach maximum potential (Dave et. al 2013, Raisbeck et.al., 2010).

Like Ambrose (2012) Dave et. al (2013) also argues that BIM visualisation is superior and that "traditional design methods do not support sophisticated and accurate visualisation or rapid iteration and evaluation of ideas that will help clients decide the option(s) to select." Invoking parametric design and seeming to limit and lock in strategic or conceptual design they state: "The Lean and BIM processes and tools not only provide a much more accurate and sophisticated 3D visualisation capability, but also help evaluate the options from a range of criteria set by the client" Dave et. al (2013) Echoing an anti design sentiment they argue that conceptual design work will be contained because once a design has been formed under BIM it will not change: "Through parametric design and collaborative processes, the value loss is minimised when the conceptual design is passed along to later stages" Dave et. al (2013).

### **BIM representations and spatial information**

Perhaps because of its seductive visualisation capabilities BIM has been linked to other visually rich modes of digital technology that embody spatial data such as GIS and computer games. These new forms of digital-technical visualisation can be distinguished from socio-technical systems. This is because BIM in that they concern the flows to, and the interdependencies between, digitised data and information and physical construction technologies and processes. For example, in identifying the migration of architects to BIM from CAD formats, Yan et al. (2011) look at the possibilities of linking BIM and game engines into design visualisation. A socio-technical interaction between people and users is eschewed in favour of digital-technical interactions. Like a computer game a play process developed by Yan et al. (2011) is centered around a BIM model that is intended to simulate both physical features and life activities. Characters are embedded into the model as virtual building users and they can then access the game space from either an avatar viewpoint or third person viewpoint located outside of the screen image. But, the primary digital-technical representational mode of the game is an "omnipresent" viewpoint. in what is described as, a "photorealistic" mode. Yet, the rooms of this game space are limited visualisations of a residence which is claimed to be a "customised building" with a "realistic environment." The published images of the environment that have been created by this method have a low ceiling and the slabs or slices of space that are depicted are not unlike those find in computer games such as the World War II themed 3D game Wolfenstein ( ID Software, 2009)

In a similar vein Wang et al. (2012) develop a framework for integrating BIM with Augmented Reality (AR). Their aim is to create a digital-technical visualisation that enables construction activities to be “visualised in real-time”. They contend that using BIM and AR together can provide subcontractors with an interactive model that can be used to understand details and aid on-site design. Jiao et al. (2012) also examine AR in a BIM context that is linked to the cloud and social networking services. They provide proof of concept of this connection. But as they note few AR applications have been designed to link to either BIM or even Project Management tools. Irizarry et al. (2013) pursue digital-technical processes by considering how supply chain processes can be enhanced by linking GIS systems with BIM order to track materials in supply chains. In their research diagrams these researchers use a case study approach in order to establish the data and visualisation capabilities of linking BIM and GIS in a single model. This enables building product data from manufacturers to be linked to GIS in order to facilitate the mapping of costs, ordering, transport, warehousing. These researchers depict the construction supply chain network as being linear: directly running from the design phase to the construction phase without any iteration or feedback loops.

Becerik-Gerber et al. (2012) also see possibilities in BIM being linked to and supporting Facilities Management information systems. Through an online survey and 22 expert interviews with FM professionals they highlight the synergies between BIM and FM. The areas of benefit were seen as locating building components and creating Knowledge Management databases using information from a BIM model. Digital-technical visualisation is a central theme of this study and the authors illustrate this argument with a depiction of a BIM based digital interface. This shows a simplistic orthogonal three story structure with columns beams and floor plates reminiscent of Corbusier’s Domino house prototype. BIM’s efficacy and potential also extends to construction safety. Zhang et al (2012) argue that BIM has a role to play in construction safety and they develop number of algorithms that can analyse a BIM model to detect and suggest solutions to safety hazards.

### **BIM and 4D simulation**

As early as 2007 Tulke and Hanff (2007) argued that 4D simulation in BIM models had the ability to visualise complex time scheduling of data which would ordinarily only be available in quantitative spreadsheets. They claimed that in BIM practice their approach would compress time and assist project managers in optimising construction processes. To this end they proposed a new 4D simulation approach to enable the creation of time schedules and 4D simulations using data stored in a BIM model. They came to this conclusion by attempting to create a 4D model which connects together what they call a CAD or BIM product model with a time schedule process model (Tulke and Hanff, 2007). More recently, Kim, Kim and Kim (2013) look at how 4D CAD models can be easily updated. As they note updating 4D CAD models can be time consuming because this is not a workflow automated by software. In order to overcome this they propose a image processing methodology that uses site image data, employing filters and image templates, which is compared to the projects 3D CAD reference model. They explain this research using a deck segment of a cable-stayed bridge structure. The entire process is described in the research using a series of screen shots that are limited to 3D CAD models, excel spreadsheets and graphical user interfaces. In separate research, Kim, Kim and Kim (2013) develop a method for measuring construction project measurement using a 4D BIM model linked to 3D data gained from remote sensing technology in the form of laser scanners. This research

claims that it's contribution is to go beyond previous methods based on simple geometric and scheduling information.

### **Seven deadly sins of BIM**

Whilst much of the research into BIM emphatically argues that BIM is a digital-technical paradigm which will revolutionise design and construction there are still voices that counter this view. Bynum et al. (2012) point out that very little BIM research focuses on sustainable construction. In support of this they develop a survey to ascertain expert opinion. They find that "sustainability was not a primary application of BIM and that project coordination and visualization were instead more important." They go on to write that "Although BIM is perceived as a multidisciplinary tool, problems with interoperability continue to persist among the various BIM applications in the industry" Bynum et al. (2012). Khosrowshahi and Arayici (2012), in research assessing the level of BIM implementation and maturity in UK construction, describe a diagram that structures BIM maturity and implementation into 3 stages. In a comprehensive study the authors devise a roadmap for BIM implementation in the UK industry concluding that there is no evidence of BIM use at the penultimate maturity level. In other countervailing research Sebastian (2010) examines BIM using hospital building projects and concludes the full complement of BIM functionalities has not been utilised in these complex projects

Holzer (2011) brings some useful analysis to the fervent claims of BIM proponents commenting on the gap between fervent BIM idealists and the practicalities of BIM design practice. Using a number of research resources based on his own experience Holzer identifies "Seven Deadly Sins" of BIM implementation. These include: privileging software implementation over an organisation's design culture and ambiguity around the actual productivity benefits of BIM, Holzer also questions the data on which the MacLeamy graph is based as well as its conceptual underpinnings. Holzer notes that collaboration between disciplines between early design stages is problematic. This is due to the difficulty of using BIM models to quickly test and evaluate different conceptual design options (Holzer, 2011). Clearly more research should be done on the MacLeamy graph's premises.

### **Construction site comparison**

A new Faculty building being constructed at Melbourne University serves as a useful point of comparison to the representations that characterise BIM research and marketing. This alternative viewpoint is constituted by 3 timelapse cameras in different positions take hourly images as the building is constructed. To date (June 28) these cameras have documented the demolition of the building and the excavation of the site for the lower floors. What distinguishes these representations and images is the fact that one is witness to a performance of machine and people. Over the time of the photographic sequence there are tracks and traces which do not appear to follow any particular order. The telescopic crane positioned on the site does not follow a simple sequence of movements. The amplitude of its movement from east to west is not consistent and the time lapse images give the impression that the crane is moving as a result of the wind. Similarly the movement of demolition workers and other equipment in and around the site do not follow predetermined linear tracks or production lines. Whilst the risks in this process have been carefully managed and anticipated the time lapse photography and video stream indicates that the actual movement on site is not the result of predetermined production techniques but the result of stochastic processes and random performances.

## DISCUSSION

A dichotomy emerges in the published BIM research between two different types of images. On the one hand there are many seductive images of BIM models. But, the representational modes of BIM research are limited because on the other hand many of the rendered 3D CAD buildings linked to BIM models are often very simplistic and naive orthogonal designs. Often these designs seem to have been developed as simplistic projections of plans. Perhaps it is harsh to expect more of research diagrams and examples but these are at odds with the BIM models of complex buildings that are shown as exemplars. These representations often rely on colorful computer graphics which present singular, static and complete—rather than incomplete—images of a particular project that has used BIM. BIM animations and simulations in the public domain such as those found on YouTube and as promotional images of software also appear seductive and unambiguous in what they present. In the research literature, it is the new architects of BIM, the software coder, CAD operator or BIM engineer whose viewpoint is often seen as being paramount. Other subjectivities of either the model itself, multiple viewpoints or the avatars embedded in the models are never presented. The diagrams of the IT architecture of BIM processes in the literature often have at their centre a digital-technical entity called the BIM model. The BIM model is a largely static and centralised conceptual entity. It is often described as a component of a flow chart. It is usually represented as an object that is complete and well formed. The BIM model is conceptualised as a black box into which everything connects from which representations emerge. In all of these representations non-linear or stochastic notions of time are not often considered in the research discourse.

Given the increasing prevalence of digital-technical processes and workflows in design and construction new research methodologies, instruments, and perspectives are required. As argued above the prevailing discourse on BIM has viewed project time and conceptions of time as simply being about speed and compressing activities into smaller and smaller time frames. Time is regarded as being linear and a part of a production or manufacturing line process. Design and construction workflows are seen as sites where an all powerful operator manipulates a screen image and linked database. There is no iterative work or feedback loops between new and so-called old design techniques conceptual drawing and sketches simply cease to exist in this context. In current BIM research the building model or object, as it is represented, is not seen as a spatial entity embedded in cultural milieu. Instead the diagrams and representation of buildings in this research skip between glamorous images of a BIM future and simplistic buildings embedded in graphical user interfaces. The actions that take place in these screen based models are highly prescribed and robotic. There are no traces of random or stochastic processes of movement in these theatres. BIM models are rendered as being complete solutions where there are no mistakes and ambiguities in the construction processes that 4D BIM and AR models hope to mimic. They are closely related to the lineage of lean construction with its intellectual in product manufacturing.

As noted by Pink et al. (2010) some of the ethnographic methodologies developed in the social sciences are occasionally being imported into the field of construction management research. They explicate and explain that ethnographic methods should be rigorously applied in construction research. They note that construction site ethnographies describe how people learn, know, transmit knowledge, and move. Ethnographic viewpoints thus have an aesthetic component in that it might identify the way people move, and vocalise, especially if this movement is the result of craft based

knowledge and traditional construction practices. Traditional ethnographic research methods focused on observation of human agents have now been augmented with participatory, collaborative methods that use new techniques to observe, record, notate, reflect, and test theories as they emerge. In the construction Industry participant observation studies have sometimes involved the researcher participating in the process or workflow that the researcher is observing. Pink et al. (2010) focus their work on safety issues in construction. But their conclusions also apply to digital-technical work practices and point to the need to develop ethnographic methods and critical theory in relation to the rise of BIM. As they argue, ethnographic methods can help us to understand BIM as a ‘shared and embodied form of “knowing in practice”’ (Pink et al,2010) which can help us to understand the workflows and processes of communication involved with BIM implementation.). As Phelps et al. (2009) note, qualitative-theory building methodologies and ethnographic methods aligned with ethnographic studies offer a different and necessary viewpoint to quantitative and positivist research methodologies. Alongside these perspectives, the predominant digital-technical nature of current BIM research and practice may also be usefully interrogated by viewpoints from critical theory and philosophical traditions. As Brown and Phua (2011) argue in a discussion of the concept of identity in construction research there is a need for ‘multi-layered, nuanced, unfolding and dynamic relationships between self, work and organization.’

The French Philosopher Gille Deleuze’s encounter with cinema is a useful critical framework in this context. Deleuze wrote two philosophical books about cinema. Deleuze saw cinema as a “new practice of images and signs, whose theory philosophy must produce as conceptual practice.” (Deleuze, 1989, 1985: p.280) Deleuze’s concern is not a philosophical investigation of cinema’s essential nature. Deleuze did not simply proclaim cinema as a technological revolution. Rather, he was interested in interrogating the cinema for its possibilities about what it might become. (Rushton, 2012) As Rushton notes, Deleuze argues that cinema establishes the problems of traditional subject orientated epistemologies. Deleuze cites Henri Bergson as a philosopher who opposed a view of the world that is predicated on a static and centred viewpoint or subject. Deleuze sees in Bergson a philosophy that accounts for the early technological advances of cinema as well as anticipating its later developments. But, Deleuze also sees the cinema as constituting a language of images. Deleuze’s conception of image is something which is neither representation, secondary copy, imitation or mimesis. These perspectives suggest that construction R&D should oppose a concept of BIM that privileges linear sequences, singular perspectives and robotic notions of construction that ignore the randomness of craft. As Simone Brott notes in her investigation of Deleuze and architecture states ‘Deleuze saw the cinematic image not as a picture or representation of something but an entity with the presence of both colour and movement.’ (Brott 2011) BIM should be theorised in a multi-layered and nuance way which accords with Deleuze’s philosophy of cinema and: “puts into play a moving image, a moving image in which the centre of the image is also constantly in movement: a camera which moves, editing which constantly shifts the centre of perspective and emphasis of the shot, an emphasis which might at one moment be seen from one character’s perspective, at the next moment from another’s, then from the perspective of no character at all” (Rushton, 2007)

## **CONCLUSION**

The above considerations suggest that new methodological approaches are needed in the area of BIM research if BIM is to reach it’s full potential as a tool which saves

resources and allows better design outcomes and project risk management. Future BIM research needs to recognise the power of different representational modes, stochastic and random events, social milieu and avoid seeing a building as a simplistic digital-technical object or diagram linked to a database. Stochastic processes which are random and are capable of using agents and swarms to predict what will happen within BIM models may reveal more than the static and mechanical models which plague BIM research today. Notions of time should be seen as being multi-layered and interdependent of sequential BIM animations and screenshots. BIM models should be conceived as entities which develop over time from the beginning of the design process where there is a iterative transfer of information between designers, teams, and 3D representations of buildings built in computers. In BIM research ethnographic approaches and critical theory should be employed to ensure that future designers and builders do not relinquish their canon of knowledge regarding the craft of building as the industry moves to digital databases.

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# DESIGN STRATEGIES FOR A FUTURE CLIMATE: A QUALITATIVE COMPARATIVE ANALYSIS

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Following on from international efforts to reduce carbon emissions and mitigate climate change, there is growing recognition that some change is inevitable and a degree of adaptation will be required. Beginning in 2009 the Technology Strategy Board provided funding for 50 live projects to undertake climate adaptation studies of their designs; 24 of the studies are now complete and provide insightful case studies of current practice in adaptive design. This study problematizes the applicability of existing construction management analysis tools to such a problem, proposing qualitative comparative analysis (QCA) as a rigorous and replicable alternative. Through describing the actual practice of the method by application to the problem of adaptive design in non-domestic buildings the paper explores both the benefits of a systematic, repeatable method when working with large data sets and ill-defined concepts, and reveals the 'hidden' data reduction that such an analysis requires.

Keywords: adaptation, climate change, design, non-domestic building, qualitative comparative analysis.

## INTRODUCTION

It is now recognised that regardless of the success of current and future mitigation efforts, some level of climate change is inevitable (Jenkins et al. 2009). In the UK this is likely to mean warmer, drier summers, milder winters and general increases in the unpredictability of weather events that will result in an increased summer overheating risk, lower demands for winter heating, more frequent flooding and the possibilities of drought and clay heave related subsidence (DEFRA 2012). While change is predicted to be gradual over the next century, this presents an immediate challenge for our built environment because of its long lifetime – buildings constructed today typically have design lives of 60 years; many will be expected to remain in service beyond this.

Construction researchers have begun to address this challenge through the provision of climate data in a format familiar to designers (Eames, Kershaw and Coley 2010) and commentary on how it might be best applied to generate an accurate picture of risk (Kershaw, Eames and Coley 2011). Similarly climate impact studies (see de Wilde and Coley 2012 for a good list of examples) are describing how we might best design for resilience. However there are few, if any, efforts to describe reactions to emerging policy measures or the emergent climate change design guidance. While we are developing a picture of what designers could do, we know very little about what they are doing. How are designers reacting to climate change risk? Is this concurrent with academic findings? Are building designs changing as a result?

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Beginning in 2009 the Technology Strategy Board (TSB) initiated a funding competition entitled 'Design for Future Climate Change'. The competition provided funding of up to £100,000 for live building projects to undertake climate adaptation studies and deliver recommendation reports (TSB 2011). Eligible projects included both new build and refurbishments with a contract value exceeding £5M which were able to demonstrate "low impact goals" (e.g. BREEAM Very Good, or higher, aspirations). The funded projects created large volumes of readily accessible information: TSB adaptation reports, planning applications (available from the relevant local authority planning portal), construction media articles and online publicity material. While the provision of funding and the nature of the competition introduce an element of artificiality, the projects nonetheless represent a unique opportunity to study design for adaptation 'in action'.

We find ourselves in possession of a socio-technical problem, a type increasingly important to construction researchers (Oreszczyn and Lowe 2010), and a 'ready-made' rich data set with which to address it. What we are also presented with are obvious problems with using traditional construction management methods developed for large random samples or comparative case studies. A quantitative treatment of the data is problematic for both methodological and practical reasons: methodologically, while we could reduce the data using quantitative methods, applying content analysis or extracting structured variables, this would undoubtedly overlook the social, qualitative complexity of any design process. Practically, the data set both lacks the random sampling requirements and is too small for meaningful statistical analysis.

Considering we have a rich, mixed data set and a desire to reflect real practice, rather than practice under ideal conditions, a case study approach seems more appropriate. Compatible with the use of multiple data types the case study provides a means to examine the complexity and depth of the data. A multiple case study approach (Yin 2003) allows for contrasts and differences between the cases to be brought to the fore and potentially demonstrates a "more compelling" (Yin 2003) evidence base on which to base conclusions, yet case research is intensive and resource demanding (Yin, 2003; Eisenhardt 1989) and there is a risk that theorists lose "their sense of proportion as they confront vivid, voluminous data" (Eisenhardt 1989). Thus, what is required is a method for the middle ground, which allows us to deal with complexity in a manageable way without entirely decomposing it. This paper proposes qualitative comparative analysis (QCA) as a potentially useful bridge.

## **QUALITATIVE COMPARATIVE ANALYSIS**

Qualitative comparative analysis (QCA) is an alternative, set theoretic approach to case study research that maintains the view of cases as holistic entities (Rihoux and Lobe 2009), but allows for a larger number of cases to be considered and compared. In the context of a field where it has been observed there is unlikely to be a "one size fits all solution...but rather a range of multiple pathways" (Williams et al. 2012) to climate proof buildings, QCA is appealing because of its acceptance of multiple pathways to the same outcome (Rihoux and Lobe 2009; Ragin 2008) and deliberate emphasis on exploring diversity (Ragin and Amarosso 2011). Developed by Charles Ragin during the 1980's (Ragin 1987) and subsequently refined (Ragin 2002; Ragin 2008) the method is now well established, if not widely used, in the fields of comparative politics and some social science disciplines and has attracted recent interest from built environment researchers in the US (Gross and Garvin, 2011a, 2011b, McAdam et al. 2010; Jordan et al. 2011; Chan, Levitt and Garvin 2010).

QCA has been described as a method that “starts by assuming causal complexity and then mounts an assault on that complexity” (Ragin 1987), highlighting two important aspects of QCA as an approach: firstly that it provides a means to selectively reduce the complexity of case data enabling comparative analysis across a greater number of cases than might otherwise be possible, but secondly that it does so in a way which is explicit and replicable. Thus, QCA is a systematic process and comprises a number of ordered steps through which to proceed. Yet it is also iterative (Berg-Schlosser and de Meur, 2009); researchers are encouraged to revisit both what constitutes a case and those conditions which are considered relevant to the outcome in light of the case evidence. Figure 1 visualises the key stages and highlights the main iterative loops.

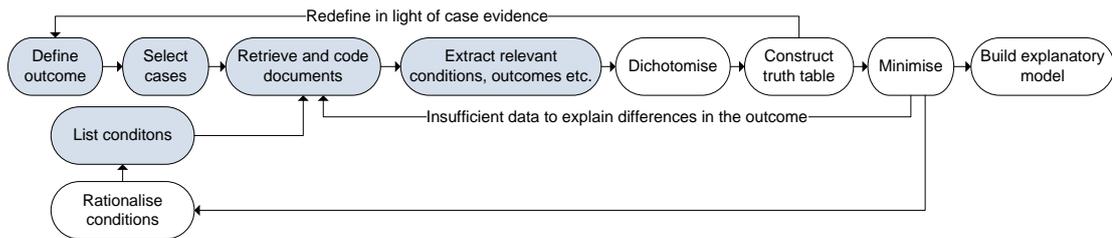


Figure 1 Graphical representation of the intended research process. Blue boxes indicate external theory.

This paper presents the preliminary stages of a method ‘experiment’, designed to test the applicability of QCA to construction management and design problems such as outlined above. Descriptions of the initial stages (shaded in figure 1) are provided below; readers interested in the latter steps will find comprehensive but accessible introductions in Ragin (2008), Rihoux and Ragin (2009) and Jordan et al. (2011).

## DEVELOPING A QCA RESEARCH DESIGN

In the absence of a working familiarity with QCA analysis, a number of avenues were pursued to enable construction of an appropriate approach: formal methods training, a literature review of QCA studies and a study trip to meet with other researchers in comparable disciplines currently undertaking, or supervising, QCA analyses. The review focussed on exemplar studies identified from QCA textbooks, studies from the construction sector and other studies that aligned well with the proposed approach (see appendix 1 for a full, referenced listing) and forms a reference point for common practice. Due to advantageous timing the study trip was able to garner feedback from Charles Ragin on the outline research design at an early stage. All of these activities helped to formulate the approach outlined below, which details how the typical QCA steps were operationalized in the context of this climate adaptation design study, paying particular attention to aspects of the method that require a thoughtful approach in order to transfer the method successfully into a construction design setting.

### Defining the outcome

The initial step of any QCA analysis is to define the outcome of interest, a process broadly comparable with defining a unit of analysis in replication type case studies (see Yin 2003) in that it defines what the cases are to be cases of and sets the boundaries for the study. This study is concerned with the nature and success of climate adaptation activities in buildings. Given that buildings typically have design lives of 60-100 years, we define success as the continued usefulness - through resilience and/or adaptive capacity - of a building to the end of the century.

Having decided on what we consider adaptation to be, it is also important to understand how we will observe, or measure, it. Since simply waiting to assess each building's performance in a future climate is infeasible, metrics are required that assess the as-designed building. At a national scale the Adaptation Sub-Committee (ASC, 2011) has developed a range of indicators to assess progress on adaptation in the built environment. While these measures are no doubt helpful in assessing movement towards national preparedness, being designed to observe trends rather than absolutes they are less appropriate for the judgement of individual buildings at a single point in time.

At the building scale, assessment of adaptation to climate change has largely centred on thermal comfort; de Wilde and Tian (2011) provide a good overview of the range of metrics employed by these types of study and demonstrate the current lack of consensus. There are limited examples of attempts to define more holistic methods for assessing the adaptation potential of the built environment. Pyke et al. (2012) attempt to utilise existing sustainability metrics in the form of LEED credits, but while this metric represents a useful step towards holistic measurement of climate adaptation and its addition into mainstream sustainability assessment, its reliance on LEED criteria used by only a minority of UK projects annually negates its adoption for this study.

In the absence of a single, coherent metric, a composite success measure using the available indicators and qualitative interpretation is proposed (Table 1). The assessment constitutes four aspects, in an attempt to both compensate for deficiencies in any single approach and provide a limited form of internal consistency.

*Table 1: Climate adaptation success metrics*

Definition	Evidence Source
Is the report consistent with current climate adaptation guidance?	Comparison of recommendations made to metrics currently found in the literature, and compliance with leading guidance.
Do the Technology Strategy Board, initiators of the competition, believe the project was successful?	Interview with TSB representative, to include a discussion of how they define success.
Does the report suggest that the project's undertakers believed the measures suggested successfully managed future climate risk?	Excerpts from the reports themselves, validated by project actors through interview where practical.
Is there evidence the required measures would be installed and/or form part of the detailed design?	Project reports (TSB requirement to state adopted measures).

The final outcome specification step is to determine how the metric will be applied to allocate cases to one set or another: calibration. Metrics are calibrated such that they are meaningful; they should relate to external standards that make them interpretable in a qualitative sense (Ragin, 2008). This allows for us to go beyond comparison (X is more than Y, X is less than average): a calibrated measure defines what is 'successful adaptation design', and what is not.

QCA has come under sustained attack for this process which is seen as artificially truncating the diversity of a sample (Vaisey 2009) and rendering an overly simplistic view of rich, qualitative ideas. In response the original crisp set QCA (csQCA) was revisited, resulting in the three variants on the original method now in existence: csQCA, multi-variate QCA (mvQCA) and fuzzy set QCA (fsQCA). fsQCA draws on

fuzzy logic to allow cases to be allocated membership of a set on a partial scale (see Ragin, 2008). Despite these improvements the criticism remains and it is considered that an alternative response to the complexity of fsQCA is more appealing: any method of qualitative analysis necessitates some form of reduction, and QCA both does this in a way that is compatible with people's general methods of making sense of the social world they inhabit (categorisation) and does so in a manner that is transparent rather than developed through an opaque analytical process. This idea of transparency is particularly appealing to a built environment application where many concepts still lack consensus in definition and metric (e.g. value, design quality). QCA ensures a contribution to the debate on appropriate metrics through an explicit presentation and justification of the approach adopted.

For the purposes of this methodological 'experiment', csQCA was selected on the basis that it is considered the most easily interpreted and that it can be accomplished with the smallest case set (Gross and Garvin, 2010). Preliminary attempts were made to specify the means by which cases are to be allocated to the success set, paying particular attention to good practice in calibration: be transparent when justifying thresholds, ideally justify thresholds on substantive or theoretical grounds using mechanical cut offs as a last resort (Rihoux & De Meur, 2009). However, because calibrations should 'make sense' in relation to the data (Rihoux & De Meur, 2009) data collection included the amassing of information on how the cases themselves were 'measuring' success – comparisons made, benchmarks mentioned etc.

### **Sampling**

QCA is described as applicable to "medium N" studies meaning that it is applicable in the range between theoretical replication type case studies and the probability samples of generalising quantitative methods. Samples in QCA are constructed rather than given (Yamasaki and Rihoux 2009) – they are purposeful. The intention is to create a sample which is sufficiently homogeneous to allow sensible comparison, while demonstrating sufficient diversity (in outcome and the conditions of interest) to allow for a thorough understanding of the conditions in which a given outcome does and does not occur. Case selection is also an iterative and incomplete process – cases may be added to and removed from the analysis at any point on the basis of the case evidence of what is relevant to an understanding of the problem. While this is helpful in suggesting that any initial decision on case selection need not be the final one, it provides little guidance on a suitable starting point – should we assume 5, 10 or 20 cases? To infer standard practice, the sample sizes of existing studies were reviewed. This revealed (Fig. 2) that in practice, samples of between 10 and 20 were most common, although one outlier study (not shown) consisted of over 2000 cases.

On the basis of the review it was decided that circa 25 cases would be appropriate. This allows for some cases to be excluded during the case definition refinement process (by the inclusion of a considerable 'buffer' in data collection activities – given sufficient diversity 10 cases would be permissible) while allowing for limiting the study to those projects for which the TSB competition was 'complete' at the time of data collection activities (Oct 2012 – Apr 2013).

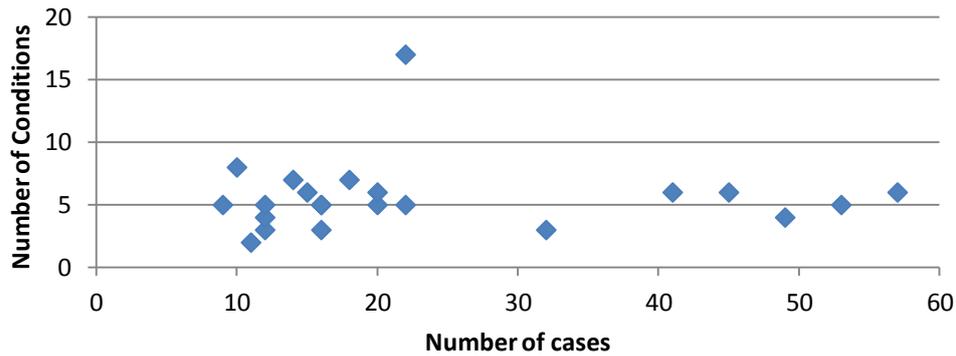


Figure 2 QCA studies review: case populations and causal conditions

As a partial aim of this study was to test QCA's applicability to the selected data set, features of the data set were compared to sampling best practice: the importance of sufficient diversity to ensure explanatory strength in the QCA minimisation (Jordan et al. 2011) and retaining a sufficiently bounded case set to enable comparison. On considering the TSB cases it was realised that several of the projects were masterplans rather than isolated projects and as such adopted a spatial scale approach that made them distinct from the wider case set. Similarly projects that made use of multiple, single family dwellings were excluded on the basis of having a significantly different approach due to the scale of the buildings they considered. On the question of diversity, assessing the TSB cases was more problematic; given the comprehensive-inductive approach to condition selection this study adopts (see below) a complete a-priori framework against which to assess diversity was not available. The TSB data set does however demonstrate a range of project sizes and types, a mixture of new build and refurbishments, client types and procurement approach and the projects were undertaken by different combinations of designers. As such, it was considered the TSB cases were as likely as any other constructed sample to demonstrate diversity and the use of a subset of the available cases would allow the inclusion of additions if deemed necessary later in the analysis.

### Selecting Conditions

For the purpose of complexity reduction QCA relies on the identification of factors that influence the outcome: conditions the outcome is contingent upon. Yamasaki and Rihoux (2009) list several ways that this may be accomplished: comprehensive, perspective, significance (statistical), second look, conjunctural and inductive. Perspective, second look and conjunctural approaches rely on the existence of theory in the area to be studied and were dismissed on the basis of an absence of a coherent theory of adaptation in the construction literature. Instead a comprehensive-inductive approach (Yamasaki and Rihoux 2009) to condition selection has been adopted. This draws on adaptation literature, while allowing for the latter addition of conditions drawn from the cases themselves. This latter feature was considered important given recent comments by those such as Nicol and Stevenson (2013) on the necessity for research to be informed by the practice of adaptive design.

For the comprehensive element a detailed literature review of both academic and practice adaptation literatures and also more general studies of design process was undertaken to identify all factors influencing the successfulness of an adaptation design process. This produced a long list that was condensed to remove duplication. In accordance with good QCA practice (Berg-Schlosser and De Meur, 2009) a note

was made as to the likely effect of the condition on the outcome. This condensed list formed the base code listing for the preliminary data analysis and is in line with Miles and Huberman's (1994) suggestion to begin data analysis with a preliminary list of codes. The inductive element followed a similar logic but applied to the case data: new conditions were added in accordance with the qualitative data handling procedures detailed in a comprehensive case protocol.

This process produced an extensive number of codes on the first pass. Returning to figure 2 we see how almost all the studies limited themselves to between four and six conditions. This highlights a key limitation of QCA: while it is necessary to sample for as much of the diversity existing in a population as possible, this diversity expands exponentially as the number of conditions included in the analysis increases: four conditions can be combined in 16 (24) ways, six conditions in 64 (26) ways. Beyond circa 10 conditions the 'logic space' becomes so large as to render any increase in the number of cases meaningless. This means we are limited to problems explainable with a limited number of conditions, perhaps undermining QCA's assertion of retained complexity (Ragin, 2008) somewhat, or we must choose to examine only those variables of significant interest. Assuming the latter, there is a realisation that QCA is not a panacea for data reduction and as Coverdill and Finlay (1995) note, "one cannot use QCA until quite a bit of thought and analysis has been completed".

### **How do we decide which conditions are important and which are not?**

The problem of too many conditions is by no means novel for QCA theorists, and various methods for reducing the number of conditions have been suggested including Schnieder and Wagemann's (2006) formalised MSMD (most-similar, most-different) method. We opted to first apply qualitative techniques to group and condense our data, before confronting the results with the extant literature to further direct our search. We then propose to follow Yamasaki and Rihoux's (2009) example, subjecting the condensed listing to an iterative process of "many preliminary tests".

Due to the volume of documentary material (around 800 documents) we followed Dainty et al.'s (2000) example and employed NVivo for data management and retrieval. We then, as Coverdill and Finlay (1995), resort to "old fashioned techniques" of qualitative analysis. The use of NVivo as an interim recording mechanism, rather than the direct transposition of data to condition tables etc. enabled a return to information easily: node content could be extracted to Microsoft Word allowing for a further round of manual coding and database queries could be used to retrieve data with which to construct timelines, organisational trees and case vignettes in an attempt to elicit key themes. Future work will operationalize and calibrate the identified conditions to enable selection of those most relevant to the problem domain.

## **CONCLUSION: REFLECTIONS ON THE METHOD EXPERIMENT AND ITS APPLICATION**

This paper has outlined the initial stages of a 'method experiment' to test the applicability of QCA to a complex socio-technical problem. QCA was initially seen as a way of systematically and efficiently managing the inevitable data reduction process. However, QCA requires considerable 'up front' data processing and, in the case of an inductive approach (not well represented in existing QCA studies), analysis too. Yet if structured rules are adhered to, QCA appears to provide a methodical and transparent way in which to perform data reduction. While this systemisation could be problematic in the context of a research problem with vague, ill-defined concepts, it

was beneficial in forcing the development of a thorough understanding of what was meant by adaptation and project success, and how they might be best operationalized. While the QCA literature tends towards social concepts that come with pre-defined indicators, this experiment has demonstrated the plausibility of an involved metric creation stage where measures are less well defined. This finding should resonate with the wider QCA community, as should the analysis of sample size practice in QCA studies. In relation to the specific socio-technical problem at hand - to better understand the effectiveness of design strategies for mitigating future climate change effects - we conclude that QCA has potential for application to problems in low carbon and energy reduction fields, and especially those that require hard, technical data on consumption and building characteristics to be studied in their social context (see Oreszczyn and Lowe 2010). However, further work will be required to fully understand the effects of the data minimisation process on the efficacy of the design principles which emerge from such an analysis.

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## **APPENDIX 1:**

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# MAKING CHANGES IN PRACTICE: AN ETHNOGRAPHIC STUDY OF A HOSPITAL PROJECT

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Changes to client requirements are inevitable during the construction phase of a project. Dominant industry discourse is concerned with minimising and controlling changes. However, there is a lack of understanding about processes of making changes. In response to calls for more research to be undertaken into working practices, the aim is to explore how changes are made in a live project. An ethnographic study of a public hospital project was undertaken over an eight-month period in order to gain insights into these practices. It was found that there was a strong emphasis on following contract change control procedures, partly as a means of demonstrating best-practice and ensuring accountability, which was deemed to be important in the public sector project. However, it often overshadowed considerations about whether or not a change was required in terms of the functionality of the building. Drawing upon structuration theory, these practices were the product of, and reaffirmed, structures of legitimation in the construction industry and the public sector concerning change management. This representation of making changes highlights how contract procedures can be useful and insufficient and where attention can be focused to explore better change management practices.

Keywords: change, ethnography, practice, project management, structuration theory.

## INTRODUCTION

The phenomenon of change in construction projects is widespread and familiar. Project changes are often regarded as inevitable (Cox *et al.* 1999, Stocks and Singh 1999, Sun and Meng 2009). Indeed, the presence of specific clauses in standard forms of construction contract endorses this stance (Cox *et al.* 1999) as they provide standardised mechanisms by which to manage project change. The contract provides an important benchmark with which to define and evaluate project changes when they occur. Changes occur for many reasons. For example, as a result of a client change to requirements, in response to changing material availability, or due to unforeseen ground conditions. Client changes to contract requirements during the construction phase are the focus of this research. There is a dominant discourse in the construction industry that changes are detrimental during this stage of a project due to the potential time and cost implications for the client. Moreover, the focus of existing construction management (CM) research highlight these concerns by focusing on the causes and effects of changes with the intention of reducing the likelihood of their occurrence, which perpetuates the discourse. From the literature, it would appear that there is

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limited understanding of the process of making changes in a project. However, there is a growing body of CM literature adopting ethnographic approaches to understand the lived experiences and practices of people in project settings, which provide a highly immersed way in which to explore project change. Giddens' structuration theory provides a useful lens through which to relate observed patterns of practices to the structures in which they take place and are reproduced through ongoing action. The aim is to explore processes of making changes in a live project. This study provides theoretically informed insights into practices around making changes which challenge and reaffirm practical understandings about contract change control.

## **CHANGES ON CONSTRUCTION PROJECTS**

A change refers to “an alteration to design, building work, project program or other project aspects caused by modifications to pre-existing conditions assumptions or requirements” (Sun and Meng 2009: 560). Changes are common, their causes are numerous and they are a frequent source of conflict (Love 2002). Nevertheless, projects with high change costs are still capable of coming in on time and budget (Love 2002), which highlights the importance of how changes are managed. Existing studies use quantitative analysis of actual changes on projects to produce taxonomies of the reasons for changes (Stocks and Singh 1999) and the effects of changes (Sun and Meng 2009). However, these approaches do not provide insights into the processes of making changes. The dominant discourse within the construction industry is that changes during construction are detrimental to a project and that changes should be minimised or, if unavoidable, tightly controlled. There are valid reasons for this view as changes often have time and cost implications. However, this industry discourse overwhelms alternative views of changes. Similarly, governance practices in the public sector are based on a discourse of demonstrating transparent change control and accountability. The discourses of PM best-practice and public sector governance are complementary and advocate strict change control.

## **EXPLORING PRACTICES**

An alternative approach to the “technical rationalism” of much CM research advocates a need to explore formal and informal discourses and practices (Chan and Räsänen 2009: 907). A body of PM research calls for a better understanding of the ‘actuality’ of project based-working by focusing on the routine and complex lived experiences of practitioners in their local environments (Cicmil *et al.* 2006). This builds upon the so-called ‘practice-turn’ in the social sciences whereby phenomena such as human activity and social institutions are believed to occur with the ‘field of practices’. Practices help to understand the shaping of shared meanings: “practices are the source and carrier of meaning, language and normativity. The generation, maintenance, and transformation of these phenomena are achievements of extant practices that are realized in the public realm of actions [...] where these matters are conserved and novelty and transformation take their start” (Schatzki 2001: 12).

From an ontological perspective, by using practices as the focus of study, traditional dichotomies of agency and structure may be transcended. Giddens' structuration theory and the notion of ‘duality of structure’ posits that structure is both “the medium and outcome of the conduct it recursively organizes” (Giddens 1984: 374). Hence human action is influenced by structures; structures exist because they are produced and reproduced by knowledgeable agents. Structures are sets of “[r]ules and resources, recursively implicated in the reproduction of social systems” (Giddens 1984: 377). Giddens (1984: 5) posits that humans are knowledgeable agents who “routinely

monitor aspects, social and physical, of the contexts in which they move". In this respect, structuration theory is suited to understanding the minutia of everyday practices and how shared meanings are constructed by actors (Baert 1998). However, the representation of social meanings involves interpretation, which Giddens refers to as the 'double hermeneutic'. First, descriptions of social systems and action are bound by the frames of meaning of the actors being studied, and this requires the social scientist to interpret these meanings. Second, social scientists are also influenced by other frames of reference, particularly from their research discipline, which imposes additional meanings on the descriptions. Researchers overlay their own meanings on what they believe are the participants' meanings, thereby creating a double layer of interpretation. The concept of 'double hermeneutic' supports reflexive approaches to social science research, particularly ethnographic research, emphasising the need to consider the influence of researchers on meanings they induce from social settings.

### **Ethnography**

Ethnography has "deep and diverse roots" (Atkinson *et al.* 2001: 4) and like other approaches to social research, it continues to develop across disciplines over time. As an intellectual pursuit, ethnography is rooted in early-twentieth century anthropology. From the 1920s onwards it was developed as an approach to sociological research and was widely used by the Chicago School. Classic anthropology studies typically documented the lives of native inhabitants in unfamiliar cultures, requiring the researcher to spend lengthy durations, sometimes several years, in the field. Sociologists using ethnographic methods have tended to study more localised settings but have often focused on understanding unfamiliar phenomena. Throughout the twentieth century there have been many developments in ethnographic research and it is increasingly used in a diverse range of fields. Despite differences in approaches, ethnographic research can be said to be "grounded in a commitment to the first-hand experience and exploration of a particular social or cultural setting on the basis of (though not exclusively by) participant observation" (Atkinson *et al.* 2001: 4). However, many commentators regard ethnography as a written representation of culture and the strategies used to produce this final textual product are an important part of the practice of ethnography (e.g. Clifford 1986, Van Maanen 1988). Hence there are ontological assumptions that underlie ethnography whereby "social reality is presented, not known" (Van Maanen 1988: 7). Central to the representation of social reality is the role of the ethnographer. Choices and biases which influence fieldwork and the writing of the ethnography shape this representation. This has been widely acknowledged within the 'reflexive turn' in ethnography with the recognition of "ethnographic truths" as "inherently *partial*" (Clifford 1986: 7, emphasis in original).

There are many different approaches and literary devices used in writing an ethnography. Differences in textual representation highlight some of the demarcations between ethnography traditions and different theoretical approaches to ethnographic research as an approach to understanding social reality. Van Maanen (1988) classifies approaches to writing ethnography into 'realist', 'confessional' and 'impressionist' tales, with 'impressionist' tales resembling the self-reflexive narratives and thick descriptions used in many contemporary ethnographies. The author of an ethnography represents the voices of those he or she has studied. As such, ethnographies are constructions and not direct reflections of the reality they seek to represent in that time and place. Ethnography is a way of investigating social life and there is no single way in which to undertake this investigation and represent its findings, but different approaches produce different kinds of knowledge (Pink *et al.* 2013: 11). It is highly

suited to gaining an understanding of the everyday practices of people on projects. As each project is affected by the context in which it takes place, practices are said to be embedded and must be understood within this context. Using naturally occurring data to describe how a phenomenon is “locally constituted” helps to unpack the character of a phenomenon (Silverman 2006: 43). There are many ethnographies of working practices in a range of fields and a growing body of CM studies, including Pink *et al.* (2010) and Sage and Dainty (2012). CM ethnographic research incorporate a range of approaches, from classic, long-term studies to contemporary studies in applied settings focusing on the co-production of knowledge (Pink *et al.* 2013). There is a range of representation styles, from extensive narrative descriptions (e.g. Fletcher and Watson 2007) to more targeted approaches (e.g. Sage and Dainty 2012). Nevertheless, ethnography is not widely used in CM research. As such, it is an innovative, highly immersed approach to exploring lived experiences of making changes on projects.

### **RESEARCH PROBLEM**

Our interest is in the process of making changes to requirements on construction projects. The dominant PM and public sector discourses state that changes should be avoided or strictly and transparently controlled. However, changes may be required for many reasons, not all of which are detrimental to a project. For example, changing the specification to create something previously unforeseen that is more useful to the client is a positive step. Exploring practices using ethnography provides insights into the lived experiences of individuals in their local environments and how meanings are produced. Structuration theory goes further by considering how structures are both the medium and the outcome of these human actions. The aim of the research is to explore practices of making changes on a live project. This is important in order to gain insights into practices around how changes are instigated, developed and agreed, rejected or left unanswered, about which our understanding is limited. Understanding project changes remains important, as change clauses continue to be included in standard-form contracts while unchallenged discourses of minimising and controlling changes prevail. Therefore, it is meaningful to gain a better understanding about practices of making changes rather than a preoccupation with prevention and control.

### **RESEARCH DESIGN**

The research was carried out by the first author, Clare Shipton, who composed the first-hand account of her experiences that follows. A new-build public sector hospital project was studied over a period of eight months, following ethical approval being obtained from the University of Reading in accordance with the established procedure. As I already had experience of managing changes in the construction industry, the culture was familiar to me and so a more contemporary ethnographic approach was adopted whereby I attended site several days a week over several months. At the start of the fieldwork the project was in the third month of a 34-month construction programme and it was being procured through a partnering framework that had a ‘design and build’ arrangement using an NEC3 contract. Data was collected through more than 200 hours of observations, 17 interviews and document study. Access to the project was gained through my contacts from my time spent working as a Project Manager for a consultancy firm. My previous experience in this role both influenced the particular choice of study and inevitably influenced approaches to fieldwork. The ‘key informant’ for the study was the Client Project Manager (PM) on the hospital project, whose position facilitated the initial access to the project. It also influenced some people’s attitudes towards me as some saw me as being closely associated with,

and even employed by, the PM's company, an impression that had to be corrected. The majority of the fieldwork was conducted at the Contracting Organisation's site offices, with some time spent at the client's offices. I mostly had a participant-observer role by attending and observing meetings, talking to people and generally being present when they were doing their daily work. With certain individuals, my role was more active and I became someone from whom updates could be requested about the progress of changes. Rapport-building was important and some people were more amenable than others. My age (24 at the time), 'student' status and presumed inexperience were beneficial in getting people to talk about their work. However, my status as a young, female novice meant that some topics were, perhaps, not discussed.

As time went on, it became easier to talk with different people involved in the project. As my knowledge of the changes grew, it provided shared topics of interest and a common language with which to discuss them. In addition, I became a familiar face amongst the project team and so it became easier to be included in, and instigate conversations, with humour playing a big part in signalling insider-status. There were many instances where my outsider-status was obvious, such as when doors were deliberately closed and hushed conversations were held when I was in earshot. These instances generally became fewer as time went on and I was included in more confidential conversations, from commercially sensitive ones to workplace politics and gossip. However, certain people, like subcontractors, remained off-limits. Hence, changes that were being instigated by the client, and were dealt with by the Contractor and their design team, were more visible than changes further down the supply chain between the Contractor and their subcontractors. As the study progressed, certain project changes became the focus of the fieldwork. This iterative process of data informing the ongoing research design is typical of ethnographic research. This approach has resulted in vast amounts of qualitative data about everyday practices which contribute to building an holistic picture of the setting. The data was collected and analysed following a mixture of emic and etic orientations, whereby these orientations are on a continuum rather than an either-or approach (Fetterman 1998). The focus of the study on making changes was informed by etic a priori assumptions based on the literature. During the study a more emic approach was adopted, whereby the making of changes was exploring based on the internal practices used by the people involved in the project. Nevertheless, there is no entirely emic data as the fieldwork was influenced by my experience on the project (professional experience, theoretical assumptions, personal relations and so on). Emic internal insights into a social setting cannot be divorced from the researcher's etic external assumptions. Instead, reflections on the researchers' role and stance can assist in highlighting some of the assumptions around which insights and findings are based.

Observation notes were coded in terms of events, people and changes. Specific changes were coded using emic terms routinely used by individuals in the project team. Each change provides a timeline of the process of making that change during the fieldwork period, based on the information that was available. Analysis was conducted following two approaches: first, the making of specific changes was tracked; second, a general thematic analysis of patterns of practices was undertaken across the study and in the making of specific changes. The findings that are presented in this paper are representative of the second type of analysis, which are one step removed from the field data. Within the constraints of this paper, the findings are presented in a way that highlights connections to the existing change literature and CM discourse in order to discuss practical and theoretical implications of the findings.

Representations of making changes using thick descriptions to unpack specific episodes observed in the fieldwork form part of my ongoing doctoral research.

## DISCUSSION

Despite the construction phase being in its infancy at the start of the fieldwork, the contingency budget for the project was very small. Nevertheless, potential client changes were instigated from the start of the construction period and potential changes were abundant during my time on site. The majority of the changes encountered on the project were client design changes. The benchmark for evaluating the changes was the contract, comparing the potential new requirements against those that were designed, included and priced in the contract. Most of the changes required additional work or specification enhancements, resulting in additions to the contract sum.

### **Controlling changes: “You issue an RFQ, we’ll respond, *then* you issue the PMI”**

The process of making a change on the project was largely based on the contract procedures of which I was aware based on my previous experience as a PM. However, timescales were often extended and there was a lot of upfront work gathering information to determine requirements before a Requests For Quotation (RFQs) for the change could be issued, following which the change could potentially be instructed using a Project Manager’s Instruction (PMI). The contract procedures start from a point where it is assumed that the proposed change has well-formulated requirements. In practice, RFQs were generally issued later in the process when information had been processed and the change had been discussed at length during the regular cycle of meetings that I attended. As a result, the change process was much longer in practice than what was set out in the contract procedures. Despite some of their shortcomings, there was an acceptance of using the contract procedures amongst the project team. Rather than the procedures being seen as contractual or adversarial, many of the project team members claimed that they preferred to work in this manner as it was easier to maintain a clear, auditable trail to follow the development of a change, although they also acknowledged the political nature of the processes. It became clear to me that accountability was seen to be very important to the people in the project team on this high-profile public sector project. They frequently referred to the need to be able to demonstrate how decisions had been made for audit purposes and in case anybody like end-users or people in the framework organisation questioned these decisions in the future. Therefore, following the contract procedures was one way of demonstrating accountability and best-practice in terms of making and rejecting potential changes. However, timescales for issuing information from the client-side were often slow, which was a source of frustration for the contracting team. There were also some individuals who did not adhere to these procedures when making changes. These individuals tended to be project stakeholders who were less familiar with the contract practices and who were not as involved in the project team where these routine practices were being used. Some end-users expressed their frustration at having to follow the procedures and communication channels set out by the contract rather than acquire information directly from people involved in making changes. However, it was not just maverick end-users that I observed bypassing the contract procedures. Frequently, the Client Representative would request proposals from the Contractor PM via email, often citing piecemeal, unclear and changeable information. This was a common example that the Contractor PM would hold up to me as a reason why he felt it was better to follow the contract procedures. Following the contract procedures provided a record of proposals and decisions with regards to

making changes for the Client and Contractor PM and the other people involved in making changes. However, I noted mixed reactions to this approach: for some people it was attractive as it helped to avoid some of the risks and uncertainties associated with informal communications; for others it posed obstacles to making changes.

**Accountability and minimising changes: “We’ve said it’s compliant, what else do they want?!”**

Sometimes the project team’s focus on following contract procedures meant that the process of making the change seemed more important than the content of the change and whether or not it was actually required in terms of the functionality of the building. Frequently, I did not understand, beyond a very superficial understanding, the technicalities of what a change entailed, and it appeared that I was not alone in this lack of knowledge. The individuals in the project team managing the process of making changes often did not have the technical knowledge to understand the technicalities a change and judge whether or not it should be accepted or rejected. Instead these individuals focused on what is required in their role on the project and the outcomes they needed to know, chiefly the time and cost implications of the change. Moreover, these individuals did not have the authority to make decisions. Instead they assembled information on which the Client Director, or Project Board, could make the ultimate decision. Changes were made against a political backdrop where demonstrating best-practice and accountability often resulted in the content of the change being overlooked. The concern with adhering to contract procedures and demonstrating accountability can be partly attributed to the dominant attitudes towards change. Attitudes towards project changes that I observed were generally negative, largely as they were associated with additional time and cost implications and design rework. Thus the focus of many people in the project team was largely on minimising and tightly controlling changes, and the contract procedures assisted them in this aim. On reflection, my own biases reflected the dominant discourse of the need to minimise and control changes and it was a challenge to set them aside during the fieldwork. It is impossible to fully block out personal predispositions and no researcher is neutral. Yet, I was able to acknowledge and query my biases, and those of other people involved in the project, and the meanings constructed around making changes.

Not everyone involved in the project thought that changes were ‘bad’ and had to be minimised. Indeed, it depended entirely on the nature of the change and why it was being instigated. Some changes were essential for the functionality of an area; others would enhance the infrastructure and ultimately the service provision of the hospital. The end-users, who were typically instigated changes, clearly felt that their changes were essential for the functioning of the building and I could empathise with their understandable ambitions to want the best-possible facility. Often these individuals, who typically possessed highly technical building, clinical or health service knowledge, would use their knowledge and position to emphasise certain changes as being essential for the functioning of the building. This highlights the need to have some control over end-user groups and their “shopping list” of requirements in order to prioritise how the contingency budget will be spent on changes. This was a difficult task for the Client Representative and his approach was ad hoc, just addressing requests for changes as they surfaced from end-users. The notion of end-user sign-off was seen as very important on the project, but was deeply flawed. During the construction phase of the project, everything that had been incorporated into the contract had, technically, been signed-off. Yet, individuals in the project team were still focused on getting uncertain aspects of the design, including changes, signed off

by the relevance end-users. Sign-off was seen to represent a state after which no further changes could be made, or it would be more difficult for the end-users to justify changes, and so it was seen as a way to minimise potential changes. Of course, achieving sign-off of an area did not prevent changes from happening. In fact, some areas had been changed multiple times and end-users were making further changes to their own changes. This was a frequent topic of conversation whereby many of the people in the project team would complain to one another, and me, about the end-users and how the Client Representative was dealing with their requests for changes. Undoubtedly, these multiple changes shaped attitudes towards change and towards end-users instigating them biases about the need to minimise and control change.

### **Structuration: reproducing and challenging change management practices**

As an organisation, the project consists of patterns of recurring practices called social systems. Social systems have structural properties, “especially institutionalized features, stretching across time and space” (Giddens 1984: 377) that are produced through, and influence, action by knowledgeable agents. In this paper, discussions will focus on what Giddens terms ‘structures of legitimation’ which are reproduced through norms of interaction that “always centre upon relations between the rights and obligations ‘expected’ of those participating in a range of interaction contexts” (Giddens 1984: 30). Norms are backed up by sanctions, which reinforce ‘legitimate’ conduct. Humans, as knowledgeable agents, reproduce legitimate actions due to embedded norms which they have learnt and reproduced in past interactions. Therefore, “norms articulate and sustain established structures of legitimation. They reinforce the normative order through tradition, rituals, and practices of socialization” (Orlikowski and Robey 1991:149). Actors can choose not to follow norms and break away from conventions and existing structures of legitimation. The challenge for ethnographic research is to understand people’s lived experiences, how meanings are constructed around practices and notions of ‘legitimate’ and ‘illegitimate’ conduct.

Concerns to minimise and tightly control changes were evident in practices around the use of the contract and attitudes towards sign-off of designs. Contract conventions set out the ‘expected’ way of managing changes under that contract type. This establishes sanctions by the incorrect use of the contract being potentially regarded as poor PM practice which can have reputational and commercial consequences. Moreover, there are specific contractual sanctions for not following contract procedures; particularly in relation to the time periods for reply (the parties can become ‘time-barred’). Contract practices establish norms of conduct of making changes that are informed by the traditions and conventions of the project organisation and the construction industry, which constitute structures of legitimation. The dominant industry discourse, which advocates that changes should be minimised and, if unavoidable, tightly controlled, shape these norms and subsequent interactions on the project. By people in the project team closely following contract procedures and pursuing sign-off in order to minimise and control changes, their behaviour reaffirmed this dominant industry discourse, and thereby reproduced these structures of legitimation. Expectations of actors’ conduct were reinforced by the presence of the framework organisation, which monitored practices in the project and posed a threat of sanctions for non-compliance. Contract procedures were also used due to concerns for demonstrating accountability. This reinforces the dominant discourse within the public sector with regards to the need to demonstrate transparent control of public spending. This structure of legitimation influenced approaches to making changes on the project and was reaffirmed through

certain individuals' concerns for following processes, which sometimes detracted from considerations about the need for the change in terms of building functionality.

There were also opposing practices which challenged structures of legitimation. This was apparent in practices where, rather than minimising changes, end-users were actively pursuing changes that they regarded as important for the functionality of the building. This highlights the alternative view of changes as opportunities to improve the end product so that end-users have a building that suits their needs rather than adhering to an out-of-date design specification. Yet it also emphasises the need to have some form of control over end-users' requests for changes as it would not be economically viable to agree to all requests. This reinforces the need for change control measures which are in place under the contract, but it also highlights the need for a more proactive way of dealing with these constant requests, rather than the ad hoc 'fire-fighting' practices that were observed. Practices which challenged structures of legitimation were also evident in informal practices with regards to information processing and individuals not adhering to contract procedures and communication protocols. These practices challenge the assumption that strict contract change control is the best way to manage changes. However, these practices were not considered favourably by individuals in the project team who were 'kept out of the loop' and it often created more work for them trying to find out what proposals and decisions had been exchanged between end-users and other people involved in making changes. As a result, they had little impact in modifying the dominant shared conventions about best-practice change control. Instead the unfavourable views of some individuals with regards to these informal practices reinforced the perceived importance of contract practices. However, contract procedures were insufficient as they did not account for the complex process to determine the requirements of a change. This altered existing structures of legitimation as alternative practices were adopted to cope with changes.

## CONCLUSIONS

The aim was to explore how changes are made in a construction project. This aim was founded on a call for more research into project practices in order to provide practical and theoretical understandings of the lived experiences of individuals in local settings. There was a need to better understand practices rather than following unchallenged discourses that changes should be minimised and strictly controlled. Using an ethnographic approach, the making of changes in a hospital project is explored and presented in the form of thematic findings which have been interpreted from descriptive narratives that are the focus of ongoing doctoral research. The findings highlight the importance of contract procedures for individuals involved in making changes in order to control and minimise changes and demonstrate accountability. Existing structures of legitimation both influenced practices and were reaffirmed by them. At times the dominant discourse overshadowed actors' considerations about the content of the change and whether or not it was required. There were also challenges to structures of legitimation, evident in informal practices of change control and the active pursuit of changes by end-users. This highlights the practical implications of the study, whereby contract drafting could be informed by these insights into how contract procedures are used in practice and their shortcomings. Moreover, it provides insights for policy guidance. Following the norms of PM and public sector best-practice, demonstrating accountability was often put first by certain individuals in the project team, with considerations about the change being secondary. This highlights how these concerns can be detrimental to a project by shifting the focus from the actual change to the process of making the change. There is a theoretical contribution

by drawing upon concepts from structuration theory to further our understandings of structures and interactions involved in making changes in a project.

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# IMPROVING COLLABORATION IN CONSTRUCTION: AN OPPORTUNITY FOR ACTION RESEARCH

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One perceived constraint to more effective collaborative working in UK construction is the current practice whereby individual team members each insure for their respective liabilities. It is argued that this promotes risk avoidance and other non-collaborative behaviour among them. An innovative form of insurance, called Integrated Project Insurance (IPI), promises to help alleviate these constraints by insuring the design and construction team as a whole. An Action Research (AR) project is currently being designed to support the development and implementation of key IPI features on a live construction project from 2013 to 2016, with a focus on improving collaborative working among team members. This paper provides a critical review of AR with a particular focus on its recent application in construction research. It seeks to build on previous studies by introducing the key features of a proposed AR approach in terms of their methodological basis, the roles of participants and the nature of AR ‘interventions’ occurring over time.

Keywords: action research, research method, collaboration, project insurance.

## INTRODUCTION

### **Improving collaborative working: an opportunity for Action Research**

The UK Technology Strategy Board (TSB) is funding a practitioner-led research project adopting an Action Research approach - with the authors as academic research partners - aimed at improving collaborative working on a new construction project commencing in 2013 for the Defence Infrastructure Organisation (DIO). The project involves the introduction of a new form of insurance for all design and construction team members that, together with a range of other arrangements, are intended to improve the effectiveness of collaborative working among them.

The background to this initiative is a belief that current insurance arrangements within UK design and construction teams – whereby each member is individually liable for their own negligence and error, and insures accordingly – promotes risk avoidance behaviour among them. This is seen to be at odds with team working, problem sharing and the joint pursuit of project goals that are believed to be essential to

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The project reported here is part of the Technology Strategy Board’s Rethinking the Build programme and acknowledgement is made of the financial support provided by that programme. Specific results and their interpretation remain the responsibility of the project team.

effective collaborative working (Cabinet Office 2012, Specialist Engineering Contractors (SEC) 2011). A proposed solution is an alternative form of insurance, called integrated project insurance (IPI) providing single cover for the construction project team as a whole and covering all their liabilities.

By covering the project team as a whole, the central proposition is that IPI helps provide a context in which the potential of members to work better together may be unlocked and exploited. To do this, a range of further measures, including project team selection and facilitation processes, are to be introduced at different stages in the project to support IPI. The practitioner-led research team recognised early in the process that the active participation of the project team in the development and implementation of these measures could help improve their effectiveness. Providing clear opportunities for collective reflection, learning by experience and further action could help team members improve their collaborative practices on an ongoing basis, and made a powerful case for the use of an Action Research (AR) approach.

### **Aim, objectives and scope of the review**

This paper provides a critical review of AR with a particular focus on its application in construction. It outlines the main elements of the approach proposed on this project, and the likely challenges to be addressed. It is intended to be the first in a series of papers on this theme that reflect on and contribute to the development and use of AR in construction research.

Details of our proposed AR approach are provided later in the paper. For now we assert our belief in the importance of participatory research with a focus on improving the practices of participants (McTaggart, 1995, Eden and Huxham, 1996). This helps put the following review in context which, following a brief historic overview, concentrates on:

- AR in education and healthcare (in recognition of the strong pedigree of AR in these areas, and the potential to learn from the approaches adopted);
- AR in organisational research;
- AR in construction; and
- Important distinctions between AR and consultancy, emphasising that our endeavour is one of social enquiry requiring critical reflection by participants.

With the focus on improving practices, wider discussions of AR in relation to issues of emancipation and community engagement, for example, are of necessity excluded.

## **ACTION RESEARCH: AN OVERVIEW**

### **Action research – origins and key developments**

Kurt Lewin is generally recognised as one of the originators of AR and defined it as a process of organisational change having ‘a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action’ (Lewin 1946: 38). An alternative to the ‘disinterested’ social science models (Reason 2003), AR acknowledges the researcher as an active participant in the process rather than a passive observer. Its focus is on doing research with, for and by ‘subjects’ rather than on them, in order to produce practical, useful knowledge (Reason and Bradbury 2007). Its aim is to bring about change in specific contexts (Parkin 2009), and it has a dual goal of improvement and of generating knowledge (Eden and Huxham 1996).

AR has a very strong pedigree of social justice and community action, with the practitioner actively involved in the ‘cause’ for which the research is being conducted

(Greenwood 2002, Reason 2003). More recently, AR has been used to effect organisational change, with origins in work arising after WWII on productivity in the British coal mining industry and, subsequently, in other industries (Gustavsen, 2008).

These two forms of AR are often contrasted as Southern vs. Northern: "the Southern tradition is committed to community transformation through empowering disenfranchised groups; the Northern tradition is concerned with reforming organisations through problem solving" (Brown 1993: 249). With its focus on group problem-solving for a practical outcome, within a commercially-driven organisational context, this research project is firmly aligned with the Northern tradition.

### **Key forms and principles**

Whilst the context and use of AR varies, there are generally agreed to be a number of key features which distinguish AR from other social science research methodologies (Heller 2004, Eden and Huxham, 1996; (Elden & Chisholm, 1993); Kemmis and McTaggart 1990):

- Addressing a 'real life' problem, often of shared concern;
- Participant (rather than researcher) led and performed collaboratively, with collective judgement on the outcome;
- Practical problem solving and knowledge expansion through interpretation and intervention;
- Paying attention to ethical and power considerations;
- A focus on how learning and change processes become self-generating and self-maintaining;
- Often longitudinal and involving more than one discipline.

While it is often argued that AR be defined in broad terms, reflecting its flexible, pragmatic, collective nature (Greenwood and Levin 2007), over the years there have been many attempts to categorise AR, with Jönsson (1991) claiming, "there probably are as many definitions of action research as there are authors on the subject". In order to focus our activity, we have selected the related definitions of Participant - where diagnosing and action planning are carried out in collaboration between researcher and client system (Chein et al. 1948), and Practical - involving active participation and cooperation with practitioners (Zuber-Skerritt 1996). The Participant/Practical form identifies the embedded nature of the researchers, and aligns most closely with the activity on this research project. Having participants embedded in the research team has been argued to enhance scientific validity (Whyte 1989), and the importance of participation from members of the organisation has been commonly accepted in recent AR theory (Pålshaugen, 2006).

Building on Lewin's model, the AR process continues to be seen as a cycle or spiral comprising a continuous, iterative sequence of activities (Baskerville 1999) involving: diagnosis; action-planning; action-taking and observing; reflecting; and further re-diagnosis and planning leading to subsequent cycles of AR.

Baskerville (1999) argues for a specific learning stage once the research cycle is complete. This can take the form of 'single' or 'double loop' learning (Argyris and Schön 1978) – the latter with an explicit acknowledgement of context (Greenwood and Levin, 2007) – where knowledge of unsuccessful intervention/failed change leading to a further cycle of diagnosis, planning and so on.

Although criticisms in relation to its replicability, reliability, generalisability and objectivity continue to be levelled at AR (Hales and Chakravorty 2006, Stokes and

Dainty 2011), AR has been recognised as helping to overcome the gap between theory and practice and improving the relevance and impact of academic research through its proactive nature (Azhar et al. 2010; Reason and Bradbury, 2007; McKay and Marshall, 2001). By explicitly rejecting notions of objectivity, the AR researcher is clearly acknowledged as a key participant and to many this lends strength to research aiming for relevance and utility, overcoming researchers' "self-imposed distance from the world of action" (Dash 1999: 479). Validity is provided by the joint interpretation of the results by all of the participants, not just the researcher (Heller 2004). A detailed contextual narrative of the work allows readers to underwrite the accounts by bringing to bear their own knowledge of the situation and context (Koshy et al. 2010).

## **ACTION RESEARCH IN CONSTRUCTION**

### **Overview and focus of AR in construction**

There has been a growing interest in AR in construction since around the late 1990s. Early contributions include Seymour et al. (1997), for example, who reflected on the methodological challenges of AR in terms of their own role as participant researchers in a local government organisation. Hauck and Chen (1998) proposed AR as a research strategy for graduate students in construction management to enable them to tackle 'real' problems. In one of the earlier applications of AR in construction, Cushman (2001), who studied information systems in construction project teams, noted the (then) novelty of AR in construction, especially within the wider UK government-sponsored industrial R&D programme of which his project was a part.

In the decade or so since Cushman, construction researchers have continued to use AR in work with a strong focus on information systems and knowledge management. For example, Davey and London (2005) used AR in an ethnographic study of the development of company systems for knowledge sharing. Rezgui (2007) studied the development and implementation of IT systems to support collaborative working among construction team members. Graham et al. (2008) focused on the development of knowledge sharing within a contracting organisation; Azhar (2007) and Azhar et al. (2010), used the approach to examine improvements in construction data systems.

AR has also been used in other areas where issues of stakeholder participation and collaboration take centre stage, including:

- Collaborative working (including partnering) - e.g. Alexander et al. (2003) ;
- Value management - e.g. Perera et al. (2011);
- Stakeholder engagement, particularly at community level - e.g. Gansmo (2012)
- Organisational change, including the development and implementation of new systems and processes - e.g. Miller and Dorée (2008) - and skills development and training - e.g. Chan and Moehler (2007), Cano-Lopez et al. (2008);
- Project development, including the development and implementation of systems and processes - e.g. Al-Balushi et al. (2004), Zimina et al. (2012) - and building design processes - e.g. Johnston and Miles-Shenton (2009)
- Innovation - e.g. Sexton and Lu (2009)
- Building operation - e.g. Beadle et al. (2008)

### **Important issues and themes**

In looking critically at the use of AR in construction research, four key themes emerge as potentially important to our enquiry: the formality of the AR approach adopted;

methodological issues; the definition and treatment of researcher and participant roles; and the nature and management of AR 'interventions'.

First, the literature portrays something of a spectrum of approaches to AR adoption in construction: between, at one end, an explicit application of an established AR 'model' within a formal research design (examples include Al-Balushi et al. (2004), Graham et al (2008), Sexton and Lu (2009) and Azhar et al. (2010)); and, at the other, a rather more implicit adoption of the approach in a less specific manner (e.g. Miller and Dorée (2008), Chan and Moehler (2007)). Those applying AR more formally tend to rely on established four- or five-step AR models taken from the more general social science research methods literature that each has a similar 'diagnose-plan-act-observe-reflect' cycle. Models include those by Denscombe (2003), Susman (1983), and Kemmis and McTaggart (1990). No new models of AR for construction have yet emerged. Further, there is as yet very little in the way of results or guidance available on the appropriateness of different AR models in different construction contexts.

Second, and perhaps more fundamentally, there are differences in the literature in the degree to which construction researchers consider theoretical and methodological implications of the AR approach in the construction context. While most afford these issues little or no consideration at all, among the small number who do, many seem mainly concerned with critiques of the participatory approach - and the potential for loss of objectivity and rigour from involving researchers in the problem/solution axis (e.g. Seymour et al. 1997; Stokes and Dainty, 2011). This connects to an important ongoing debate on 'co-production' research (also referred to as Mode 2 knowledge production in the language of Gibbons et al. (1994)) that views research as a transdisciplinary, collaborative endeavour aimed at resolving complex problems in their social setting. Sexton and Lu (2009), for example, argue that AR provides a useful approach for Mode 2, especially in the generation of 'actionable knowledge' (pp 686-8) which practitioners can use to change practice. Conversely, Stokes and Dainty (2011) argue that fundamental challenges to Mode 2 in the management and organisation studies literatures have been largely ignored in construction. While a detailed discussion of the debate - and particularly its research policy dimension - is beyond the scope of this paper, it raises important issues for the use of AR. Two unresolved questions in particular are discussed further below. One concerns roles in AR, and specifically the role of collaborators as 'co-producers', with all that might entail for the nature and status of research in AR. Another related question, returned to under Outline Proposals below, is about distinctions between research and action.

Third, the roles of various participants in construction AR remain generally unexplored. Construction project organisations are complex entities involving clients, end-users, consultants, contractors and third-party stakeholders (not to mention researchers!) - in contrast to the simpler researcher/client relationship portrayed in much of the traditional AR literature (e.g. Schein 1995). Such complexity is not unique to construction, of course, but it might be expected that action researchers would be concerned strongly about role allocation on AR - who, for example, is responsible for action, observation, reflection and so on. Graham, et al. (2008) are among the few who provide detail on role allocation in construction AR, allocating a role of 'facilitator' (and 'moderator') to the academic researcher, with non-academic 'practitioners' undertaking primary research duties such as interviewing. While this follows (Denscombe 2003) who views the practitioner in AR as the dominant partner, its implications are not fully explored. In particular, it is not clear how challenges to

objectivity and reliability that invariably arise with participant research are addressed, especially where the more typical roles of participant and researcher appear reversed.

Fourth, the critical AR concept of 'intervention' is not always clearly delineated in construction AR. It is not always entirely clear what 'interventions' (actions) are being introduced, observed, reflected upon and used as a basis for a further cycle of AR. Further, how these interventions might change and evolve over time, and what this means for the AR process is generally not considered. While Cano-Lopez et al (2008), for example, outline a three-year AR model involving successive cycles of interventions in the development of a training programme, these appear more in the nature of planned implementation than as an outcome of successive rounds of AR.

### **AR and consultancy - are they the same?**

Without generally accepted and well understood AR models, a clear underlying methodology, clarity about participant roles and about how interventions are defined and managed in AR, it becomes difficult to distinguish the approach from more general problem-solving consultancy. This, of course, is not a problem exclusive to construction research. Building on Eden and Huxham's contention that "action research demands an explicit concern for theory" (1996: 79), McKay and Marshall (2001) propose a dual cycle process that explicitly acknowledges the distinct but complementary interests of problem-solving and research, with the two inter-related cycles focused on the aims of problem solving/improvement, and the generation of new knowledge respectively. Whilst consultancy can be viewed as a problem-solving interest, an action researcher must explicitly adopt and acknowledge the research interest in order to remain distinct from, and indeed to move beyond consultancy.

This dual focus is further supported by Blichfeldt's (2006) argument that action researchers should consider the action and research cycles in AR as distinct, and distinguish themselves from the heavily action-oriented behaviour of consultants and "practical problem-solvers" (2006: 5). We expect to explore this approach further in the construction context to develop a deeper understand of the dual cycle process.

## **OUTLINE PROPOSALS AND CONCLUSIONS**

### **Key features of our approach**

Our approach to AR on the construction project has the following key features:

- It is motivated by improvement through research-driven understanding and learning; it is cognisant of the problem solving and research 'cycles' and is distinct from more general consultancy approaches.
- It takes a participant/practical form of AR (after Chein et al. 1948; McTaggart, 1995; and Zuber-Skerritt 1996) involving diagnosis and action planning as a joint endeavour between participants and researchers, and aligned more with the 'Northern' tradition of change through problem-solving (Brown 1993)
- This integrated co-production of knowledge within a real world setting aligns the research firmly within that of Mode 2. The provision of a 'new' context for collaboration will support 'double-loop' learning (Argyris and Schön 1978).
- It adopts a five step diagnose-plan-act-observe-reflect process in the manner of e.g. Al-Balushi et al. 2004 and Azhar et al. 2010. It acknowledges the complexities arising from multiple and phased 'interventions' over time (see further under Interventions below)

- It highlights the distinctive roles of researchers, participants (practitioners and 'clients' of different forms) and also recognises the shifting boundaries between them, not least in terms of how each participates in key stages of AR 'cycles' (see further under Participant Roles below)
- As well as a commitment to the project participants, it makes a commitment to the research community regarding the production of scientific knowledge (including further development of the AR methodology). In that sense it lies in the interpretive research tradition and seeks validation partly through participants' own accounts of the problem area and context (Koshy et al. 2010)

### **Interventions**

The use of IPI on the construction project for DIO will be supported by a range of measures intended to improve collaborative working. These are the 'interventions' that are the main focus of this action research, and include:

- Processes and criteria for team selection that emphasise a willingness to adopt collaborative working under IPI arrangements;
- A target cost approach adopted by the project team as a whole, including pain/gain share provisions (e.g. as described in Zimina et al. 2012) ;
- Insurance cover for project cost overrun above a guaranteed maximum price (GMP) up to an agreed limit;
- A facilitated approach to design and construction to encourage the joint development and testing of solutions to the client's requirements;
- Active input from an independent research and facilitation team, focused on supporting the design and construction team in 'learning by doing'.

The AR action-reflection-action dynamic will alter the context for, and the nature of these and subsequent interventions. Interventions will be developed in collaboration between researchers and the project team, and will draw on participants' experience, ideas of 'best practice' in key areas, and on underlying theories relating to elements of collaborative working. Participants will thus be engaged in a progressive and dynamic AR endeavour focused on the cumulative effects of multiple interventions.

### **Participant roles**

It is recognised that the participants' roles throughout the process will be fluid - at different stages they will represent the researcher, the client, and the practitioner. The adoption of the AR approach allows for this by acknowledging all participants as "co-researchers". Inherent within all roles will be the need to reflect on the process and the observations of others, and to consider opportunities for improvement and for taking further action. The full research implications of this deep level of participant engagement have yet to be examined, though we recognise that they add to the complexity of tracking successful interventions in terms of outcomes.

### **CONCLUSION**

While this four-year project offers the opportunity for academic and practitioner learning on a number of levels - and not least the prospect of improving collaborative working in construction - we have concentrated in this paper primarily on the methodological challenges and potential. Many further questions arise of course, and we see this paper as the first in a series designed ultimately to contribute to the further development and application of AR in construction. Indeed, it is tempting to wonder whether slow progress in the development of construction AR to date may be due to a lack of an underlying AR 'mechanism' of reflection and learning in the application of

the approach. By providing explicitly for observation, reflection and learning in the methods used as well as in the more practitioner/client-oriented interventions, we hope our approach will ultimately help construction researchers - and of course we include ourselves in this - improve their understanding and use of AR.

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## **RISK MANAGEMENT**

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# PERCEPTION OF BARRIERS TO IMPLEMENTING RISK ASSESSMENT AND MANAGEMENT PRACTICES BY CONSTRUCTION PROFESSIONALS IN TANZANIA

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The performance of construction projects is often affected by the inherent risks existing within the internal and external environments. Risk management and assessment practices (RAMP) can be used to identify these risks and propose appropriate strategies to mitigate them. This could lead to the attainment of the Millennium Development Goal (MDG), thereby, enabling construction organisations to remain competitive. The implementation of RAMP is usually fraught with barriers despite the extensive research on barriers affecting the implementation of RAMP. There is a paucity of empirical studies that examine these barriers for the deployment of RAMP in developing countries, particularly Africa. In an attempt to fill this knowledge gap, a questionnaire survey was used to investigate the perception of construction professionals' on the barriers to RAMP in Tanzania. Data was collected using a sample survey of 67 construction professionals drawn from 27 consultants, 24 contractors and 16 client organizations within the Tanzanian construction industry. Response data was subjected to descriptive statistics and subsequently ranking analysis were used to examine the barriers affecting the implementation of RAMP. The results indicated the following barriers as most significant: (i) awareness of risk management processes; (ii) lack of experience; (iii) and lack of information. In contrast, "cost implementations" and "time constraints" were ranked lowly. Despite the disparity in the ranking of the 7 barriers, one-way analysis of variance (ANOVA) indicates that, the differences were not statistically significant. The identified barriers could be used as a 'road map' for the development of appropriate solutions for the successful implementation of RAMP, and to improve the decision making processes of construction organisations. In addition, knowledge and understanding of risk management process would contribute in identifying and managing inherent risk effectively. The effect would lead to the achievement of project objectives in terms of time, cost and quality.

Keywords: barrier, Tanzania, construction industry, risk assessment, risk management, questionnaire survey.

## INTRODUCTION

The construction industry is vital and plays a critical role to the economic development of most countries. According to Lema (2008), the construction industry in Tanzania accounts for approximately 7 % of Tanzania's gross domestic product (GDP). Studies conducted by Kikwasi (2012) showed that the construction industry is

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responsible for 9 % of employment creation, and about 57% of the capital formation. Conversely, recent studies indicate that, the Tanzanian construction industry is fraught with frequent cost overruns and delays on a lot of projects (Kikwasi, 1999). In order to improve the performance of the construction industry, some studies signify casual linkages between implementation of some of the risk management practices and project success (Tabish and Jha, 2011). It could thus be argued that, awareness of, and subsequent implementation of risk management practices could contribute to the enhanced project performance of the construction industry. Additionally, empirical evidence has shown that some construction organisations in Sub Saharan Africa (SSA), that don't implement risk assessment; management practices and the techniques as part of managing their projects, often resulted in project costs exceeding budget and behind schedule (Kululanga and Kuotcha, 2010; Kikwasi, 2012).

The observation above calls for further exploration into barriers to implementation of risk assessment and management practices in Tanzania. For example, what is the level of risk assessment and management practices awareness among the Tanzanian construction stakeholders? Can the barriers to the usage and implementation of RAMP be assessed? Can solutions to these barriers be proposed thereby, leading to the attainment of the Millennium Development Goal (MDG)? The impetus for this paper lies within seeking answers to the questions posed.

There is therefore, a need of exploring the barriers affecting the implementation of risk assessment and management practices in developing countries in an African context such as Tanzania. The present study is aimed at filling the knowledge gap by conducting a survey among construction professionals' in Tanzania. It is aimed at eliciting perception, identifying and ranking the barriers to the deployment of risk assessment and management practices.

The following is an overview of some of the challenges facing the Tanzania Construction Industry (TCI). A brief summary of discussions is provided on the extant literature on the barriers affecting the adoption and implementation of RAMP, and the knowledge gap knowledge. Preceded by the methodological approach adopted and a discussion of the findings and implications of the study. Some advocated solutions to the barriers of RAMP implementation are also suggested. The final section concludes with recommendations and conclusions drawn.

## **LITERATURE REVIEW**

### **Challenges facing the Tanzanian construction industry**

In spite of Tanzania aspiring to have one of the best construction industries in the world, it is still inundated with poor project performance (Ofori, 2012), lack of trained professionals (Debrah and Ofori, 2005). Tanzania is over reliant on foreign institutions to train her indigenous professionals, contractors and consultants to execute big projects (Debrah and Ofori, 2005; van Egmond, 2012). These challenges have impacted the overall execution and application of project management concepts and principles among the stakeholders. Previous Tanzanian studies such as (Kikwasi, 1999; Ministry of Works, (MoW) 2003; Lema, 2008) though focused on addressing project management related issues such as procurement and project performance have never addressed the risk management issues directly. Furthermore, recent studies such as Kikwasi (2012) aimed at assessing the causes, effects and disruptions in Tanzanian construction projects. This study concluded that there are still a number of causes of

delays and disruptions existing. These effects put construction projects at great risk affect performance. One of the main causes identified by the same study was poor project management.

It is recognised that the construction operational environment within Tanzania includes foreign contractors. These foreign contractors often have the competitive advantage over local contractors in relation to skills, training, competencies, and human resources development (HRD) practices. For example, according to the CRB (2010), there are over 4,470 contractors registered in Tanzania of which 134 (3%) are foreign and 4336 (97%) are local. Despite the limited numbers of foreign contractors, they own about 96% of the market share in construction. This appears to be the trend among other neighbouring African countries such as Zambia (Zulu and Chileshe, 2008).

### **Barriers affecting the adoption and implementation of RAMP**

A number of studies have examined the barriers affecting the adoption and implementation of risk assessment practices. However, the majority of these studies have been within the context of developed countries. Table 1 presents a summary of selected studies on barriers to RAMP.

It must be noted that this review is by no means exhaustive. By contrast the context of this study is Tanzania, Africa. Care has been taken to include some studies from within the African context, and some examples have been included from developed (western) economies. The following section briefly discusses some of the barriers as identified both in perception of developed and developing economies or countries. For example, Frimpong *et al.* (2003) a study in Ghana, and the following two studies in the U.K (Wood and Ellis, 2003; Akintoye and MacLeod, 1997).

In regards to Ghana, a study conducted by Frimpong *et al.* (2003) aimed at identifying the causes of delay and cost overruns in construction established one of the reasons being a lack of awareness of risk management processes. This inevitability led to poor resource management. The same study established that, project management tools and techniques played an important role in the effective management of a project. Elsewhere (U.K), Akintoye and MacLeod (1997) also identified lack of familiarity with the techniques as one of the reasons provided by contractors for not using techniques of risk analysis and management. Whereas Wood and Ellis (2003) study which focussed on cost consultants identified the relative lack of training and skills development among the factors underpinning the risk management provision.

Table 1 depicts the lack of usage of risk management practices is not just limited to developing economies, but also affects developed countries such as Australia (Lynos and Skitmore, 2004). There is also the issue of risk management being in its infancy stage as a reason for the lack of implementation indicating a barrier. This problem affects developing countries like Korea (Kim and Bajaj, 2000), and Singapore (Hwang *et al.* 2013). There is a plethora of studies on barriers to RAMP, and the list portrayed in Table 1 is just indicative. However, notwithstanding the previous barriers derived from a cross section of the literature, what is notable from the summary (Table 1) is an obvious omission with the exception of Kikwasi (2011), particularly in the Tanzanian context, of studies focussed on the identification of the barriers to RAMP.

*Table 1: Summary of selected studies on barriers to risk assessment and management practices application*

Researchers <sup>1</sup> / Context	Findings
Kim and Bajaj (2000) - Interviews of 13 <b>Korean</b> managers of general construction firms.	Three reasons limiting the usage of risk management techniques: a lack of familiarity with techniques; most clients and / or owners wanted to see tangible calculations and unambiguous evidence of risk; and lack of expertise with techniques
Lynos and Skitmore (2004) - General survey of 17 contractors, 11 consultants, 10 clients and 6 developers in Queensland ( <b>Australia</b> ) construction engineering organisations	Identified nine barriers inhibiting the implementation of risk management: lack of time; lack of familiarity with the techniques; lack of dedicated resources; lack of expertise; lack of information; difficulties in seeing the benefits; human / organisation resistance; lack of accepted industry model for analysis; and cost effectiveness.
Liu <i>et al.</i> (2007) <sup>2</sup> - General survey of contractors' attitudes in <b>China</b>	Investigated the key issues and challenges in risk management and insurance in the Chinese construction industry: contractors' attitudes and perception; knowledge; cultural considerations; lack of experience; and expertise
Tang <i>et al.</i> (2007) <sup>2</sup> - General survey of 115 stakeholders comprising 19 clients, 30 contractors, 21 designers, 20 superintendents, 10 management organizations, 8 planning organisations and 7 others in <b>China</b>	Eleven barriers to risk management: lack of joint management mechanisms by parties; shortage of knowledge /techniques on risk management; different recognition of risk control strategies; ineffective implementation of risk control strategies; ineffective monitoring; lack of formal risk control strategies; ineffective monitoring; lack of formal risk management systems; no incentive for better risk management; lack of risk consciousness; inappropriate risk allocation; lack of historical data for risk trend analysis; inappropriate risk allocation; and insufficient ongoing project information
Chileshe and Yirenyi-Fianko (2012)*- General survey of 34 contractors, 46 consultants and 23 clients (public and private) in construction projects in <b>Ghana</b> .	Identified seven main barriers to risk assessment and management practices: awareness; lack of experience; lack of coordination between parties involved; lack of information; availability of specialist risk management consultants; time constraints; and lack of knowledge and expertise
Kikwasi (2011) <sup>3</sup> - Interviews of 55 consultants, architects and quantity surveyors in <b>Tanzania</b> .	Identified three challenges inadequate risk management knowledge; not being a priority in clients requirements; lack of holistic approach to risk management; and reluctance of consultants to spearhead risk management process
Hwang, Zhao and Toh (2013) - A questionnaire survey of 15 consultants and 19 contractors in <b>Singapore</b> based on data collected from 668 projects.	Identified ten probable barriers to RM implementation in small project: competition among small and medium contractors (SMC);complexity of analytical tools; lack of potential benefits; lack of budget; lack of government legislation; lack of knowledge; lack of manpower; lack of time; low profit margin; and not economical

**Notes:** <sup>1</sup>The studies are arranged in chronological order; \*this current study is based on the survey instrument as utilised in Chileshe and Yirenyi-Fianko (2012); <sup>2</sup>selected studies within the Chinese context; <sup>3</sup>Specific Tanzanian study on RAMP.

## RESEARCH METHOD

To investigate the perception of construction professionals' on the barriers to RAMP in Tanzania, the following research methods were employed in the study.

### Measurement instrument

The finalised questionnaire used in this study is based on the Chileshe and Yirenyi-Fianko (2012) instrument and compared with other studies as illustrated in Table 1. The first section of the questionnaire included the overarching aims of the research

projects and covered the demographics. The second section was designed to evaluate the RAMP, and the respondents were asked to rate the likelihood of occurrence and severity of impact of various risk factors. In the third section, the main objective was on establishing the awareness, extent of usage and benefits of RAMP. This was in form of closed questions based on 'yes' and 'no', while the scale for ascertaining the benefits varied from 1 to 4 with 1 representing low agreement and 4 strong agreement. In the fourth section, which forms the basis of this paper, comprised the 7 barriers to the adoption, usage and implementation of RAMP as identified in the Chileshe and Yirenyi-Fianko (2012) studies and compared with previous studies as summarised in Table 1. Respondents were asked to rate their opinions on these barriers using a five point Likert-scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). The resultant values of mean scores were further classified to address the limitations associated with the single point or number changing from 1 to 5 in the verbal scaling expressions (Chileshe and Yirenyi-Fianko, 2012). The final section was focused on identifying the critical success factors for adopting RAMP. The findings reported here relate to only the first and fourth sections of the questionnaire dealing with the barriers. It was also beyond the scope of this study to report all the results.

### **Data analysis**

This paper seeks to investigate the perception of construction professionals' on the barriers to RAMP in Tanzania. The *Statistical Package for Social Sciences* (SPSS) computer program was also used to analyse the data generated by the research questions. In order to analyse the data as provided by the questionnaire, the following five statistical methods were used: (1) frequency analysis; (2) ranking analysis; and (3) ANOVA. Review of the literature shows that such approaches have been adopted before in survey related studies (Tang *et al.*, 2007, Chileshe and Yirenyi-Fianko, 2012). Rank differentiation was employed for barriers having the same mean score through utilisation of the lowest standard deviation (Chileshe and Yirenyi-Fianko, 2012). The measurement instrument was also tested for validity and internal consistency. According to Cronbach (1951), one of the most popular reliability statistics is the Cronbach alpha. This was found to be 0.608 ( $F$ -statistic = 4.335, sig. = 0.000) for the barriers sub instrument. While the value was less than the recommended (0.7), as this was an existing instrument, the value was deemed as acceptable, (Nunnally, 1978).

### **Population and sampling**

600 questionnaires were administered to 2,500 delegates, mainly professionals representing the following three registered bodies: architects and quantity surveyor's registration board (AQRB), contractors' registration board (CRB) and engineers' registration board (ERB) attending a three day construction forum in 2012.

### **Characteristics of the sample**

Out of 600 questionnaires distributed, 300 were collected by delegates at an estimate of one hundred 100 questionnaires to each board. At the end of the forum, only 21 questionnaires were returned despite the call which was made by floor managers. These comprised of 8 from the AQRB, 8 from CRB and 5 from ERB. Following the low response to questionnaires, contacts of forum participants were sought from relevant bodies. This resulted in about 150 respondents being contacted. It should be noted that most of them could not locate the questionnaires supplied during the forum. Henceforth, a further 50 questionnaires were emailed and 100 were hand delivered.

This was followed by constant telephone reminders out of which 8 and 48 responses were received from emailed and hand delivered questionnaires respectively. It should be noted that the delegates were contacted before the questionnaires were either emailed or hand delivered to them. In addition, those who returned questionnaires had their firms' /employers' details recorded. Consequently 77 returned questionnaires, of which 12 were considered incomplete. 67 were rendered usable for the data analysis representing 22.33 %. Table 2 provides the breakdown of respondents according to the professional background. As indicated in Table 2, majority respondents were quantity surveyors 19 (28.4 per cent) followed by the engineers (25.4 per cent). The minority of the respondents (9.0 per cent) were drawn from the 'others' category comprising 4 construction managers and 2 contracts managers.

*Table 2: Demographical information of survey respondents*

Professional background	Frequency	Percentage	Cumulative percentage
Quantity Surveyor	19	28.4	28.4
Engineers	17	25.4	53.7
Project Manager	13	19.4	73.1
Architect	12	17.9	91.0
*Others	6	9.0	100.0

**Notes:**\*Other category comprised 4 (6%) Managing directors 1(1.5%) Construction manager and 1 (1.5%) contract manager.

This observation is interesting, given that from the total number of delegates, this was a minority group. The proportions of the respondents in terms of organisation size (number of employees) were: The majority 46.3% (31) of the respondent organisations had less than 25 employees, followed by 20.9% (14) with more than 25 but less than 49 employees. The remainder of the categories had a fair distribution ranging from 6.0% (4) to 9.0% (6) in the '50-99', to more than 300 employees categories. The majority, almost two thirds of the respondents were small and medium sized organisations. The proportions of the respondents in terms of years of experience were: less than 1 year (3.03%); 1-5 years (13.63%); 6-10 years (18.18%); 11-15 years (13.63%); and more than 15 years (51.51%). The breakdown of the final respondents according to the sector of industry was as follows: The majority 40.3% (27) were consultants. This was followed by 35.5 % (24) contractors and 23.9 % (16) clients.

## **SURVEY RESULTS AND DISCUSSION**

### **Ranking of barriers by contractors, clients and consultants**

This sub section examines the individual responses of three groups (contractor's, clients and consultants) perception of barriers to the adoption and implementation of RAMP. Table 3 summarizes the results of the analysis of barriers for the group wise ratings of the respondents based on the sector.

“Awareness of risk management processes” was regarded as the most critical barrier by both contractors and clients. This result is consistent with the findings in Table 1, as well as the results from the literature review of earlier studies within developing and developed countries. For example, a study conducted by Kim and Bajaj (2000) among South Korean contractors cited the lack of familiarity with risk management concepts and methods as one of the reasons for the lack of usage. South Korea, like

Tanzania is relatively new to risk management concepts, therefore drawing such comparisons is useful to provide further understanding of the issues at hand.

Table 3: Descriptive statistics (mean, standard deviation) for items on the barriers according to the sector.

[ ] Barriers	Contractors <i>n</i> =24			Clients <i>n</i> =15			Consultants <i>n</i> =27		
	MS <sup>1</sup>	SD <sup>2</sup>	R <sup>3</sup>	MS <sup>1</sup>	SD	R	MS <sup>1</sup>	SD	R
[1]. Awareness of risk management processes	4.087	0.793	<b>1</b>	4.133	1.187	<b>1</b>	4.074	0.958	<b>4</b>
[2]. Lack of experience	4.042	0.908	<b>2</b>	3.600	1.056	<b>2</b>	4.111	0.698	<b>2</b>
[4]. Lack of coordination between parties involved	3.625	0.924	<b>4</b>	3.400	1.056	<b>4</b>	4.074	0.874	<b>3</b>
[3]. Lack of information	3.583	0.929	<b>3</b>	3.400	1.121	<b>5</b>	4.185	0.786	<b>1</b>
[5]. Availability of specialist risk management consultants	3.435	1.308	<b>7</b>	3.467	1.407	<b>3</b>	3.962	1.113	<b>5</b>
[7]. Time constraints	3.435	0.945	<b>6</b>	3.267	1.163	<b>=7</b>	3.346	1.056	<b>7</b>
[6]. Implementation costs	3.565	0.728	<b>5</b>	3.267	1.163	<b>=7</b>	3.769	0.908	<b>6</b>
<b>Average scores</b>	<b>3.682</b>			<b>3.505</b>			<b>3.932</b>		

Notes: MS<sup>1</sup> = Mean score of the barrier factor where 5 = strongly agree; 4 = agree; 3 = neutral; 2 = disagree; and 1 = strongly agree. The higher the mean, the more impact the barrier has to deployment of risk assessment; <sup>2</sup>SD = standard deviation; <sup>3</sup>R = ranking [ ] overall ranking based on full sample.

Conversely, the consultants ranked this barrier fourth (mean score = 4.074, std dev = 0.958) and the “lack of information” as the first (mean score = 4.185, std dev = 0.874). The plausible explanation for disparity in the ranking of this barrier is that, the consultants are not exposed to any of the risks themselves, and therefore in no position to engage in complete risk control procedure.

Lack of experience, lack of information, and lack of coordination between parties involved which are all related to education, knowledge management and procurement practices were next three highly ranked barriers based on the overall sample. For example, China like, Tanzania is a developing country. The problem of ‘lack of experience’ in Tanzanian professionals has been highlighted by numerous studies (MoW, 2003; Debrah and Ofori, 2005, 2006). For instance, Debrah and Ofori (2006) observed that many construction firms in developing countries are small-to medium-sized organisations and, hence do not have the facilities to provide for training. This is also compounded by the fact that, for a long time, foreign contractors have dominated construction business in Tanzania (MoW, 2003).

It should be noted that, the identified barriers are also found in the western economies, such as China (Tang *et al.* 2007). These two studies require particular mentioning as Chinese companies dominate the group of foreign contractors that are fully owned and operating in Tanzania (van Egmond, 2012). In anticipation that these organisations might transfer some of their knowledge and expertise to the local Tanzanian contractors, this warranted particular attention in regards to their perception and attitudes towards risk management practices.

#### Analysis of variance (ANOVA)

In order to test the hypothesis of no significant difference in the perception of the different professionals practising with construction clients (private and public),

consultants and contractors on the ranking of the barriers to RAMP, and ANOVA was conducted. The statistical significance level of the analysis was set at a  $p$ -value of 0.05. The results revealed that there was no statistical significant difference ( $p < 0.05$ ) in the perception of the construction professionals working for the different types of organisations regarding the barriers considered necessary for the deployment of RAMP. This suggests that construction professionals within the Tanzanian construction industry, irrespective of the sector (clients, consultants or contractors) that they worked for generally have similar opinions regarding the barriers affecting the deployment of RAMP. As such, the null hypothesis of no significant difference in the perception of different types of organisations to the barriers to RAMP is upheld.

## LIMITATIONS

While the study makes several contributions to risk management theory and practice, several limitations of the research need to be acknowledged. Firstly, this study did not distinguish between local organisations (i.e. contractors) and those that tended to collaborate with the foreign contractors. Skill levels among the employees tended to differ, with Tanzanian contractors working with foreign contractors being more experienced (Egmond, 2012). In addition, from the contractor's perspective, this study did not distinguish between the different classes of contractors. In Tanzania there are seven classes for building, civil, electrical and mechanical contractors that is, from class one to seven based on the capacity of such contractors to execute works. Therefore, the barriers identified in this study are generic.

Secondly, the sample consisted of organisations in one industry, which is construction operating in Tanzania. Consequently, the findings may not generalize to other industries or organisations operating in other East African or Sub-Saharan countries. Thirdly, the sample size in this study (67) was small. As such caution should be exercised in the interpretation and generalisation of the results. However, despite that limitation, the findings represent a snapshot of the barriers affecting the implementation of RAMP. Future studies should employ a large number of cases representing the population of interest, in order to determine the statistical significance of the results. Finally, this study relied on the usage of self-report data and indicators of the construct are sensitive and difficult for respondents. Nevertheless, there is consistency within the results from the quantitative and qualitative (literature review) parts of the study. Additionally the results do appear to be consistent with previous research (Table 1) that has examined the barriers to RAMP within developed and developing economies.

## CONCLUSIONS & RECOMMENDATIONS

The study investigates the barriers to RAMP among constructional related organisations in Tanzania. In the quest to investigate the reasons for low level uptake of RAMP implementation, "awareness of risk management processes", "lack of experience", and "lack of information" were the most significant barriers that the Tanzanian stakeholders needed to overcome. The analysis results showed that the clients, contractors and consultants agreed with the overall ranking of the barriers, despite some differences in the mean scores. However, these differences were not statistically significant.

In the context of Tanzania, the relevant regulatory bodies play a key role in upholding the standards of its members. In order to raise the awareness of RAMP benefits, there is a need for a 'cultural shift' in the mindset of senior management and relevant

stakeholders within the Tanzanian construction industry. In addition, the organisations should also be encouraged to engage or utilise internal auditors through the application of enterprise risk management (ERM) as part of the implementation of RAMP. To assist the clients, consultants and contractors with the training issues associated with RAMP, the government could further focus on the development of vocational training and apprenticeships for its citizenry and relevant professionals or provide capacity building. This would act as a source of skills for the majority of the Tanzanian employees. Another avenue worth pursuing is the entering of joint ventures with foreign contractors.

Findings of this study further reinforce the observation that, despite the quest of the Tanzania Construction Industry to remain competitive, it is faced with a number of challenges. These challenges undoubtedly have an impact of implementation of practices such as risk management. Other performance constraints contributing to the inefficient and deteriorated state of the construction industry cited by the same report included the 'low capacity and capability of the local contractors and consultants due to weak resource base and inadequate experience'. One of the main contributions of this study lies in the identification of an ordered grouped set of barriers for RAMP for construction projects in Tanzania. Another significant contribution of this paper is that it sheds light and provides insights on the understanding of the barriers affecting the implementation of RAMP within the Tanzanian construction sector, an area previously under-researched. It also expands the efforts of studying and evaluating barriers across the developing economies and particularly within the (East) African context. One notable contribution of this study is that, it extends and builds upon the work of Kululunga and Kuotcha (2010) who acknowledged, albeit from the contractors' perspective in Sub-Saharan Africa (SSA), that the extent to which they [contractors] followed the series of steps of risk management processes conceived from project management was severely lacking in the literature. Furthermore, this study makes a contribution to the body of knowledge on the subject within a previously unexplored context. The study provides insights on the barriers to implementation of RAMP across the Tanzanian construction sector, involving more stakeholders such as clients, consultants in addition to the contractors

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# THE GULF COOPERATION COUNCIL RAILWAY

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The members of Gulf Co-operation Council – Saudi Arabia, Kuwait, Bahrain, Qatar, United Arab Emirates (UAE), and Oman – are proposing to build a heavy railway line to link all six states. It is intended to run from Kuwait City to Muscat via Saudi Arabia and the United Arab Emirates with a loop via causeways through Bahrain and Qatar. This will present a formidable task in a region where there is little or no history of railways with the exception of Saudi Arabia and to a lesser extent the UAE. This will involve the co-ordination of standards across six states and integrating with the existing heavy rail system in Saudi Arabia and the proposed rail networks of the other five states. Heavy rail has advantages over road transport for long haul freight and passenger transportation in terms of operational efficiency, carbon dioxide emissions, and cost. However, these advantages have not been apparent for the GCC members – Saudi Arabia and Oman aside – because they do not kick-in for shorter distances involved in domestic transportation. Kuwait, Qatar, and UAE have a maximum internal journey of 250 km to 300 km with Bahrain considerably less. This gives a potential journey by road of up to five hours. It is only when considering transport between GCC member states as they become more closely economically integrated that the advantages of heavy rail become apparent. This paper aims to present an overview of the risks involved with this project from design to construction and operation. While the research will focus on the analysis and response to technical risks concerned with the challenging terrain, through-running, signalling, and communication, it will also outline the legal and commercial risks of ticketing, customs, tariffs and regulation and the political issues between member states.

Keywords: project management, risk management, civil engineering.

## INTRODUCTION

The Gulf Co-operation Council rail project is a very ambitious attempt to connect the six member states with a railway running the length of the Arabian Peninsula from Kuwait via Saudi Arabia and the United Arab Emirates to Oman over challenging terrain. There will be either a loop or branches to link to Bahrain and Qatar. Only Saudi Arabia, of the above states, has any experience of constructing and operating heavy railways and that experience is fairly limited. This line has produced echoes in scale of the narrow-gauge Hejaz Railway (Nicholson, 2005) of a century ago. It was built by the Ottomans with German technical assistance. It ran from Damascus to Medina and opened in 1914. It proved to be short-lived and closed in 1915 during the

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First World War. It was never successfully re-opened south of the Saudi Arabian border with Jordan although parts of the line are still in operation to the north.

## THE GULF CO-OPERATION COUNCIL

### Background

The Co-operation Council for the Arab States of the Gulf (GCC) was established in 1981 by the Kingdom of Saudi Arabia (KSA), Kuwait, Bahrain, Qatar, the United Arab Emirates (UAE), and Oman. They are all monarchies, absolute in the case of Saudi Arabia and Oman, federal in the case of the UAE and constitutional in the other states. The logic of the GCC was to provide protection from the real or perceived threats from their powerful Arab neighbours of Iraq and Syria plus the strong regional power of Iran and the threat of radical Islam. Iraq invaded Kuwait in 1990 while Iran claimed sovereignty over Bahrain from 1957 to 1965 (Downs, 2012). It seems possible that the membership of the GCC will be expanded at some stage to include the two remaining Arab monarchies: Jordan and Morocco. Jordan shares a land border with Saudi Arabia. The inclusion of Yemen will bring the whole of the Arabian Peninsula into the GCC. The Candidate States are low to medium income in contrast with the high income Member States. All current members have significant oil and gas reserves although the oil reserves in the case of Bahrain and Oman are depleting.

*Table 1: GCC Member States*

Member state	Population	GDP (PPP) US\$ billion	GDP per capita US\$	Land area km <sup>2</sup>	Oil reserves million bbl.	Gas reserves million m <sup>3</sup>
KSA	26,939,583	740.500	25,700	2,149,690	267,017	8,028,000
UAE	5,473,972	271.200	49,000	83,600	97,800	6,089,000
Oman	3,154,135	90.660	28,500	309,501	5,500	850,030
Kuwait	2,695,318	165.900	43,318	17,818	101,500	1,798,000
Qatar	2,042,444	189.000	102,800	11,571	25,382	25,200,000
Bahrain	1,234,571	32.440	28,200	765	125	92,030

### Economic Development in the GCC

The changing circumstances of the GCC countries into the 21st century have led to rapid urbanization and growth of cities such as Riyadh, Muscat, Abu Dhabi and especially Dubai. In addition, there is pressure to diversify away from oil and gas, particularly in those countries where their oil reserves are running down. This is leading GCC countries towards exploitation of mineral wealth and industrialisation plus moving into other sectors such as real estate and tourism. It has demonstrated a need for the GCC countries to economically integrate to meet the above challenges (Aluwaisheg, 2004). The GCC was founded with the objective of being a regional bloc although this has now moved towards becoming an economic, monetary and military confederation intended to meet the needs of its citizens in response to democratic change within the Arab world, radical Islam and Iranian pressure.

Saudi Arabia is probably leading the move to integration, and it will have the leading role with effective hegemony over the federation. Other GCC states, with the exception of Bahrain appear to be rather less enthusiastic about closer integration. Economic union within the GCC has developed with a Customs Union being declared in 2003 and a Common Market in 2008. This was intended to remove all barriers to trade in services and investment. A single currency for the GCC – the Khaleeji – is

proposed although Oman and the UAE have recently withdrawn from this. The new currency is not expected to be launched before 2015 in the four remaining countries.

### Rail Projects in the GCC

The improvement of transportation and communications by use of rail transport has been identified as a means to achieve the above goals. All GCC member states have domestic railway systems under development apart from the main GCC line. These include urban metro systems for Abu Dhabi City, Dubai, Bahrain, and Kuwait City as well as long distance mixed freight and passenger lines in Saudi Arabia and the UAE.

*Table 2: Rail Projects within GCC (Frost & Sullivan, 2011)*

Project	Budget	Length	Target	Coverage	Usage
GCC Rail Network	\$30.0 bn	2,177 km	End 2017	Kuwait City-Muscat	Mixed
Qatar Rail System	\$25.0 bn	850 km	Mid 2015	North-South	Mixed
UAE Etihad Railway	\$10.9 bn	1,500 km	End 2015	All of UAE	Mixed
Dubai Metro	\$10.6 bn	180 km	End 2015	All of Dubai	Passenger
Bahrain Rail Masterplan	\$7.9 bn	103 km	End 2025	All of Bahrain	Passenger
Abu Dhabi Metro	\$7.0 bn	131 km	End 2020	Abu Dhabi City	Passenger
Kuwait City Rapid Transit	\$7.0 bn	171 km	End 2016	Kuwait City	Passenger
Saudi Land Bridge Rail	\$7.0 bn	950 km	End 2014	Jeddah-Riyadh	Mixed
Haramain High Speed Rail	\$7.0 bn	444 km	End 2014	Mecca-Medina	Passenger
North-South Railway	\$5.3 bn	1,486 km	Complete	Al-Haditha-Riyadh	Mixed

## THE GCC RAILWAY

### Justifications

Railways make better use of space for transporting people and freight. Rail uses 60-80% less energy, results in 80% less carbon dioxide emissions and is 30% cheaper. It is also much safer and causes in less noise pollution (Frost & Sullivan, 2011). It has less scope for disruption due to climatic factors. The rail transportation of bulk solids and liquids as well as containerised cargo will be cheaper than road provided that the journey is over 500km. For shorter journeys, the overheads associated with trips to and from the railhead will erode this advantage. The GCC members, with the exception of Saudi Arabia and Oman are geographically small. Domestic trips will have a maximum 'stretch' of 250-300km. Hence for domestic freight transport within most GCC states, rail tends to be at a disadvantage compared with road.

Further economic integration within the GCC will result in longer journeys and ensure that the advantages of rail will kick-in. The economic diversification away from oil and gas – where pipeline is the best form of transportation – towards industrialisation and exploitation of mineral resources will justify the high capital costs of a railway.

### The Route

The main route for the railway follows the coast from Kuwait City to Jubail in Saudi Arabia and on to Dammam where there is an existing line to Riyadh. The route continues along this line to Al Hofuf and then on to Ghuwarfat in the UAE. It then goes direct to Sohar in Oman via Al Ain and hence to Muscat with a loop via Abu Dhabi, Dubai and Fujairah to Sohar. The total length will be around 1,770km. In addition a loop was proposed from Dammam via a new causeway to Bahrain and on

by another causeway/bridge to Qatar before re-joining the main line at Salwa giving a total length of 2,177km.

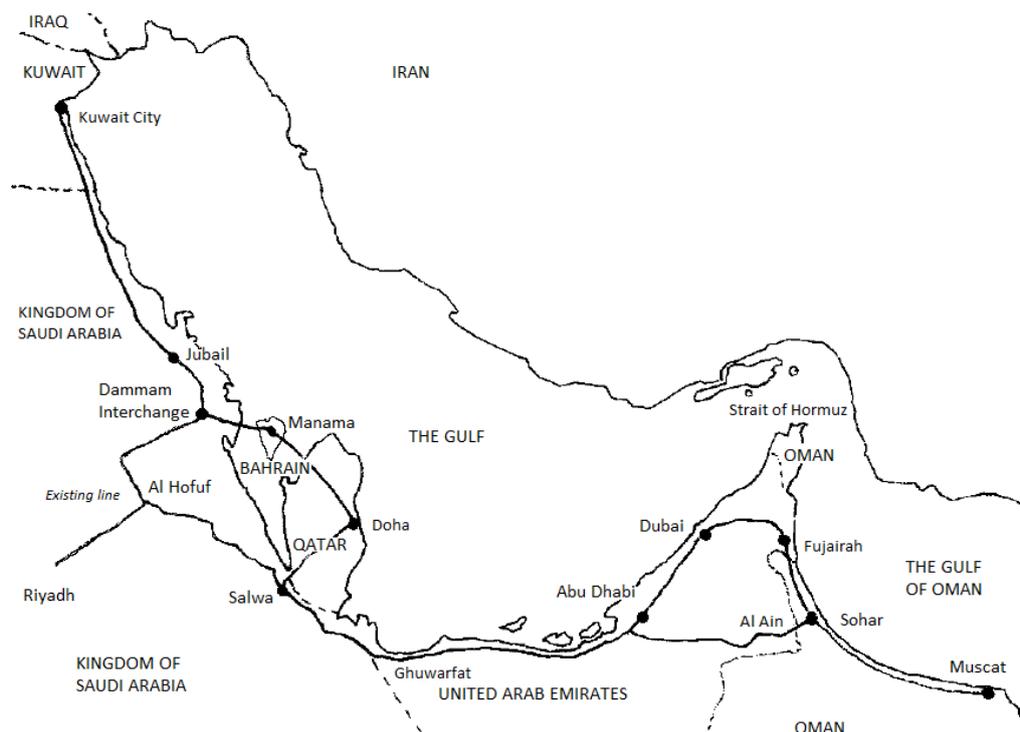


Figure 1: Proposed Route

There will be seven large stations and four smaller stations on the line. It is hoped that the line will be go beyond the GCC to Jordan and the European Union (Yousef, 2013)

Table 3: Stations on the GCC Railway (after GPCA, 2013)

Station	Line	Type	Member State
Kuwait City	Main Line	Large	Kuwait
Jubail	Main Line	Small	KSA
Dammam Interchange	Main Line	Large	KSA
Manama	Branch or Loop Line	Large	Bahrain
Doha	Branch or Loop Line	Large	Qatar
Salwa	Main Line	Small	KSA
Abu Dhabi	Loop Line	Large	UAE
Dubai	Loop Line	Large	UAE
Fujairah	Loop Line	Small	UAE
Sohar	Main Line	Small	Oman
Muscat	Main Line	Large	Oman

### Finance for the Railway

The total cost of the line is currently estimated at around US\$15.5 billion (Arab News, 2013). The proposals suggest that the cost of the construction of the line be carried by the members proportional to the length of track running in their state. Each state will construct their own stations, freight terminals and branch lines plus links to national railway and urban transportation systems. The causeway linking Saudi Arabia with

Bahrain will probably have to be largely financed by the Saudis. Similarly the bridge/causeway linking Bahrain with Qatar will probably be financed by Qatar if it goes ahead. The procurement of rolling stock is expected to use private funding.

This will result in an unequal distribution of cost with Kuwait, for example, paying far less than Oman and the UAE. Saudi Arabia is expected to make the largest contribution to the costs. Each country will opt for different funding approaches to reflect their varying economic circumstances. These might involve public private partnerships or funding packages from banks and the use of Islamic Bonds.

The basic line runs from Kuwait City through to Muscat. The full line includes the loop via Bahrain and Qatar. This includes around 180km of connecting lines to traffic nodes and ports, airports and industrial cities. The existing US-built line from Dammam via Al Hofuf to Riyadh (Henry, 1952) and the proposed extensions in Oman not included in the figures below.

*Table 4: Funding criteria: the length of track within each Member State (GPCA, 2013)*

Member State	Basic line	Percentage	With loop	Percentage
Kuwait	145km	8.2%	145km	6.7%
Kingdom of Saudi Arabia	635km	35.9%	695km	31.9%
Bahrain	–	–	64km	2.9%
Qatar	–	–	283km	13.0%
United Arab Emirates	684km	38.6%	684km	31.4%
Oman	306km	17.3%	306km	14.1%
Total	1,770km	100.0%	2,177km	100.0%

## **RISKS IDENTIFIED**

### **Introduction**

The risks facing this project can be divided into three main groups:

- Technical risks related to co-ordination of issues such as the loading gauge of the railway, the standards of train protection and the signalling systems used for the system so as to ensure that through-running is possible.
- Economic and financial risks concerned with the provision of finance for the project and its economic viability.
- Political and legal risks associated with any failure to fully implement the GCC Customs Union and Common Market.

The main focus of this research is the analysis and possible responses to the technical risks. These will be dealt with in the section below. The economic and political risks will not be analysed in detail as they fall outside the scope of the research but are outlined so as to set the technical risks in context.

### **Economic and Financial Risks**

The total cost of the project has been estimated at \$15.5 billion using 200kph diesel power or \$25.6 billion using 350kph electric power. Some commentators argue that the cost could end up at \$30 billion (Frost & Sullivan, 2011). The largest contribution to costs will probably come from Saudi Arabia with an economy flush with liquidity. Saudi Arabia has the cash to provide sovereign guarantees and make it easier to secure

private sector funding. Saudi Arabia has a number of on-going strategic rail projects and is also planning a \$3 billion light rail system for Riyadh. They are likely to use a public private partnership for the latter.

The second biggest contribution will come from the UAE who suffer from tighter financial constraints. They also have to pay for the Etihad Rail Project and the Abu Dhabi Metro not to mention completing the Dubai Metro. They will certainly require funding packages to ensure that the projects go ahead. Stage one of the Etihad Railway has been financed by a consortium of banks.

The other major section of the line is in Oman who received an offer of a package of assistance from the GCC of \$10 billion over 10 years, although this has yet to be received. This is intended for infrastructure developments part of which is earmarked for the GCC railway and the potential extensions to Duqm, Salalah, and Yemen.

The section in Kuwait is very short and will not be a problem in financial terms. The causeway link to Bahrain is expected to cost \$4.5 billion for a 90km line. It is currently undergoing a feasibility study. The link from Qatar to the main line in KSA will not present any financial problems. The Bahrain-Qatar causeway and line, by contrast, looks years away at the moment. It will probably depend on Qatar to provide the bulk of the funding and this is not likely to be forthcoming at this stage. However the link was promised as part of the successful 2022 FIFA World Cup bid so it could well be revived. Recent unrest in Bahrain (Mabon, 2012) has turned Qatari opinion against a link. The other sections appear to present few problems for funding although the domestic rail systems in Kuwait and Bahrain appear to be experiencing slippage.

Of more concern than capital requirements, will be the operational viability of the project. This will require through running of goods trains and through ticketing for passengers. This in turn will depend on political decisions on the common market and border controls within the GCC. This falls into the remit of political and legal risks.

### **Political and Legal Risks**

The economic case for the GCC railway appears to be based on an assumption that there will be free movement of goods and people throughout the council area. The economic underpinnings for the line depend on continued economic growth and more trade between GCC member states (Shediac et al, 2011). At the moment, long queues of trucks at border control posts are all too familiar. Despite that, trade within the GCC has continued to grow although most trade is still with the rest of the world.

For freight, this will require a joint customs system for all member states to permit a single point of entry into the GCC and a uniform tariff for imported goods. That would eliminate custom controls at borders within the GCC. It would also require free movement of people throughout the GCC with no passport controls at borders. Hence passenger trains would not be able to travel through borders without stopping.

All the above issues were included in the GCC plans for economic integration (Hertog, 2007). The customs union was declared in 2003 and the common market in 2008. The proposed monetary union was planned to take effect by 2010 (Buiter, 2008). However the withdrawal of Oman and the UAE has cast doubt on the single currency project which is currently running five years behind schedule (World Bank, 2010). The perception is that the whole integration programme is running behind schedule. In particular the failure to implement the sharing of customs duty on goods entering the GCC remains outstanding. There is agreement of zero import duty on inter-GCC trade but it is not implemented consistently. Inter-GCC trade is rising but

remains very small in comparison with trade with rest of the world (Shediak et al, 2011). If the issues of import duty and border controls are not fully resolved before the planned opening of the line in 2017, this could cause real problems for the project.

## **TECHNICAL ISSUES**

### **Technical risk identification**

Ostensibly technical co-ordination should not appear to be a problem as only one GCC member – Saudi Arabia – had a functioning heavy rail system when the project was first mooted (ignoring the Dubai Metro). However, each member state is likely to have its own objectives and agenda. In some cases the GCC railway will be only a small component in the developing domestic rail networks. The terrain with shifting sand dunes and at times a narrow coastal strip between the sea and rocky outcrops may also represent a challenge for railway construction and operation.

Technical standards are a frequently encountered issue with rail systems running across international borders. This can affect the gauge of the railway – the distance between the tracks – that was once a major problem when travelling from France with standard gauge to Spain with a broader gauge. This will not be a problem with the GCC railway but the loading gauge – the distance between platforms and the height required for tunnels and bridges – is more likely to cause conflict.

Freight transport is likely to be the issue here. The loading gauge will affect the size of solid/liquid bulk carriers and containers that the system is designed to carry. Most containers were originally of a standard 2.4m width by 2.4m height with varying lengths. However the advent of taller 'hi-cube' containers of 2.9m or 3.2m height has complicated this. Even more challenging, the practice of 'double-stacking' of standard containers on freight trains, is common in countries such as India, China, and the USA. If this practice is to be employed on the GCC railway, it will require bigger tunnels and higher bridges. It will also complicate the use of overhead electrification systems on such lines. In this case the wires would have to be 7.45m above track level resulting in even higher bridges and more expensive tunnelling. This leads to a potential point of conflict concerns the issue of running with diesel powered or electric locomotives. It, in turn, probably depends on whether the prime motivation for building the rail system is to run slow diesel-powered goods trains or high speed electric-powered passenger trains. The other technical issues such as signalling and train protection systems need to be consistent throughout the railway.

### **Technical risk analysis**

Many of these issues solve themselves given the preponderance of standard gauge railways in the region and the emerging world standards for train protection and signalling systems. Where conflicts arise, the established systems used in Saudi Arabia will certainly prevail over the other mooted systems. A political decision was required to resolve the connected issues such as loading gauge, the speed of operation and the mode of traction. All these will impinge upon the cost. The loading gauge will be particularly an issue in the mountainous areas of the UAE and Oman as it will impact on the cost of tunnelling. Electrification will increase the capital costs given the installation of overhead wires and this will also require higher tunnels and bridges. A high speed line will be more expensive to construct and to maintain than one of conventional speed especially in the challenging conditions of the GCC.

It became clear that GCC member states had very different objectives in mind for the rail network. Qatar clearly favoured electric powered fast passenger trains as did

Oman. However the other four states wanted diesel powered trains throughout. This would lead to problems for through running with either locomotive changes needed at the borders or diesel traction for through trains under the overhead wires.

Given that double-stacking of containers is likely to be desired by most states, this will mean that electrification will either not be possible on any section of the GCC railway without massive headroom for the wires or else the tracks will have to be duplicated with and without overhead equipment with all the added expense.

Qatar clearly has an agenda to establish a modern high-speed passenger rail network in time for the 2022 FIFA World Cup and probably see an electrified system as the most appropriate for this (Nambiar, 2012). Qatar also has the fourth biggest reserves of natural gas in the world and this is well suited to generating electricity.

Oman is in a very different economic category to Qatar but the motivations may also be similar. Oman has ambitious plans to link the GCC railway beyond Muscat to the special economic zone of Duqm and to Salalah and beyond. Oman also wishes to develop tourism and sees the construction of a fast passenger-oriented railway network as part of that strategy. Oman's reserves of oil are depleting fast. They do have decent reserves of natural gas although this is likely to be costly to exploit. Oman also has ambitions to develop solar power. They probably see an electrified rail network as more suited to their future energy potential.

Saudi Arabia has the objective of transporting bulk minerals and passenger traffic. Its current lines are diesel powered as are most of its planned lines. However the KSA is currently planning the Haramain High Speed Rail project that is expected to run with 360kph electric trains from Mecca to Medina via Jeddah. This line is primarily intended to transport Hajj pilgrims. The UAE is aiming at containerized goods transport and passenger traffic (Nambiar, 2012). The UAE intend to go for diesel power on its proposed Etihad Rail network with the option to electrify the route at some unspecified future date (Gavin, 2012).

The long distances involved with the GCC railway along with the arid nature and sparse population has convinced the most member states that diesel power is the best and most cost-effective option at least for the moment. The very low price for diesel in the GCC that has in the past promoted the development of road transport adds to these cost advantages of diesel trains over electric.

The problems associated with the terrain should not be insurmountable given technical advances along with careful planning and preparation and by selecting paths using the most stable dunes. This may involve consultation with the local Bedouin to establish the exact track route to use through the dunes (Kuwait Times, 2012).

### **Response to technical risks**

It was agreed to establish a GCC Railway Authority to oversee the application of consistent technical standards for the railway as well as methods of procurement. This will deal with issues such as train protection and signalling plus also loading gauge and tunnel/bridge heights to ensure safe through running. This should avoid the problem of different member states building their portion of the line to meet their own technical objectives and in line their budgetary situation. The connected issues of diesel versus electric traction, the double-stacking of containers and loading gauge used, remained points of contention that were resolved by a political solution.

The GCC Railway Authority needs to ensure the use of common standards and specifications, interoperability and regional integration of the GCC railway. This is so as to co-ordinate with the Saudi Railway Organization, Saudi Arabian Railway, the UAE National Transport Authority, Etihad Railways, Qatar Rail, and the Kuwait Transport Company.

It was been decided that the European Train Control System (ETCS) Level Two would be used for the GCC railway (GPCA, 2013). This system has no trackside signals with control by radio. It is a well-established system that is in commercial use for high speed lines throughout Europe. It will be possible to get competitive bids for installation. It is well suited for mixed high and low speed traffic

While all the current GCC members are all high income states, there are marked differences in liquidity even between Saudi Arabia and the UAE and particularly so when compared to Oman and Bahrain. This disparity may have helped to resolve the issue of traction power. The proposed \$10 billion package of assistance to Oman from the GCC for infrastructure projects may have been the factor that helped to persuade them to come into line over diesel traction. The announcement that diesel traction will be employed in Oman was made in January 2013.

Qatar is in a different position with the highest per capita income in the GCC. The line through Qatar is less central to the GCC railway than for other member states. The original proposals show a loop from the main GCC line going through Bahrain and Qatar. Saudi Arabia appears very keen to build a new causeway link to take the line to Bahrain but is not so enthusiastic about the proposed road and rail marine crossing 'Friendship Bridge' from Bahrain to Qatar. At the moment all road traffic to Bahrain has to travel via Saudi Arabia. A direct link to Qatar would reduce the dependency of Bahrain on Saudi Arabia.

Also Qatar has lost out in a major long-standing territorial dispute with Bahrain over the Hawar Islands and their oil and gas potential (Wiegand, 2012). A clash in 2010 between Bahraini fishermen and the Qatari military reignited this dispute. As things stand, there are doubts if the full loop will be built in the immediate future and there may only be branches from the main line to serve Bahrain and Qatar. Hence the choice of traction power by Qatar will have little impact on the main GCC line. However through running of double-stacked container trains to Qatar may not be possible if the branch is equipped with standard overhead wires.

The tunnels in the mountainous areas of the UAE and Oman will be built to facilitate double-stacking of containers. Air-conditioned diesel powered passenger trains will run at two hour intervals at 200kph mostly during the day. Container and bulk freight trains will run at 80-120kph mostly at night (GPCA, 2013). There appear to be technical solutions to the challenges presented by the difficult terrain.

## **CONCLUSIONS**

The line was proposed by the GCC in order meet its strategy objectives of increasing trade between members and economic integration. This integration was seen as an approach to dealing with external and internal threats to sovereignty and security.

It would appear that the measures to be taken such as the establishment of the GCC Railway Authority to oversee the overall implementation of the project will go some way to solve the technical issues identified above. This appears likely to deal with the most, if not all, of the risks associated with technical co-ordination.

The key political decisions about the specification of the railway appear to have been taken that will resolve other technical issues. The line will be diesel powered and will be designed to a loading gauge suitable to accommodate double-stacked containers. That leaves the political issues concerning the completion of the Common Market that remains beyond the remit of this research.

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# RISK ATTITUDE OF CHINESE CONTRACTORS IN BID/NO BID DECISION-MAKING OF INTERNATIONAL PROJECTS: A PRELIMINARY STUDY

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Decision-makers' attitude towards risk plays a critical role in the bid/no bid decision of international projects. As a descriptive model of decision making under uncertainty and risk, cumulative prospect theory (CPT) proposed a distinctive fourfold pattern of risk attitude. According to the CPT, the fundamental goal of this research is to explore the risk attitude of Chinese contractors in bid/no bid decision process of international projects. The research is also devoted to answer the question whether the risk attitude of Chinese decision-makers in international construction firms is consistent with the conclusions in CPT. An experiment based on Tversky and Kahneman's CPT research in 1992 was conducted. With limited source of Chinese contractors subjects, this research conducted a preliminary study on 48 post-graduates majoring in construction management in Tianjin University. Thirty five valid data were eventually obtained. Multivariate statistical analysis indicated that: 1) the risk attitude of Chinese contractors in bid/no bid decision-making of international projects accords with the fourfold pattern, the same in CPT; 2) all the parameters are less than 1, in accord with diminishing sensitivity in CPT; 3) when bidding international projects, the tendency of Chinese contractors to take high-risk projects for losses with moderate and high probabilities is higher than that to avoid risk for gains. The results show that the application of CPT should take different cultures and situations into consideration and this research also benefits contractors to make reasonable and proper bid/no bid strategies.

Keywords: bidding, contractor, cumulative prospect theory, international project, risk attitude.

## INTRODUCTION

Globalization of international project market has provided tremendous opportunities for Chinese contractors to expand into the contracting markets. Chinese international project contracting has been increasing at a high speed in recent years, but that serious decision problems appeared in several international projects reveals the existing

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limitations of the decision-making of contracting enterprises. Appropriate bidding decision not only plays a critical role in the success of construction projects, but also has a direct bearing on the profit and development of enterprises. Generally bidding decision includes two major and interrelated decisions, bid/no bid decision and what bid price to use (Lin and Chen, 2004; Cheng et al., 2011). This research focuses on the bid/no bid decision-making, which is associated with uncertainty and complexity because of subjective considerations. Any decision involving risk and people's attitude toward risk differs (Hillson and Murray-Webster, 2007). Risk attitude of decision-maker will produce direct impact on one's choice (Harbaugh and Krause, 2010), so with the bid/no bid decision.

One of the major approaches to study risk attitude is derived from the traditional utility theory (Au and Chan, 2005). According to expected utility (EU) theory, risk attitude can be divided into three types, namely risk aversion, risk neutral and risk preference (Flanagan and Norman, 1993). Recognizing the limitations of the utility theory, Tversky and Kahneman (1979, 1992) proposed prospect theory and then cumulative prospect theory (CPT). Cattell et al (2011), considering that CPT serves to equate different return-risk alternatives to find one set of item prices which will provide the optimal outcome, introduced and applied CPT in the study of unbalanced bidding model. Therefore, CPT, as the descriptive model of decision making under uncertainty, is introduced in this research to investigate into the risk attitude of Chinese contractors when selecting international projects.

Han et al. (2005) put forward in his study that construction firms apt to display severe risk aversion which may bias consistent bid decisions in threat or opportunity situations. Meanwhile, cultural differences are considered to be one of the driving forces of different risk attitude. Weber and Hsee (1998) suggested that Chinese respondents were significantly less risk-averse in their pricing than Americans, which were associated primarily with cultural differences in the perception of the risk of the financial options. Therefore, the fundamental goal is to explore Chinese decision-makers' attitude towards risk in bid/no bid decision-making in international projects contracting domain based on CPT, as well as test and verify whether the risk attitude of decision-maker in China corresponds to the relative conclusions in CPT.

## **LITERATURE REVIEW**

### **Relationship between risk attitude and bid/no bid decision-making**

Risk attitude can be defined as a chosen response to an uncertainty that matters, influenced by perception (Hillson and Murray-Webster, 2007). Risk attitude is often seen as a stable personal trait, which will apply regardless of the context, the risk and consequences involved. Different people differ in the ways they resolve work-related or personal decisions which involve risk and uncertainty and decision-making behavior is often described or explained by risk attitude (Weber and Blais, 2002; Wang and Yuan, 2011). Both risk perception and risk attitude under uncertainty are well described determinants of risk decision-making behavior (Pennings and Smidts, 2000; Au and Chan, 2005). Limited by both the nature and competition for bid opportunities, bid/no bid decision as a critical activity for contractors is associated with uncertainty and complexity (Lin and Chen, 2004). Therefore, great academic attention should be paid to the risk attitude of bid/no bid decision-making.

Relationship between risk attitude and decision-making is studied in many domains including the construction management area (Au and Chan, 2005). Contractors

conduct different behaviours when dealing with small and large projects, and operating in good or bad years so that they tend to be most risk averse toward larger projects in lean years. (de Neufville et al., 1977). Han et al. (2005) emphasized the importance of risk attitude of international project contractor in decision-making and explored the relationship through questionnaire survey. According to Wang and Yuan (2011), decision-makers' attitudes towards risks play an important role in risk-based decision making, which is critical in successful construction project management. During the bidding decision-making process, the preference structure and the risk attitude of the decision maker should be taken into consideration, which reflect the bidder's subjective evaluation (Ahmad, 1990). Thus, this research focuses on the risk attitude from the perspective of decision-makers in bid/no bid decision in international project contracting context.

### Cumulative Prospect Theory

CPT was derived from Expected Utility (EU) theory, the assumption of which is that all the decision-makers are completely rational. Due to the limitation of Expected Utility (EU)-based assessments of risk attitude, a developed model of choice, prospect (PT) (Kahneman and Tversky, 1979) and CPT (an extension of PT) (Tversky and Kahneman, 1992), explained the major violations of EU theory in choices between risky prospects with a small number of outcomes. CPT can help describe people's decision-making behaviour when faced with uncertain choices. A quantitative description of CPT is presented by value function ( $v$ ) and weighing functions ( $w$ ), fitted the following function functional form (Tversky and Kahneman, 1992):

$$v(x) = \begin{cases} x^\alpha & (x \geq 0) \\ -\lambda(-x)^\beta & (x < 0) \end{cases} \quad (\text{value function})$$

$$w^+ = \frac{p^\gamma}{(p^\gamma + (1-p)^\gamma)^{1/\gamma}} \quad w^- = \frac{p^\delta}{(p^\delta + (1-p)^\delta)^{1/\delta}} \quad (\text{weighing functions})$$

( $x$  represents for a set of consequences, like gains or losses;  $\alpha$  and  $\beta$  are estimable coefficients determining the convexity or concavity of the function.  $p$  stands for the possibility level of outcome  $x$ ;  $\gamma$  and  $\delta$  are estimable parameters indicating the level of distortion in probability judgment)

According to CPT, risk aversion and risk seeking are determined jointly by the value and weighting functions. There are three main conclusions of CPT. 1) The most distinctive implication is a distinctive fourfold pattern of risk attitude: risk aversion for gains and risk seeking for losses of high probability; while risk seeking for gains and risk aversion for losses of low probability. 2) The second conclusion is that all the parameters ( $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\delta$ ) are less than 1, in accord with diminishing sensitivity: the impact of a change diminishes with the distance from the reference point. The functions are concave for gains, convex for losses, and steeper for losses than for gains. 3) The third conclusion of CPT revealed that for moderate and high probability, risk aversion for gains is more pronounced than risk seeking for losses.

### Effect of Culture Difference

Cross-cultural difference in risk preference attributed difference in risky choices (Weber and Hsee 1998). As a dimension of culture variation identified by Hofstede (1980), collectivism-individualism is considered to be related to people's decision-making behaviors. Some previous studies have demonstrated that cultural differences

in interpersonal relationships between individualism and collectivism may impact the extent to which group members make risky decisions under conditions of uncertainty (Hofstede, 1981; Triandis, Bontempo, Villareal, Asai and Lucca, 1988).

A proposed cushion hypothesis proposed stated that members of socially-collectivist cultures, such as the Chinese culture, can afford to take greater financial risks because the social network insure against catastrophic outcomes (Hsee and Weber, 1999; Weber and Hsee, 2000). While in individualist cultures, a person making a risky decision will be expected to bear the consequences himself. Therefore, it can be supposed that the risk-taking tendency of Chinese people can be higher than that in individualist cultures.

Above all, considering the conclusions of CPT and the collectivism-individualism difference, the following hypotheses in this specific domain of international construction projects can be put forward:

- Chinese contractors display different risk attitude when making bid/no bid decision of international projects, according with the fourfold pattern presented in CPT.
- The parameters ( $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\delta$ ) estimated from the functions are all less than 1, indicating the diminishing sensitivity.
- When bidding international projects, the tendency of Chinese contractors to take high-risk projects for losses with moderate and high probabilities is higher than that to avoid risk for gains.

## **RESEARCH METHOD**

Experiment is an efficient method to conduct research into individual risk attitude, which is widely adopted by many scholars (Harrison et al., 2007; Charness and Gneezy, 2010; Gloede et al., 2011). Given that there are so many factors affecting decision-making, an experimental research design would allow for manipulation of variables. Thus, experiment approach is chosen to investigate risk attitudes of contractors in choosing between projects with risky opportunity and sure payoff in the case of both gain and loss within the international construction environment. Based on the similar research of CPT by Tversky and Kahneman (1992), "Certainty Equivalent" (CE) research paradigm was adopted, which could qualitatively describe and quantitatively obtain the magnitude of risk aversion or risk seeking. A program in Java was designed on the computer to measure the magnitude of subjects' risk attitudes. Multivariate statistical analyses, mainly including correlation analysis, sign test and regression analysis, were performed by the application of the SPSS 19.0 software package.

## **RISK ATTITUDE EXPERIMENT**

### **Subject selection**

Experiment subjects are required to be equipped with certain professional knowledge and ability to make decisions. Due to the fact that it is difficult to invite Chinese contractors to participate in the experiments, post-graduates majoring in project management in Tianjin University were adopted to conduct a preliminary study. They have cognitive ability and theoretical foundation for international projects and bidding decisions. Eventually, 48 post-graduate students participated and each was rewarded 50 yuan for their contribution to the research.

With regard to the study of human decision activity, the adoption of student subjects is to some extent acceptable. The existing literature of experiment often chose college students as subjects for the reason that students are apt to understand experimental rules and learn new knowledge at a relatively rapid speed. Empirical evidence suggests that students are the appropriate and adequate surrogates for practitioners when the experiment refers to the basic human information processing and decision-making tasks (Ashton and Kramer, 1980, Liyanarachchi and Milne, 2005; Liyanarachchi, 2007). Therefore, post-graduates with a high level of construction bidding knowledge were enrolled in the risk attitude experiment.

### **Experiment design**

"Certainty Equivalent" (CE) method is used to measure the subjects' risk attitude to examine its influence on bid/no bid decision-making. The experiment was carried out on the computer and programmed by JAVA, an application development language. This program was primary based on the experiment of Tversky and Kahneman (1992). Students major in computer technology were invited to join in the experiment team to help design the program. After the program was firstly designed, we had a pre-experiment on the post-graduates. With their suggestions, some minor errors were revised and the program was adjusted well.

Data collecting was derived from a series of choices between a given prospect and several sure outcomes. The computer displayed a prospect and its expected value (EV) as Choice A. Choice B included a descending series of five sure outcomes linearly spaced between the extreme outcomes of the prospect (not including two extreme outcomes). For instance, computer screen exhibited the following trial to subjects. Then the subjects took a preference between the risky choices or each of the sure outcomes.

Assume that as the decision-maker of one international project contracting enterprise, you are about to make the bid/no bid decision between two overseas projects (A and B). From the perspective of project return and ignoring other factors, please choose:

A. [p1] chance to win/loss a1 million yuan and [p2] chance to win/loss a2 million; EV as expected value;

B. Surely win/loss x million yuan.

To obtain a more refined estimate of CE, a new set of five sure outcomes was presented based on the first round, linearly spaced between the lowest amount accepted value and the highest amount rejected value. The CE value of prospect was derived from ten choices and estimated by the midpoint in the second set. The program could itself monitor the internal consistency of the responses to each prospect and reject errors. When subjects accepted a cash value lower than one previously rejected, warning appeared that "You have inconsistent choices, please choose again by pressing the enter button".

After choosing all the questions, subjects were told to write their response to this experiment. The value of a1 and a2 has 8 probabilities; while (p1, p2) has the following values (see Table 1). Therefore, 72 problems were formed from the combination and we finally chose 56 problems, 28 with positive prospect and 28 with negative. Besides, six random prospects appeared twice during the experiment program to check out the consistency of subjects choices. The experiment was finished in 30 minutes to one hour.

## **Experiment results**

After experiment implementation, data of 35 subjects in total was aggregated. We firstly examined the consistency of repeated-twice six prospects and the correlations calculated, across subjects, averaged 0.53 over six different prospects. Each prospect is significantly related, which reveals that the choices of subjects to some degree are reliable. The experiment results are listed below, showing the median CE of prospects of 35 subjects (see Table 1).

## **FINDINGS**

### **Risk attitude analysis**

The decision-maker of international project enterprise is regarded as risk seeking when CE exceeds EV, and risk averse when CE is less than EV. According to the distinction, Table 2 displays the percentage of risk seeking of each subject within different probabilities. To simplify the table, only data of five subjects were listed.

Last line of Table 2 shows that 91.4% of subjects prefer to take risks for gains with low probability ( $P_2 \leq 0.1$ ) and 97.1% subjects are risk seeking for losses with high probability ( $P_2 \geq 0.5$ ). In addition, for high probability, all 35 subjects are predominantly risk averse for positive prospects (11.4%) and risk seeking for negative ones. Altogether, 29 subjects are in accord with the fourfold pattern of risk attitudes. In spite of the apparent overall pattern of risk attitude, the individual data undoubtedly involve noise and differences.

Table 1: Median CE (in millions)

	p2								
	0.01	0.05	0.1	0.25	0.5	0.75	0.9	0.95	0.99
(0,50)			10.4		24.3		39.6		
(0,-50)			-10.4		-24.3		-39.6		
(0,100)		9.7		29.2	51.4	70.8		84.7	
(0,-100)		-9.7		-29.2	-40.3	-68.1		-81.9	
(0,200)	8.3		36.1		91.7		163.9		186.1
(0,-200)	-8.3		-30.6		-97.2		-152.8		-180.6
(0,400)	5.6								372.2
(0,-400)	-5.6								-372.2
(50,100)			64.6		75.7		85.4		
(-50,-100)			-60.4		-70.1		-79.9		
(50,150)		68.1		81.9	101.4	120.8		129.2	
(-50,-150)		-62.5		-73.6	-95.8	-112.5		-129.2	
(100,200)		120.8		134.7	151.4	165.3		179.2	
(-100,-200)		-115.3		-120.8	-140.4	-154.2		-179.2	

Table 2: Percentage of Risk Seeking Choices ( $CE > EV$ )

No	Gender	Gain		Loss	
		$P2 \leq 0.1$	$P2 \geq 0.5$	$P2 \leq 0.1$	$P2 \geq 0.5$
1	F	75%	0%	37.5%	100%
2	F	100%	23.5%	12.5%	100%
3	M	87.5%	11.8%	0%	64.7%
4	M	62.5%	29.4%	25%	82.4%
...	...	...	...	...	...
<b>Risk seeking</b>		<b>91.4%</b>	<b>11.4%</b>	<b>14.3%</b>	<b>97.1%</b>

For prospect of the form  $(p_1, 0; p_2, a_2)$ , EV is equalled to  $p_2 \cdot a_2$ . Risk attitude can be defined by comparing  $p_2$  and  $CE/a_2$ . Specifically speaking, subjects are risk seeking for gains if  $CE/a_2$  exceeds  $p_2$ , while it is opposite for losses. Sign test is proceeded further to analyse the experimental results as follows (see Table 3). We can figure out that the majority of Sig. values are less than 0.05, except some with the probability between low and high probability, explaining the significant difference of number of people with different attitudes. Therefore, this further verifies the fourfold pattern of risk attitudes.

Table 3: Sign Test:  $p_2$  and  $CE/a_2$

p2	a2	Sig.(2-tailed)	
		Gain	Loss
0.01	200	0.000	0.000
0.01	400	0.000	0.000
0.05	100	0.001	0.018
0.10	50	0.002	0.007
0.10	200	0.007	0.499
0.25	100	0.043	0.735
0.50	50	0.499	0.018
0.50	100	0.735	0.176
0.50	200	0.091	0.018
0.75	100	0.176	0.007
0.90	50	0.000	0.002
0.90	200	0.043	0.001
0.95	100	0.000	0.000
0.99	200	0.000	0.000
0.99	400	0.000	0.000

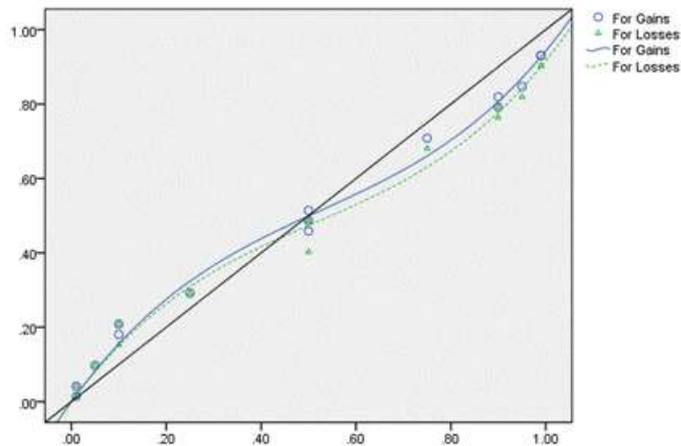


Figure 1: CE Values for Gains and Losses

**Parameter analysis**

In CPT, risk aversion and risk seeking are determined jointly by the value function and cumulative weighing functions. The principle of diminishing sensitivity reflected in both of the functions, giving rise to the value function which concave above the reference point and convex below the reference point, while the weighting function that is concave near 0 and convex near 1. All the parameters are less than 1, in accord with diminishing sensitivity. Nonlinear regression through the SPSS 19.0 was adopted to iterate and reach the value of parameters. The estimated values of  $\alpha$  and  $\gamma$  were obtained as 0.697 and 0.506 after 10 times of iterations. The relatively low standard errors (0.024 and 0.017) indicated the reliability of the estimated value of parameters. The results of variance analysis and R squared (0.996) illustrates that the fitting model is quite effective. The values of  $\beta$  (0.648) and  $\delta$  (0.648) were also obtained after 8 times of iterations. All the four parameters of them are less than 1, which reflects the diminishing sensitivity and keeps consistent with those in CPT experiment of Tversky and Kahneman (1992). Hence, hypothesis 2 is tested.

**Analysis of magnitude**

It was pointed out in CPT that the preference of risk aversion for gains is more significant than risk seeking for losses for moderate and high probabilities ( $\gamma < \delta$ ). However, in this experiment, we obtained the opposite findings ( $\gamma > \delta$ ) (see Figure 1). Figure 1 indicates that, for both positive and negative prospects, subjects overweigh low probabilities and under-weigh moderate and high probabilities, just as presented in CPT. Figure 1 also reveals that the weighting functions for gains and losses are quite close, but the latter is slightly curved than the former ( $\gamma > \delta$ ). As a consequence, it can be inferred that contractors in international project enterprises are overwhelmingly tend to overweigh low probabilities and underestimate moderate and high probabilities

for both positive and negative prospects. Besides, the curve for losses is more crooked than that of gains, indicating that for moderate and high probabilities, tendency of subjects to be risk seeking for losses is more pronounced than that of subjects to be risk averse for gains. Thus, the third hypothesis is verified, assuming the risk-taking tendency of Chinese people can be higher.

## CONCLUSIONS AND LIMITATIONS

Actually, there are various factors related to the bid/no bid decision-making of contractors, including the specific project, the uncertain environment, ability and conditions of the contracting firm, contractor's preference, and so on. As Chen et al. (2009) pointed out that cost competitiveness is the main factors for the success of the Chinese construction firms. But this paper mainly focuses on the perspective of the contractor's subjective preference and investigated the risk attitude of contractors. Through the experiment, we finally draw the following conclusions.

1) The risk attitude of Chinese contractors in bid/no bid decision of international projects accords with the fourfold pattern, the same in CPT. It refers to that decision-makers tend to be risk averse for gains and risk seeking for losses of high probability, while risk seeking for gains and risk averse for losses of low probability when making the bid/no bid decision of international projects; 2) All the parameters presented in the value function and weighting functions are lower than 1, indicating the diminishing sensitivity. The shape of the functions indicates risk aversion for gains and risk seeking for losses. 3) CPT indicates that risk aversion with moderate and high probabilities for gains is more pronounced than risk seeking for losses, but we obtained the opposite conclusion. In other words, when related to bid/no bid decision-making, tendency of Chinese contractors in international projects contracting enterprise to take high-risk projects for losses with moderate and high probabilities is higher than that to avoid risk for gains.

In the construction management field, risk-based decision making is in the core of risk management (He and Huang, 2007). This decision-making process is involved with human behaviour and related to decision maker's subjective perceptions. People's risk attitudes reflect their personal characteristics and experience. Just as Hillson and Mussray-Webster (2007) stated, different individuals can have various risk attitudes, and these play important roles in shaping decision makers' behaviour. Without a good understanding about the contractors' risk attitudes, it would be difficult to investigate or predict contractors' bid/no bid decision-making (Wang and Yuan, 2011). The findings of this research not only to some extent help scholars have better awareness and understanding of CPT theory and its application in China, but also benefit decision-makers to improve risk management in bid/no bid decision and make wise bid decision strategies.

However, Limitations are still included in this research. The first limit is the small sample size of subjects. The data of 35 subjects to some extent are not enough to conduct more comprehensive statistical analysis. A further existing problem is that all subjects participating in this experiment are post-graduates, rather than experienced workers in international construction domain. Though student subjects are widely adopted in experiment to substitute for managers, experience of decision-makers does play a non-ignorable role. This limitation resulted mainly from the high time-cost of this experiment and workers are not willing to spend that much time for the research. Therefore, further research may conduct experiment into experienced workers in international project contracting enterprises as well as enlarge the sample size, so as to

guarantee the internal and external validity. Encouraged by the experimental results that the conclusions of CPT cannot totally be available in international construction domain, we intend to focus future research on exploring the reasons, such as culture differences or situations, which lead to the different application of CPT.

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# RISK AND SECURITY CHALLENGES ON FURTHER AND HIGHER EDUCATION CAMPUSES

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For many years universities have been aware of the increasing demands on student security and safety on their campuses. The risks that are now posed through low-level crime or anti-social behaviour on campuses are many. This can undoubtedly affect their overall student experience while studying. More thought provoking; however, is the risk of a serious criminal or terrorist related incident on a campus. How is risk apportioned and assessed in a changing and challenging environment? Can risk be managed out at planning stage of building projects? Decisive decision making incorporating a strong understanding of risk intervention is needed to reduce risks on university campuses. With evidence to remind us that serious criminal activity as well as terrorist related crime is becoming more wide spread. Is it just a matter of when and not if a serious incident will occur on a university campus in the UK? The aim of this paper is to identify if staff and students perceive crime and security risks to be a relevant issue on campuses. To identify the type of serious incidents of crime that would affect campuses and how risk identification would minimise the impact on campuses. Staff and student survey indicates that that there is recognition of security related risks on campuses, however, clear distinctions can be drawn between student and staff groups. Evidence to suggest that security risks from external sources and students based activity is discussed and would form the basis for risk analysis progression. Only by understanding all security risk elements from building structure, policy and regulation and crime level indicators can a full risk assessment be authenticated. This paper reviews how crime orientated risks are assessed and fully incorporated into building design. It further argues that a coordinated approach between planners, architects and users of the estate should be instrumental in the health, safety and security of its users. This will also include how global events and political issues can manifest itself on our university campuses. It is thus proposed that evidential perception of risk be researched as a way of producing authentic risk assessment criteria, which fully identifies risks to users and to the educational establishment. With such research a concise index of risk can be applied at design stage. Hence, any risk identified could be aligned to post occupation thereby avoiding retrospective architectural realignment. This research adopts a web-based, crime and risk-based survey and analysis methodology. Identifying any resulting realignment of risk assessments and redesigning of estate will be an outcome which would have the potential to improve current practices which is solely based on construction project completion risk. It is intended that further work will include a risk matrix based on street level crime figures. From this format comparators can be extrapolated against actual campus crime and risk indices of wider scale security issues at the serious crime spectrum covering organised crime and terrorism.

Keywords: crime, risk assessment, risk perception, security, threat impact.

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## INTRODUCTION

With over 2 million students registered in UK Higher educational establishments the very size and nature of this populous and the demands of learning environment will be something that a student remembers throughout their life. The opportunity to gain knowledge and study in renowned learning establishments is a driver for one's own progression and rewarding society as a whole. To enable student life on university campuses to flourish and to aid learning, campuses have evolved and are now a mix of rich architectural heritage and modern designs incorporating cutting edge technology. The functionality of the building or space will comply with the most stringent of building control regulations and will have been through deliberations at planning committees, applications will take in-to consideration impact on the local environment infrastructure and neighbours. There will be input from user groups on what the overall functionality will be delivering and there will be provision for compliance with security led functionality from the local architectural liaison officer from the police. Nutt (1988) argues that strategic "attitudes are the wisest way to set out for distant but successful results when the actual form of the end product cannot be anticipated in advance". This will imply that considerations of how the buildings will operate under use will have been gauged and planned for at design stage, occupancy, figures crunched and compliance to fire regulations and health and safety will be an underpinning element of the occupancy. Peng (1994) states that "further exploration of communication in collaborative design from the perspective of co-operative architectural modelling". From this it must be identified how a university campus can be brought into events that could be unfolding outside its perimeters but equally have a devastating effect on the campus itself.

The consequences of external security incidents that would reflect on a university's are well documented. The Lancaster University student that was shot dead in Salford Manchester December 2011 made international news. Not only did this bring Lancaster University in to the media spotlight but also Salford University which was in close proximity to where the shooting took place. In the case of Virginia Technical College the reputation and negative publicity as well as law suits against the University are still an ominous reminder of the tragic shooting of 2007. It must be recognised that no university campus is immune to the likelihood of criminal or a terrorist act taking place up their premises. Budget constraints within police and continuing close budget controls with Higher Education are similarly negating security on campuses. Whitehead (2012) reveals that Islamic extremist preached at more than 200 universities events raising fresh fears overs radicalisation on campuses. A dozen events featured speakers with links to Hizb ut Tahrir a controversial organisation banned by the National Union of Students. In 2011 the Home Secretary stated "I think for too long there's been complacency around universities. I don't think they have been sufficiently willing to recognise what can be happening on their campuses and the radicalisation that can take place. "I think there is more that universities can do."(May T 2011). Risk from general building occupation and usage could relate to a very low impact of any incident in that controlled environment. What is more relevant however, is how the campus determines the risk of major impact events. In some instances events that would seem highly unlikely, however, could be so severe that addressing and recovering from a single incident could take years and the cost of recovery could determine a university's future. The following study aims to provide rationale underpinning the challenges of maintaining a safe campus environment. The need to respond to incidents from low level antisocial activity to

terrorism is now more than a residual low level risk and must be addressed at an early design stage process.

### Determining Risk

Risk is a familiar concept in many fields and activities including economics, business, sport, industry, also in everyday life, but it is not always referred to with exactly the same meaning. A strict definition is required, however, when the term is used in a professional environment.

Various definitions have been proposed, for example: "a situation which can lead to an unwanted negative consequence in a given event"; "the probability that a potential hazard occurs"; "the unwanted consequences of a given activity, in relation to their probability of occurrence"; or, more specifically, "a measure of human injury, environmental damage or economic loss in terms of both the incident likelihood and the magnitude of the loss or injury" (Joaquim, 2008). We define risk as representing any situation where some events are not known with certainty. This means that the prospects for risk are prevalent. In fact, it is hard to consider any situation where risk does not play a role (Chavas 2004).

It is sometimes understandable to look at buildings in isolation and not consider how one incident could impact on other areas of an estate or its surroundings. Security risks are not isolated in one area or one building as an incident can spread quite rapidly across areas and in this way affect other users and other buildings. In isolation a building can be deemed as relatively safe to occupy and warrant no specific attention. Already established security applications can be in place both in a technological format and in the form of human intervention.

Street level crime figures by post code are available from the police forces national web site; this would be an understandable point to start a risk assessment for crime related activities in the localised area. The information in Figure 1 is based on street level crime for the University of Wolverhampton Walsall Campus, Warwick University and Keele University.

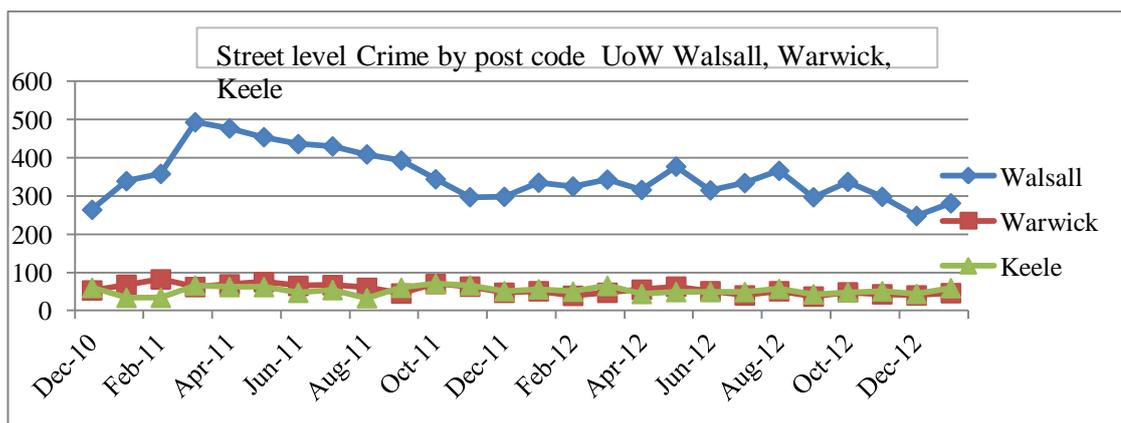


Figure 1 Street level crime by post code UoW Walsall Warwick Keele

From the figures contained in Figure 1 it would be relevant to assume that there is a far greater risk regarding crime surrounding Walsall Campus than Keele or Warwick Campuses.

Controlling risk is fundamental to our day to day lives. Risks to human beings arise from an inherent characteristic to make plans and try to make them happen, while external forces resist and tend to move our endeavours away from the plan. Any such

“endeavour” is a complex ensemble of a bewildering variety of interacting elements which together form something that (Kirchsteiger, 1999) Moskowitz, and Bunn, (1987) believes it is “the focus as much upon implementation as an analytical issues and particular attention is also given to issues of public sector risk evaluation and management”. Trends in research are discussed within the standard decision analysis model of formulation, assessment and optimisation although it is recognised that this framework itself is a subject of research and change (Ward and Chapman 1991) to some degree, the level of detail incorporated in any risk analysis depends on the purpose of the analysis. In the early stages of project design, the emphasis may be on project evaluation in economic terms, involving the aggregation of project risks to determine the total impact on the project. The circumstances of accidents may influence the seriousness, which makes it difficult to specify on a theoretical basis the type of injury to include in a risk analysis. Furthermore, risk assessment methods often do not provide a basis for assessing cumulative risk which may have more severe consequences than accidents emerging from contacting one hazardous product characteristic (Van Duijne et al, (2008)

When in the workplace or indeed planning ahead in terms of building or project development it is not always easy to simulate the overall impact of the development within a risk assessment. It is generally estimated that about 90 per cent of accidents can be attributed to human error (McKenna, 1983).

With regard to industrial-societal risks it is often recommended that risk acceptance decisions be based on a weighing of risks against benefits. Is this feasible in the case of complex and long-term activities? Or should one take a much more restricted view and rely on so-called norms for acceptable risk, which may either deal with the probability of a specified loss or with the magnitude of a just-credible accident? Vlek and Stallen (1981) and latterly (Jens) 1997 recognises that the socio-technical system involved in risk management includes several levels ranging from legislators, over managers and work planners, to system operators. This system is presently stressed by a fast pace of technological change, by an increasingly aggressive, competitive environment, and by changing regulatory practices and public pressure. Risk is an ever changing process which can be influenced by a number of factors. Waring and Glendon (2002) recognises that Security risk assessments tend to be an art and judgment approach based on analysis of hazards and threats and actual experience of criminal activity. In terms of assessing risk. O’Reilly (2010) refers to a Security Threat Matrix. This compiled data gathered post attack investigations with in-depth security audits of the relevant facility to calculate actuarially its vulnerability.

The purpose of risk analysis is to provide support in making correct management decisions. By evaluating the risk associated with a set of decision alternatives, the risk analysis helps to identify the alternative which maximises the expected utility for the stakeholders by complying with a set of specified criteria and constraints. Todinov (2007) states it is not if, but when”—how many times have we heard this mantra of every expert turned prophet, warning the viewer of the impending catastrophe of nuclear terrorism? The seemingly wise caution assumes that, by ruling out the conditional “if” from terrorists’ evil minds, we are reaffirming our own unconditional certainty. The assertion of “when” invokes some real time.

The UK is generally a safe place when considering how to approach risk assessment for events that may or may not impact on a university campus. It can be seen in figure 1, that there is a need to monitor street level crime and how this could creep into what

could be deemed as safe havens of a campus by its users. Events have shown that that if anything, always expect the unexpected. With any event that results in the modification of a physical, operational or theory remodelling the following ultimately may be heard, “well I never expected that”, or “I told you that would happen”. Both statements equally as important as the other. Firstly there should not be any unexpected incidents only the assessment of severity of an unexpected incident. Secondly find the person who recognises the most unexpected risks.

### **Methodology**

An individual’s perception of risk is specific to that person. Any number factors could determine one’s own thoughts on this. Age, physical ability, mental capacity and even location would be considered. It is therefore critical, that risk information is available for a decision to be made of one’s own risk. The framework for research in this instance will be categorised as situation influences and types, risk associated, preventative measures information sources. This is based on the duty of care that is adopted by a university for all users of its estate. And not relying on an individual to be aware of all potential risks.

By understanding the format of risk and developing an action plan each area of risk can be contained and residual risk analysed. To gather evidential data a survey of staff and students at Walsall University campus was carried out in March 2011 staff and students had the opportunity to respond to questions relating to security and how they perceived their own security while on campus and within the surrounding areas. Staff side returns were favourable at a 60% return rate 232 respondents. Student figures in comparison were low with 30 responses. Significant findings are available in tables 1,2,3 of this paper.

The fear of crime is related incidents are prevalent within today society. Nasar et al (1993) refers to the fear of crime as a serious problem on university and college campuses. Although fear has many causes, one potential source of fear may arise from the design of the physical environment. A government white paper (Higher Education: at the Heart of the System June 2011) states, There is also clear evidence that some young people may be vulnerable to the influences of extremist organisations or individuals during their time at university. To assess the risk perceptions the following data has been collected regarding crime levels and the perception of crime on and around University of Wolverhampton Walsall Campus. Staff and students were surveyed and asked to comment on a number of questions relating to security both on and off campus.

From the information contained in Table 1 it can be seen that there is some differential in how students and staffs perception of crime levels on campus correlate. Student’s responses being predominantly in the high to medium with 7% more responses than staff in the very higher section.

*Table 1 level of crime on campus*

	Staff side	Student Side
Very High	3.7%	10.71%
High	10.65%	57.14%
Medium	39.35%	21.43%
Low	37.04%	3.57%
Very Low	9.26%	7.14

The staff's response was notably at odds with students with medium to low being the largest percentiles. In considering these responses it is recognised that in many instances staff will be on campus to undertake specific tasks during set hours. Students, however who live on campus will have a full range of experiences and over a 24 hours cycle.

*Table 2 Concern about crime impact on personal campus experience*

	Staff Side	Student Side
Very Significant Impact	6.85%	58.62%
Significant Impact	10.96%	24.14%
Moderate Impact	21%	6.9%
Minimal Impact	31.05%	0%
Not at All	30.14	10.34

It can be seen in Table 2 that again there were significant differentials between staff and student responses. Staff felt that this was there was minimal impact or no impact at all both of these producing 61% of responses. It was however recognised that a total of 16% felt that they did have a concern regarding crime and the impact that this had on their experience while on campus. Students, however, who completed the survey, felt that concern regarding crime had a very significant impact on their experience. With over 82% responding within the significant or very significant field for this question. It is interesting to note that although staff assessed the overall risk of crime on campus to be medium to low.

*Table 3 Need to address the risk of crime on campus*

	Staff Side	Student Side
Yes	81.86%	89.29%
No	18.14%	10.71%

Table 3 responses from staff and student gives an indication of security improvements although not specifying what is needed. 82% of staff responded by agreeing to the question. This is somewhat contradictory to the majority of responses to table 1 and table 2. Students had already scored the level of crime and concerns about crime highly in table 1,2 so it was feasible that students would consider that more could be done on campus to address the risk of crime.

## DISCUSSION

- High Impact Events

It is critical when assessing risk that all information should be considered. The following section will identify where events have occurred and if there is a risk that

could be transposed to within a university campuses. On April 16, 2007, Virginia Tech in the United States of America suffered a significant high impact event. A student Seung Hui Cho, shot two fellow students in an accommodation block and subsequently went on to shoot a total of 32 students and staff on campus, with a number of other people injured both physically and mentally. A most traumatic event that would instantly link the name of Virginia Tech and the massacre of students for years to come. There is, however, indications that with a more robust risk evaluation mechanism the overall impact in terms of numbers of people killed or affected could have been reduced. Key findings and recommendations following the subsequent investigations were many. And the impact was felt amongst most of America's Universities. The following statement is taken from a report produced by Midwestern Higher Educational Compact, Rasmussen and Johnson (2008) "No amount of money, technology, and human resources can guarantee members of a university community that they will never fall victim to a crime. At the same time, colleges and universities are by their very nature open-access environments where people move between and among buildings and outdoor spaces in a manner akin to the free flow and exchange of ideas, discussion, and debate that is a *raison d'être* of the academy" This report was specifically in relation to the investigation of the mass shootings at Virginia Tech by the student Seung Hui Cho. The findings and conclusions of the report were wide reaching and affected a number of colleges across the United States. This statement realises the students need to experience a full and free ranging educational experience yet concedes that there is a danger in students living the student experience. Within the United States constitution the law surrounding gun ownership and the amount of guns available is a far cry from legislation and gun ownership in the United Kingdom. Guns are not freely available within the UK; however, recent history would suggest that gun related crime and random or planned shootings are not uncommon. A further view and assessing the probability of risk relating to security manifestations would indicate that a significant risk of a high impact event on a university campus cannot be discounted. The events that occurred within central London 7<sup>th</sup> July 2005 saw buses and the underground infrastructure targeted, and resulted in fifty deaths including the four perpetrators of the crimes. In addition to this over seven hundred more were injured. This was an attack that hit at the heart of the capital of England. The outcome was that of wholesale infrastructure communication and commercial impact. This was of varying time lines and dependable on the type of business and or geographical location. Longer term impact was of reputation regarding safety within the City of London for premises infrastructure and commuters.

On 3rd June 2012 a car was stopped by police on the M1 motorway in Yorkshire. The reason behind the stop was no insurance. On investigation ammunition and firearms were discovered in the boot of the car. This particular vehicular stop resulted in the arrest of six people accused of preparing acts of terrorism. It is noted that in a recent report there is a claim that 500 hundred terror suspects have been de-radicalised. This is from a total of 2500 referrals between 2007 and 2012. This particular report refers to the work of multi-agency in the recognising of vulnerable people and engaging in support mechanisms. One such group that uses the skills of multi-agency collaboration is Channel. This was set up as a direct result of the Prevent Strategy and links to Contest the UK Governments strategy document for counterterrorism. Recognising that there have been atrocities within England either by terrorist cells or by lone individuals the result will always be for maximum devastation and impact.

Levels of crime can be monitored against national statistics, police street level crime figures will help specific campuses bench mark against the wider area. The overall impact of crime on campuses can be evaluated and dealt with as and when crimes are committed. This can be done as simply as adding extra physical security provision. What becomes more problematic is overall change to layout and use of campuses and building on the campus. Campuses are in general a safe and secure environment to work and study. Petty crime amongst users is a possibility, as well as low level anti-social behaviour. Social levels of drug related incidents would be no more out of place than in any town or domestic environment. The high impact areas of a crime will, however, be open to interpretation. That is, as with all high impact events it is only the post mortem that will identify the failings. No matter how stressful the event the review of actions both from an individual or corporate perspective will be laid bare for experts to debate. Security features within Virginia Technical College USA were as prominent as any other college within the USA at the time. As the events of the day unfolded actions of police and security were in line with what would be expected with the information at hand. The outcome of the mass shootings on that day have been reviewed and scrutinized over many years since the event. As late as April 2013 there is still continuing debate regarding the fine imposed on Virginia Technical College. The main claims made are that after the first shootings a call to Virginia Tech police was made, this was at 07.15 am, within 15 minutes of that call police officers were on the scene of the first shootings they identified one body and one seriously injured student. It was at this point that a number of meetings between senior administrators took place. At 09.26 am a warning regarding a shooting incident was issued. By this time the gunman had chained the doors to an academic area and continued the massacre of students and staff. The communication time lapses are critical to the outcome. Continuing assessment must also include the response from emergency services to any critical incidents. Police restructuring could result in delays to responses. The risk of delayed attendance would be critical in evaluating time laps, and if this would then increase severity of risk.

Campuses across the United Kingdom will be of various designs, age and be situated in any number of socio demographic areas, university campuses can be forged in historical background with age of construction dating back hundreds of years. As Campuses evolve and the technology changes in the way that controls can be administered to the use of the campuses, the surrounding landscapes are also changing. Not only from a physical spectrum but also from a social, political and economic one. This will drive the security mechanisms that will be needed to maintain a safe and secure campus for its users.

It is recognised that in assessing risk the likelihood of a terrorist attack or an event such as unfolded at Virginia Technical College is low. With this in mind the likelihood of what would have been the assessment for colleges within the USA and risks assessments for London transport, most users of the mass transport system would have been comfortable in the belief that a safe and secure system was in place to carry them. It was only after the event that considerations to risk and its vulnerability were made or the mitigation of such events of this nature “Mitigation is defined as any sustained effort undertaken to reduce a hazard risk through the reduction of the likelihood and/or the consequence component of that hazard’s risk (Coppola, 2012) Structural mitigation includes resistant construction, building codes and regulatory measures, relocation, construction of community shelters, physical modification, and construction of barrier, deflection, or retention systems. To contextualise this sort of

high impact event it must be recognised modifications and the resilience planning has been modified since the 2005 July bombings. However, up until this time the risk assessments and day to day safe working process would have been felt to be robust enough to cope with most things. It is also recognised that risk assessments should identify any time laps responses from the emergency services. This is highlighted with the current police reorganisations. The following statement is in response to an estimated loss of 40,000 police officers “In reviewing risk and the impact on maintaining a safe environment we must consider external factors that could increase our response to incidents and therefore increase risk” BBC news (2010)

## **CONCLUSIONS AND RECOMMENDATIONS**

This study highlights the crime and associated risks to university campuses. The envelope of security is not all about keys and locks. The development of more advanced types of technological controls will undoubtedly enhance security systems and procedures. However, the most challenging aspect is how best to identify all risk elements and have the preventable measures in place. It may be the case that as with lone wolf type tactics that is one individual’s determination to cause loss, either against the university or fellow students. The risk associated with controlling this may be to put other people at risk. The question is how to negate the risk not only to students but also the staff who are employed to control the risks. What is apparent from the data collected from the staff and student survey is that there is some apathy toward the student’s perception of risk. The returns from this particular cohort were extremely low. Most of the students, who did respond, had witnessed crime personally and therefore had a greater understanding of the issues. From staff side there was a greater understanding of the risks, however, they felt that this was not significant to the campuses overall security status. It is therefore unclear why such a large group of respondent felt that more could be done to enhance security on the campus. Further research will be undertaken to establish how both staff and students perceive security and risk while on the campus. Technology will play a major part in the prevention of incidents occurring, this coupled with information from all sources across a wide range of spectrums. Architects, building design experts, planning officers, law enforcement, government agencies, students themselves, as well as staff user departments. The emphasis of how we use technology will have to be reviewed and more so, how to deploy the technology into working campuses. The provision of security officers is an accepted part of university life. Will the perception of risk from users of the campuses change the mind-set of expectations of human intervention to technology based framework?

Collaborative work is needed to work with planners, architects to identify a recognised format of assessing risk at early stage planning and incorporating recommendations in to the overall scheme of work. A numerical plan of risk can be identified which will give a stronger statistical element of risk. By using a numerical format the option for a personal view or perception will not cloud the overall risk. The Bayesian method of risk through probability would be a preferred system of assessment. What should be asked across all sectors is how their organisation would stand up against the intense scrutiny of dealing with an event of a critical nature. This could be of any nature ranging from fire, terrorist attacks, lone wolf attacks, or in house sabotage of estate or estate infrastructure. Building design is a significant factor in the resilience of estate as well as the occupation of these buildings or estate. It is not always enough to rely on the users or visitors to campuses with the education sector

for instance to be aware of the vulnerabilities. Users will arrive at campuses fully expecting to be safe within the confines of buildings and grounds. This will also be the case for staff who undertake their day today work within the grounds of a university campus. The response and deployment of staff to a violent or criminal activity could then put the onus of risk on to the member of staff as well as any users caught up in the incident. This is not an ideal situation and is somewhat difficult to allow for when assessing the risk and appropriate response to incidents that may occur. As any building design the brief will be direct from the client side stipulating what the building will be used for. Following the RIBA plan of Works and Office of Government and Commerce Gateways a clear path of progression is visible. The RIBA plan of works 2013 is modified from its original linear system to show a grid reference point. There has been much discussion regarding this major change, after 50 years of using the RIBA plan of works there is always going to be the for and against lobbyists . Will this change, however, hinder or enhance the profile of the client understanding of significant of impact assessment of security within the overall project scope. Usage of buildings and estate from such diverse groups as the student body staffing both academic and support services will be at pains to give opinions on what levels of security is needed and the best use of resources available.

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# HOUSING AN AGEING POPULATION: IMPLICATIONS FOR MANAGING THE SOCIAL HOUSING STOCK

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The UK is currently experiencing an exponential rise in the 50 + population with a peak not predicted until 2033. Increased life expectancy coupled with the retirement of the “post war baby boomers” presents a demographic spike which has significant implications for society. Prolonged longevity is often not accompanied by extended health, mobility and quality of life; and this represents a particular challenge for those involved in the provision and management of social housing. The choices available are heavily shaped by decreasing budgets and a lack of finance for new build solutions specific for an ageing population; and through the ‘Shifting the Balance of Care’ agenda an integrated care model based around the resident's home is promoted. The existing housing stock requires adaption but this needs to reflect the requirements and preferences of the ageing population. Despite this, providers are experiencing a significant information gap around which to base their future development plans. This research explores the available data and conducts primary research to expose the scale of the problem and readiness of the current social housing stock within North Ayrshire (Scotland). The case study allows key findings to emerge relating to the evaluation of health profile and housing stock within the Sub-Market Housing Area (SMHA); housing preferences and needs for older people established through a questionnaire survey of 1,500+ people aged 50+; and six focus groups split between residents and social housing providers. Exposing the current lack of detail within existing datasets, the research highlights the need to resolve this in order to accurately plan for the future development of the stock to ensure it responds to service needs, preferences and is appropriate for the residents.

Keywords: existing housing, housing management, ageing population, shifting balance of care

## INTRODUCTION

An exponential rise in the 50+ population during the next 20 years is emerging as a key consideration in national planning with policy makers slowly recognising that the implications of this demographic shift extend beyond traditional concerns related to pensions and health care. The Strategy for Housing Older People in Scotland (Scottish Government 2011) presents an attempt to plan for the implications of this scenario, and attaches significant focus on ensuring that the housing stock is suitable and calls on providers to consider the options available to match the needs of a rapid

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rise in the older population, especially those with a poor quality of mobility and long term conditions (Clough 2003). A challenging context is presented for social housing providers who require to address a higher portion of the problem given the strong correlation between their tenants and instances of poor quality of health in old age. This makes the problem more acute for social housing providers and presents a particular challenge when viewed in the context of decreased funding for new build solutions. Indeed, the House of Lords report in 2013 on "Ready for Ageing" identified the UK as having significantly lower levels of existing specialist housing for older people than other comparable nations. The "Shift in the Balance of Care" agenda (SBC) (Scottish Government 2009) has seen a renewed focus towards managing health and social care for older people within their own homes as opposed to investing in the provision of new housing specifically for older people such as sheltered housing or care homes (Richards et al. 2006). In the absence of new build solutions, social housing providers require to focus their future development plans on the adaptation and long term maintenance of their stock around the changing needs of their tenants.

Social housing providers are further hampered by an apparent information gap which exists between predicting the care needs and preferences of residents as they get older, and the ability to relate this to the existing housing stock and its ability to respond to these requirements in terms of its availability, condition and potential for adaptation (Croucher 2008). Indeed, the importance of ensuring that the housing stock meets the needs of an older person is highlighted by its link with determining their quality of life (Evans 2003; Appleton 2002). Adapting general needs housing where residents have often brought up their family (HAPPI 2009) has been argued to promote independence and is a strong preference of older people. A small investment in adaptation or equipment has been linked to sizable reductions in formal care spending on hospitals, care homes and subsidies for shelter housing environments (Christie 2011; Audit Commission 2010). The SBC agenda stresses the key role housing requires to play as the context for health and social care as policy makers promote a shift away from the hospital care of older people. It is increasingly recognised at all levels that this is the only viable alternative in the current financial climate as already significant pressure on health and social care budgets are heightened by these demographic shifts which makes the current care model unsustainable (COSLA 2011). Social housing providers need to resolve the current information gap in order to understand the implications for their housing stock and effectively plan resources and the future development of their stock. The potential for adaptation, the implications for cost and the suitability of their stock for the long term and future care needs of the residents is not available within current census and housing management data sets. The answer to these questions will have significant financial implications for local authorities and housing associations, and will be heavily dependent on specific local factors such as the demographics, geography, levels of deprivation, age and type of the housing stock.

The construction industry has lobbied strongly for a new build solution to meet the gap in specialist housing as part of a plan to stimulate market growth, however the current policy agenda favours adaptation of existing general needs housing in the short to medium term. The CIOB, RICS and ICE have called on the industry to embrace the resulting opportunities and to ensure it poses the knowledge, skills and capacity to deliver (Building 2009). The industry needs to work with social housing providers to understand and revise their planned and reactive work programmes to accommodate changing resident requirements and to adapt the stock to integrate resources between

health, social care, and housing provision and management. A long term view is required in terms of strategy with adaptability requiring to be considered through the design, construction, handover and the long term maintenance of the stock. Indeed, some basic Lifetime Home Standards have been incorporated in the Code for Sustainable Homes for new builds. Standards are still required for the adaptation of the existing housing stock, as a need exists to align with the SBC agenda, as well as principles of whole life value and the wider sustainability agenda.

Working together will ensure the housing stock is fit for purpose and industry is prepared to support its adaptation and long term management needs. However, managing this transition is currently difficult for social housing providers as they are experiencing an alarming information gap relating to the current demand and supply of suitable housing for an ageing population. Research is required to understand the scale of the problem and readiness of the social housing stock to meet future demand, as this is necessary to shape development plans. Plugging the information gap provides a baseline for future research to assess the fitness of the construction industry to support these plans, and to propose change and identify training needs.

This research presents an empirical study which looks at the problem at a local level and sets out to establish an evidence base for future development needs for social housing within the North Ayrshire Council (NAC) area. Authors undertook discussions with various local authorities in Scotland, and NAC responded strongly and created a funded post for the first author to conduct this research with a view to providing the evidence base for their new Strategy for Older Population. The research represented the first time the 50 + had been specifically considered within the datasets and consulted about their housing needs for the long term (2012 to 2035). On commencing the research, no established method existed for addressing the information gap and the paper outlines the research strategy and methods. Some of the key findings from a multi-method research approach are established focusing on analysis of existing datasets; a quantitative survey of 1,500 50+ residents across all tenures to explore housing needs and preferences, and a consultation exercise based on 6 focus groups with residents and service providers.

## **RESEARCH STRATEGY AND METHODS**

A case study following a pragmatist perspective was identified as the suitable lens through which to explore the context. The local authority as the unit of analysis reflects the level where most of the decisions related to the delivery of housing, health and social care services are made. Focusing on a local authority area allows for the specific needs and requirements of that area to be explored in relation to its demographics, health and deprivation levels, condition of housing stock and physical geography etc. Such an approach also lends itself to a multi-method approach, as the research questions aim to be driven by the explorative methods employed and respond to the context found. Figure 1 shows the stages of the research illustrating that no firm strategy is deployed from the outset, and emphasises during the early stages a significant level of consultation and engagement with key stakeholders in order to help shape the themes, questions and methods to be explored.

North Ayrshire Council had established an information gap following the completion of their Local Housing Strategy 2011-2016. The council responded to the enquiry from the authors and funded work to establish the empirical data required to form an operational plan for developing the housing stock in line with the needs of older population in the short, medium and long term. NAC also stated that the research

conducted would be used as the basis for the production of a North Ayrshire Older People's Housing Strategy (NAOPHS). Working with the Housing Divisional Manager as a point of contact, the research sought as a priority to respond to the wants and needs of the older population, in addition to being able to justify any recommendations. The exploratory nature of the study will help NAC establish the data gaps, and begin to consider future focus for their time and resources. The subject matter of housing an ageing population is broad and complex, and by considering a single case study in depth it allows for local context to be considered which is important for shaping decisions, in addition to providing new insights, data requirements and potentially to identify ways to make best use of existing housing stock. In addition, the case study format provides a methodological approach which other LA's could adopt in the future.

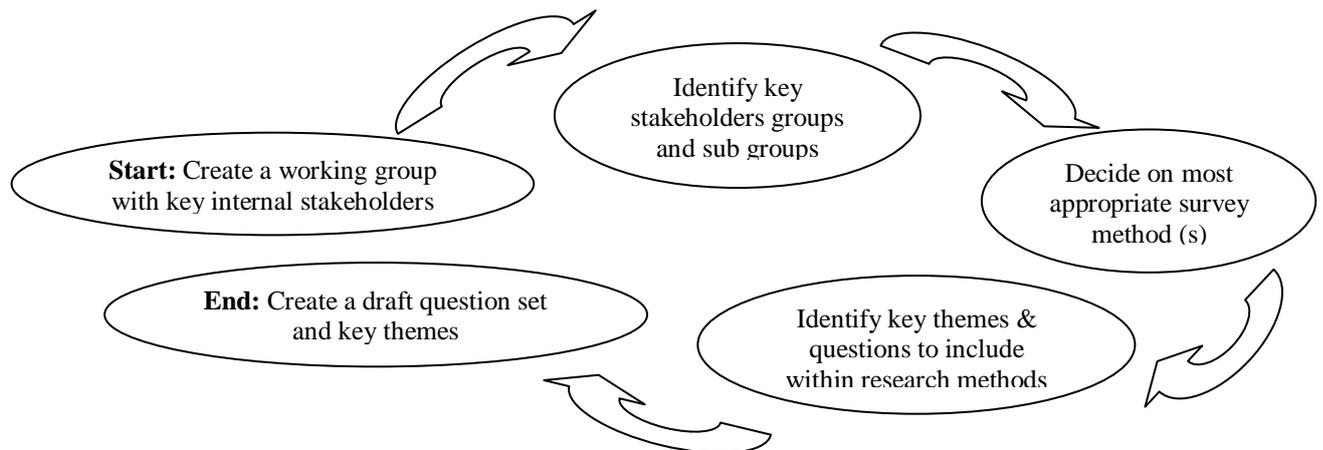


Figure 1: Initial Research Process

The research started with a literature review to establish the key themes related to this agenda from both the policy and research communities. In order to guide the overall process a working group was formed comprising of senior members from relevant internal departments within NAC i.e. Housing Services, IT (GIS specialists), Social Care, and also from external bodies such as the NHS. A series of workshops were conducted to identify the key stakeholders for the research, explore emerging themes from literature review and to establish the most appropriate methods of engagement. The stakeholders were split between category 1: Older People (50+) living in four different housing sectors: Local Authority Rental sector, Registered Social Landlord sector, Owner Occupier, and Private Rental Sector; and category 2 related to service delivery partners external to local authority: Registered Social Landlords, Private Sector providers, Voluntary Sector & Charities and the Joint Improvement Team (Scottish Government). The final category represented service delivery partners (internal) such as Housing Services, Social Services, Health (NHS), Infrastructure and Design and Elected Members.

The list of stakeholders and key themes emerging from the literature review were presented to several consultation events with each of stakeholder categories to verify and to further develop these for the local context. The process of stakeholder involvement aimed to construct validity from the outset; however it also achieved elements of stakeholder theory that were needed from NAC perspective to align with their wider commitment to stakeholder management (Simmons and Lovegrove 2005).

The findings of the working group and consultation events with key stakeholders provided the basis from which to develop the research strategy shaped around

secondary and primary data sources. The working group revealed an understanding of current data sets, areas which lack detail and the existence of data gaps. A secondary research approach founded around the existing data sources which are managed internally within NAC or by partner service providers relevant to their geographical area. Standard sources considered relate to demographics (GROS census and population projections), North Ayrshire's relation to the Scottish Index of Multiple Deprivation (employment, health, education, housing, access, and crime) and existing data related to the housing stock and development plans which is represented in Sub-Market Housing Area's (SMHA) and held in North Ayrshire Housing Register (NAHR). The first author as a development manager for the largest housing association in the area was able to supplement this data, providing access to tenure and housing management data and was involved in their future development planning. Analysis of these datasets reveals what information is available in order to shape an accurate understanding of the demand and condition of the existing housing stock.

The current housing demands outlined in the current NAC Local Housing Strategy (LHS) and Local Development Plan (LDP) are taken from the Housing Needs and Demand Assessment (HNADA) which lacks information on age specific housing demand. Without this it is difficult to effectively plan a future strategy for developing the housing stock and to identify the requirements for the construction industry. The NAHR includes all social housing applications and provides insight into the demand for older people specific accommodation and other housing preferences of those aged 50+ looking for a social rented property and is explored.

### **Resident's questionnaire survey**

The largest element of the research was the deployment of a questionnaire survey to evaluate wants and needs of older people in relation to housing preferences at a local level (across all tenures). The research intended to use a probability sample to determine the minimum sample size in line with other survey's deployed by NAC drawn from council tax data. However, it was quickly apparent that this sample frame did not exist as this source does not include age specific details. The use of a non-probability sampling method was agreed as the best route forward with the creation of quota categories and sample size in order to represent the population using GROS mid-year population estimates at a local area level to identify the estimated 50+ population within North Ayrshire by tenure. In order to overcome boundary problems with census data zones and SMHA, Geographical Information System (GIS) software was crucial in determining the best geographical fit of data zones within SMHA's. Given the complexity of establishing the sample an experienced consultancy (Research Resource) were asked to analysis and recommend acceptable confidence intervals per SMHA and Settlement Area (an aggregation of data zones). A sample size of 1,522 from a total population of 52,822 (GROS 2011) was agreed as sufficient to provide a robust general insight into the 50+ population of North Ayrshire's housing preferences, across all tenures. Regardless of arguments around statistical laws for representing populations through samples, given the practicalities the consultants developed the most robust method that could be financially afforded, given the available data and budget. The sample took a quota controlled approach based on 10 interviews linked to each sample point with 50+ resident's representative of tenure within that census data zone. This allowed for quotas to be developed through stratification by ward and 19 sampling points drawn in each ward. The questionnaire was developed using a range of closed and open questions responding to themes identified through the literature review and the earlier workshops with

stakeholders. The survey was conducted on the basis of an interview from 2 representatives of the council. The survey was conducted following NAC protocols to minimise bias, quality control and ethics.

**Focus groups**

Six focus groups were conducted to explore the central themes which emerged through the survey and literature review. The groups had differing focuses with four with older residents in different parts of North Ayrshire to explore their perceptions and needs reflective of varying levels of deprivation, and two with representatives of service providers in housing, health and social care to explore the implications and challenges faced. The transcripts were developed and analysed using thematic coding reflective of those emerging earlier in the research therefore enabling the findings to be triangulated with the secondary data, and therefore bolster and add weight to the emerging recommendations.

**RESEARCH ANALYSIS AND FINDINGS**

**Demographics and tenure patterns for NAC area**

Analysis revealed a particular demographic challenge faced in North Ayrshire on a number of key indicators. This is heightened by a predicted increase in demand for social housing for the 50+ population beyond levels observed nationally. Part of this picture is caused by a higher instance of social housing tenure in those below 50+ than in the current older population, a situation reflective of North Ayrshire's increasing levels of deprivation in this age range. Figure 2 displays a projection of the age profile in 2035 from a base line of 2010. It reveals that North Ayrshire has a declining population overall, but this is increasing between 65 and 74 observing a greater increase noted for the over 75's. Such a dynamic will see the overall proportion of the population be increasingly represented by those 50+ in higher levels than will be experienced nationally. The potential exists for a decline in the under 65 population to free up stock for over 65's, but whether this is suitable for their needs remains a big question.

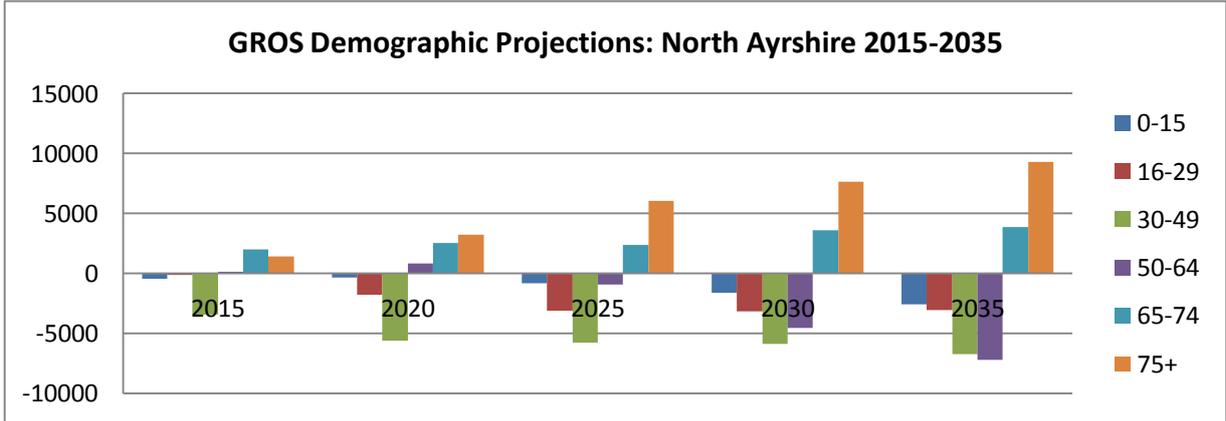


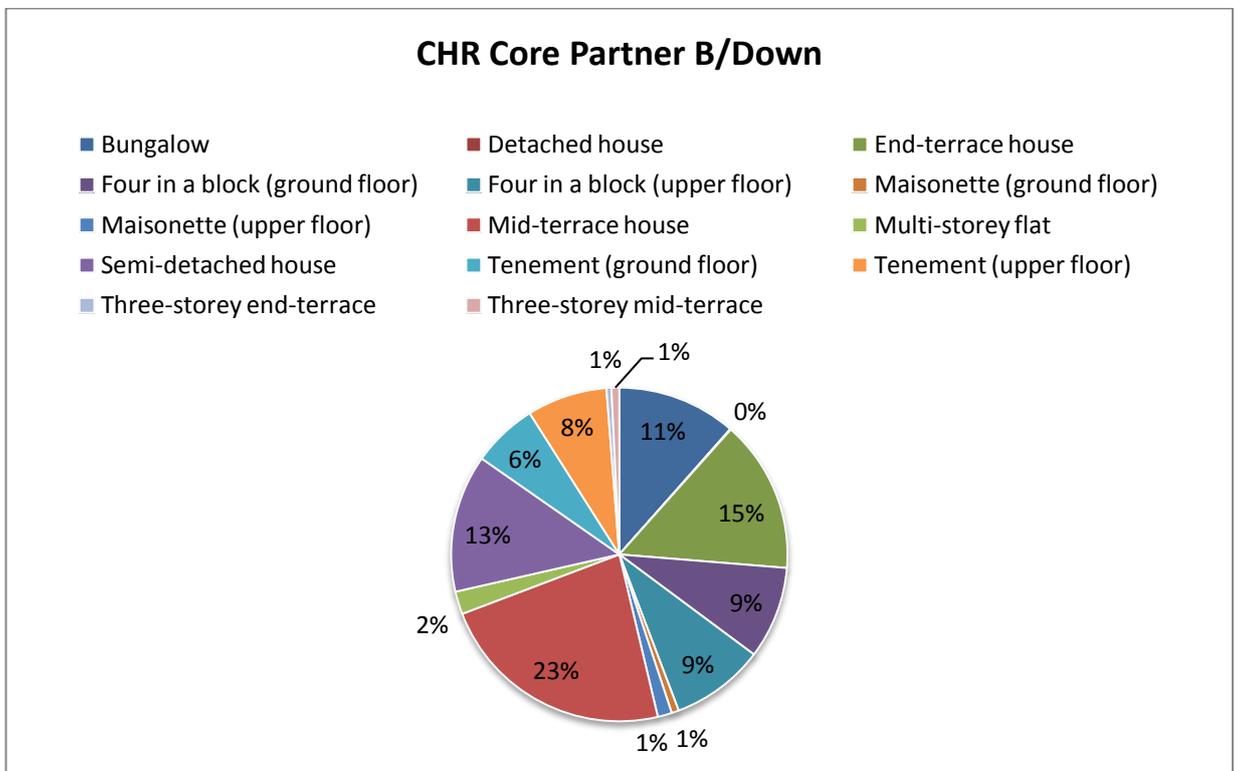
Figure 2: 20 Year Age Profile Projections for North Ayrshire

North Ayrshire displays high levels of disparity in levels of deprivation (using the Scottish Index of Multiple Deprivation) between affluent coastal towns like Largs and on the island of Arran, and inland towns with some of the highest levels of deprivation in Scotland. The coastal towns currently have a high population of 65+ residents, representing a significant proportion of NA's owner occupiers and the popularity of these towns for retirement. A significant concentration of social housing is observed

within the inland towns such as Irvine with higher levels observed than in the national average across all age ranges. The coastal towns display high life expectancy, and health data reveals an ability to maintain an active quality of life (with minimal mobility and care requirements) well into their old age. This contrasted with the inland towns, with lower life expectancies but also lower quality of life observed in their older age with an increasing proportion of those requiring care provision in their 50's and 60's. Increased care requirements, coupled with an observed increase in demand for social housing amongst those aged 50-64 within these inland towns has potential implications for housing and care provision over the next 20 years. Those with the longest life expectancies and highest quality of life (over 75) are predominantly owner occupiers and live within the coastal towns. The focus groups revealed a concern amongst social housing providers that this situation may change over time as existing home owners facing affordability issues and potential pension shortfalls apply for social rented accommodation. Indeed early data is indicating that this trend has begun and the focus groups revealed five common perceptions which have the potential to increase the reliance on the social housing: 1) lack of suitable older people specific housing in the private sector; 2) lack of suitable older people specific housing in the private sector, 3) affordability issues with owner occupation in later years, 4) the need to release home equity to generate much needed additional income, and 5) a perception that the social rented sector is the main provider of older people specific housing (Research Resource 2011).

**Supply and demand for housing for older people**

In order to understand fully supply and demand within North Ayrshire, firstly a breakdown of the property types currently available within the social housing stock is shown in figure 3.



*Figure 3: Stock Breakdown for Core Partners of Social Housing*

This provides a useful baseline to compare the findings from the resident's survey regarding their preferences and needs broken down by age bracket (50-64; 65-74; 75+). The survey revealed that within the 50-64 range there is generally a good mix of house types that would be acceptable and that the supply was available. Within the 65-74 range a very distinct pattern emerges with three clear house types emerging as preferences in priority order: Bungalows, Ground Floor Tenement and Ground Floor Four in a Block (Research Resource 2011). A basic building stock survey for NAC revealed that the properties currently available within the social housing sector that fit these broad categories only equates to approximately 26% of the stock available. A warning emerged during a focus group that there is no guarantee that all of these houses will be suitable. Only 13% of current social housing is specifically for older people, with the remainder designated for 'General Needs'. Analysis revealed that with new build rates of less than 0.4% (since 2005) of the existing stock, a picture is presented where despite an obvious demand the finance is absent for a building programme which is consistent with the literature review. This will result in the needs of the ageing population requiring to be facilitated largely through the existing stock.

The survey and focus groups consistently reported that residents want to stay in their current homes, with 77% reporting they would not want to move regardless of their care needs. Indeed, 88% of those surveyed had no plans to move home, and this coupled with the increased time people spend in their homes during older age presents a need to encourage older people to think about their current housing circumstances and whether it would fit their changing needs if their health or mobility deteriorated. For those considering moving significant problems were reported in terms of market flexibility and mobility due mainly to the economic climate and a lack of suitable social housing for their needs. The preference for bungalows is equally challenging as these tend to have a higher private market value and are rarely available in social sector. The focus groups outlined an increasing problem caused by a lack of understanding amongst residents of the options available in terms of the available house types within the stock, and their implications for differing care needs. A need was identified for social housing managers to better advise and raise awareness amongst older people of the choices available.

### **Evolving general needs housing for an ageing population**

If 'General Needs' housing is to emerge as the key environment to deliver health and social care as part of the SBC agenda, social housing managers will need to assess the extent to which the stock can be adapted and respond to people's changing health and mobility needs. The principle option for older people who have a declining quality of life but wish to remain as independent as possible within their own home is through 'equipment and adaptations'. This term is used to describe a whole range of options that can help transform a home from a burden to a safe and independent living space. Remaining at home provides greater independence and a feeling of security to people who suffer from a long term illness or disability. Equipment and adaptations involves ensuring the building fabric is energy efficient (and so reducing fuel poverty), but also assists in preventing falls in the home, helping carers and improving physical and mental health of older people. There are also many examples of the cost effectiveness of investing in equipment in adaptations when compared to the costs of emergency hospital admissions and associated care costs (Heywood and Turner 2002). This agenda places the home and community at the heart of future care provision.

However, evidence emerged through this research that this agenda is slow to be realised in practice. The questionnaire survey revealed that as many as 29% of people who reported they needed equipment and adaptations, currently have not received the work. The focus groups highlighted that this situation needs to be resolved in order to reduce the risk for older people's health and resultant increased cost for the NHS. In order to deliver this agenda effectively, housing managers will need to place equipment and adaptations within their refurbishment, renovation and maintenance planned works regimes.

Low level support was identified as playing a significant role in improving the quality of life of older residents and reducing the risk of falls around their home. Maintenance is identified as key to ensuring the equipment is functional and in removing the risk from around the house (i.e. carpets, doors, stairs, bathrooms, kitchens). Maintenance teams need to engage with older residents in order to respond to their needs. The provision of handy men and tradesman who are trained to listen to older people's concerns and periodic risk assessments for trips and falls has potential to provide low level support which has a big impact. A joint approach between housing, health and social care is recognised as part of the policy agenda, but social housing providers need to understand the implications for developing housing stock. Focus groups identified a current lack of preparedness within the local construction industry in the number of companies with capacity, knowledge and skills to support its delivery. Construction professionals were identified to lack awareness and understanding of the needs of older residents and training was highlighted as a need.

## **CONCLUSIONS/RECOMMENDATIONS**

Adapting the social housing stock to reflect the needs of an ageing population will require financial resources to facilitate its delivery. A key component of ensuring that a suitable budget is provided for social housing will be to establish the link between not adapting the general needs stock and the instance of fuel poverty and frequency of falls incurred from an unsuitable environment for older people and the resultant cost implications for health and social care. Recognising the savings which can be made between the different services is the only way to establish a joint approach, and housing provides the key context within which this will be delivered. The SBC agenda has far reaching implications for social housing providers and the future development of their stock, as they will experience a significant portion of the burden. However, evidence showed that future planning is hampered by an information gap which stops an accurate picture emerging on the current condition of the stock and its ability to respond to the needs and requirements of the ageing population. The compilation of this data in a format that can be analysed and proven to be robust will be crucial in identifying the proportion of the housing stock capable of being used or adapted for older people. Establishing the balance of existing housing currently or potentially available for housing older people across each Sub- Market Housing Area is important across all tenure types for social housing providers to plan for the future

North Ayrshire provided a worked case study revealing that the current stock profile displays insufficient detail to determine what properties are suitable for older people and which properties have been and could be adapted. Data matching, cleansing of the software systems and collection of the data gaps is required in terms of stock condition with a view to considering demographic projections over the next 20 years. NAC has responded to this finding and is in the process of finalising a 100% stock condition survey which records a number of age specific criteria (e.g. accessibility of

downstairs bathrooms) in order to construct a clearer picture of housing stock. NAC are also constructing an accessibility criteria for the existing social rented housing stock to establish 'what they have' in order to identify 'what they need' both now and in the future, to house an ageing population. Private rented and owner occupier sectors were also identified as requiring further research given the emerging realisation that even less information was currently available relating to the stock condition and tenure amongst these sectors.

Establishing a community profile (housing, health, and age profile relating to the 50+ population) initially at SMHA level would help establish the needs of different areas, identifying hot spots for action based on pressures observed within the profile and to foster a business case for adapting suitable general needs housing for older people reflecting variations in care needs and preferences. These profiles have the potential to help justify and shape local authority decisions ensuring that the limited resources available are allocated where they are most needed. The collation of robust data sets that are updated on a regular basis could provide a framework, identify data gaps and make best use of available information, with a view to making best use of the existing social housing stock. The findings have implications for social housing providers by highlighting the need to establish the readiness of the current stock by shaping future development plans for new build programmes, planned works (refurbishment) and reactive maintenance management. Work is then required with the construction industry to ensure knowledge, skills, and the capacity exists to deliver this in practice. Without this evidence, it is difficult to see how housing managers can plan the requirements to align their stock with the Shifting Balance of Care agenda, as well the wider sustainability agenda (environmental, social and economic).

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# CORPORATE ENVIRONMENTAL STRATEGIES AND PERFORMANCE: A LONGITUDINAL STUDY

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This paper focus on four environmental strategy aspects: 1) stakeholder relations, 2) management systems, 3) environmental staff, roles and responsibilities and 4) integration of environmental work. The paper aims to identify trends related to these four aspects and explores the relationship between them and environmental and business performance. The paper is based on a longitudinal and cross-sectional empirical study covering all Swedish construction companies with at least 50 employees (for architects 20 employees). Questionnaire surveys covering environmental attitudes, management practices and performance was carried out in 2002, 2006 and 2010. Respondents were environmental manager/officers in each company. Response rates for the three surveys were between 41-45%. The results show that the environmental work is on its way to be institutionalized as a strategic part of the companies. Environmental staff is increasing and environmental managers are part of top management and often also members of the management board. We can also see that communication and cooperation with stakeholders is getting more intensified and more diverse. So is the use of EMS as driver for a more active environmental work. It is concluded that a key to successful environmental and business performance is that environmental work is integrated with a variety of other corporate business areas/issues.

Keywords: environmental management, integration, stakeholder, performance, questionnaire survey, Sweden

## INTRODUCTION

A search in the Web of Science resulted in a total of 104 hits for *greening of firm surveys*. Here we found surveys that study corporate leaders' (in US Fortune 500 companies) perceptions of corporate environmental strategies (Andrews, 1998), motivation and commitment to sustainability in business (Hahn and Scheermesser, 2006), and effects from environmental management systems on international business performance (manufacturing companies) (Darnall et al., 2008a, Darnall et al., 2008b). However, few studies provide longitudinal empirical data so that it is possible to identify and predict trends and change in corporate environmental management. One exception is Lee and Rhee's study that investigated trends in environmental strategic change in South Korean pulp and paper industry (Lee and Rhee, 2007). An interesting result from their study was that they found a lack of relationship between environmental strategy, environmental performance and financial performance.

For the construction industry there are some studies that have focused on attitudes and perspectives to sustainable development in especially construction companies. Myers, for example, reviewed public disclosures of 42 UK construction companies searching for information about Corporate Social Responsibility and found that although a majority of the companies *lacked respect for sustainability* (Myers, 2005) some of the larger companies at that time were beginning to acknowledge sustainability in their reports (Myers, 2005). Based on their survey of the level of awareness of sustainable construction in US and Korea, Son et al. (2009) saw a similar tendency and concluded that there is a positive outlook for sustainable construction. Also Ahn and Pearce (2007) came to a similar conclusion in their survey regarding contractors' past experience, perceptions and expectations of green construction in the future. Thus, these studies have in common that they signal a positive development within sustainable building.

Other scholars present a less optimistic view. In a cross-sectional survey Häkkinen and Belloni (2011) explored building professionals' perceptions on barriers for sustainable building. Obstacles for management of green construction projects in Singapore were also surveyed by Hwang and Tan (2010). Both surveys identified major hindrances, by Hwang and Tan described as a *vicious cycle*; of high costs, lack of client demand, lack of R&D, and lack of collaborative efforts and communication between various stakeholders. Similar observations was made in 2006 by the authors' of this paper, when it was concluded that there was an environmental inertia within the Swedish construction industry (Gluch et al., 2009). However, there seem to be very few surveys that have followed this issue over a long period of time by collecting longitudinal empirical data. One exception is Sayce et al. (2007), which over a ten-year period have undertaken three surveys tracking investors' attitudes towards green and sustainable buildings. They concur with Hwang and Tan's less optimistic view (Hwang and Tan, 2010), calling for increased industry communication but also for an increased need for government intervention (Sayce et al., 2007).

In order to track environmental strategies and change in the Swedish construction sector (technical consultants, building contractors/ executing construction companies, property owners and managers, and companies within architecture) over time, this paper is based on three environmental barometer surveys, carried out in 2002, 2006 respectively in 2010. Each survey covers four years back in time. Thus, a period of twelve years is taken into account, from 1998 to 2010. The surveys covered a large variety of aspects related to environmental management in the construction industry. For a comprehensive account of results from the surveys see Baumann et al. (2003), Baumann et al. (2002), Gluch et al. (2007a), Gluch et al. (2007b), Thuvander et al. (2011) and Gluch et al. (2011). This paper is based on a longitudinal empirically based analysis focusing on four environmental strategy aspects: 1) stakeholder relations, 2) management systems, 3) environmental staff, roles and responsibilities and 4) integration of environmental work. The paper aims to identify trends over time related to these aspects and also explores the relationship between them and environmental and business performance.

## **METHOD**

### **Data collection**

In all three surveys the companies were selected from Statistics Sweden's company register according the Swedish Industrial Classification industry codes (SNI, corresponding to the European industrial activity classification – NACE). The surveys

2002, 2006 and 2010, cover all companies in Sweden with at least 50 employees within technical consultants, building contractors/ executing construction companies, property owners and managers, and companies within architecture, i.e. a total survey. The final population is presented in Table 1.

**Table 1** Data collection, population and response rate.

	2002	2006	2010
Population (companies)	534	542	461
Responses (No. answers)	217	246	195
Response rate (%)	41	45	42
Distribution of questionnaire	Mail	Mail	e-mail
Questionnaire form	Paper	Paper	Online form
Reminders	1 (mail)	3 (mail)	4 (e-mail)
Number of questions	32	39	23

In 2002 and 2006, the questionnaires were sent out by mail to each company in the final population together with an introductory letter and directed at environmental managers or alike. In the 2010 survey, the questionnaire was sent out by e-mail to environmental managers or alike using the online software SurveyMonkey<sup>TM</sup>.

### Preparation of questionnaires

The aim and scope of all the surveys has been consistent over time. Keeping the questionnaire as similar as possible has been a deliberate move in order to be able to make comparisons over time. The questions measured the opinion of the respondents by using a Likert scale with a four to seven-point range, a binary scale only allowing yes or no answers (with some modifications) and questions concerned demographic and more general and descriptive information.

To reduce biases in the result caused by interpretation problems and non-response several measures were taken. The questionnaires were pretested on practitioners, an instructive cover letter together with detailed contact information in case of questions accompanied the questionnaire, multiple reminders were sent out, and the reasons why some respondents failed to respond were investigated.

### Data analysis

Data has been compiled and analyzed with the purpose to identify significant changes over time. In the surveys 2002 and 2006, the data was been entered manually; stored in and analyzed by using the statistical data programme SPSS<sup>®</sup>. In the 2010 survey, the data was entered by the respondents directly in the database of the online software SurveyMonkey<sup>TM</sup>. From there, the data was exported and analysed in SPSS<sup>®</sup>.

For the analysis over time, data from all three surveys have been merged into one data set with the 2006 survey as reference. The 2006 survey has most questions and functions well as a link to both the 2002 and 2010 survey. For Likert scale variables, mean values have been calculated and one way analysis of variance (ANOVA) was performed followed by post hoc tests to statistically verify the significance of observed changes. For dichotomous variables (binary scale), cross-tabulation has been chosen for detailed analysis. For some of the questions, Likert scale variables have been translated into dichotomous variables to enable comparison over time.

In order to investigate drivers for perceived environmental performance and business performance we have also conducted two linear regression analyses.

## RESULTS

The results presented in this paper is focusing on four environmental strategy aspects: 1) stakeholder relations, 2) management systems, 3) environmental staff, roles and responsibilities and 4) integration of environmental work. How these areas have been changed over time is firstly described and thereafter analysed in relation to environmental and business performance.

### Stakeholder relations

*Clients* together with *managers* are seen as the most influential stakeholders on companies' environmental work in all three surveys. Also, the *final customer* and the *employees* are considered as important stakeholders. Seen out of an environmental research and knowledge perspective, in the early surveys it was noticed that *research institutions*, *environmental organizations*, *mass media* and *politicians* were assumed to have a very low influence on the companies' environmental work. This seems to have changed as these groups now are reported to be more influential. A similar trend shows *local citizens/groups* that were perceived to have very little influence on the companies' environmental work in the 2002 and 2006 and that now are considered as more influential. There is also a significantly increasing tendency that financial actors, such as *banks*, *insurance companies* and *financial analytics* and controlling instances such as *accountants* are perceived as more influential on the companies' environmental work than previously. Overall, the variety of stakeholders that are perceived as having influence on the companies' environmental work has increased over time. In fact, all stakeholders, beside politicians, are now perceived to have a significantly increasing influence.

### Environmental Management Systems

Many of the companies within the construction industry work in accordance with an environmental management system (EMS). It was a considerably increase of the percentage of companies that adopted EMS as a way of working between 2002, when 46% had an EMS, and 2006 (70%). This rather high figure had in 2010 remained on a about the same level (73%).

### Environmental staff, roles and responsibilities

Over the whole period companies report that they have personnel that specifically handle environmental issues within the company. However the extent (number of full-time employees) significantly increased between 2002 and 2006 to thereafter be stabilised.

The respondents were asked to what extent they agree to a number of statements concerning their perceived level of influence and their role as an environmental manager. As seen in Figure 1, the agreement is quite high for most statements (mean value around 3='agreement to a large extent'). However, the only significant increase concerns the respondents' perceived ability to influence strategic decisions, meaning that their strategic position seem to have been reinforced.

A large majority of the respondents in all three surveys answer they have, at least partly, enough knowledge to influence practice. In 2002 (28%) and 2006 (25%) a relatively large share of the respondents stated that they were not authorized to stop environmentally damaging processes, which has decreased to less than 10% in 2010.



**Figure 1:** Mean values of environmental managers' perception of their role as environmental manager in the company. The scale ranges from 1='total disagreement' to 4='full agreement'. The variable marked *bold* indicates a significant difference. *NOTE 1:* The differences were tested by means of *t*-test and significant at  $p < .05$ . *NOTE 2:* The questions were not included in the 2002 survey.

The respondents were asked about the extent of influence they had on environmental issues in the companies. About half of the environmental managers were in 2010 members of the corporate management board, which were a significant increase from 2006 and 2002. This might indicate that environmental issues have gained higher status within the companies. It might also be a sign that environmental issues are on the way to be handled as a regular part of the companies' business.

### **Integration of environmental work**

In comparison with the two first surveys the environmental work is to a higher degree integrated with other business areas in 2010. Table 2 and 3 presents mean values for 2010 year's study that shows which business areas where environmental measures has been undertaken (Table 2) respectively with which business areas that has been organisationally integrated with environmental management (Table 3). Not surprisingly most environmental measures has been done within the area of recycling and waste management but environmental considerations has also been undertaken in the design, production, purchasing and training. Finance and R&D is the areas where least environmental measures have been undertaken.

**Table 2** Mean values (M) of the degree of environmental measures taken within other business areas (Q15). The scale ranges from 1 = "not at all" over 3 = "some" to 5 = "much".

Areas	M	Sd
Design	3.22	1.50
Production	3.18	1.58
Facilities Management and Maintenance	2.62	1.88
Logistics	2.85	1.29
Recycling and Waste Management	3.65	1.26
Purchasing	3.33	1.08
Marketing/Sales	2.81	1.42
Accounting	2.27	1.52
Finance	1.67	1.43
Staff policy	2.52	1.43
R&D	1.84	1.66
In-service training	3.08	1.28

On an organisational ground the areas where environmental work has been integrated to a higher degree can be related to the EMS which may witness of that many companies today use management systems where environmental, health and safety and quality issues are handled in a similar way. Overall the degree of integration is quite high for most business areas (Table3).

**Table 3** Mean values (M) to what degree environmental work has been organizationally integrated with measures taken in other areas (Q16). The scale ranges from 1 = "not at all" over 3 = "some" to 5 = "much".

Areas	M	Sd
Health and safety	3.33	1.15
Quality	3.67	1.00
Social issues	2.67	1.10
Strategy work	3.18	1.15
Marketing	3.01	1.12
Productivity	2.94	1.13
Project Management	3.14	1.10
Operations Management	3.32	1.13
Management by objectives	3.20	1.14
Motivation	2.91	1.14
Internal Relations	2.84	1.05
External relations	3.02	1.12

### **Predictors for environmental and business performance**

The results show that the respondents perceive that environmental activities have had an effect on especially the use of non-renewable materials, forestalling risks from environmental accidents and decreasing environmental impact from transport.

A stable trend shown in all three surveys is that the companies mostly see either long-term and/or intangible business advantages. It is believed to bring advantages for principal stakeholders, such as staff, management and owners/shareholders. There is also a significant trend that environmental activities mainly are perceived to have positive effect on ‘soft’ values, such as company image, pleased personnel, pleased management, product image and recruitment. None of the more ‘hard’ values, such as short-term profit, productivity, market shares, show a significantly positive trend over time.

We performed two regression analyses in order to investigate what predicts environmental performance respectively business performance (Figure 1). The analyses are based on the 2010 survey. In the analyses we used index variables<sup>1</sup> (i.e. means of a number of individual items).

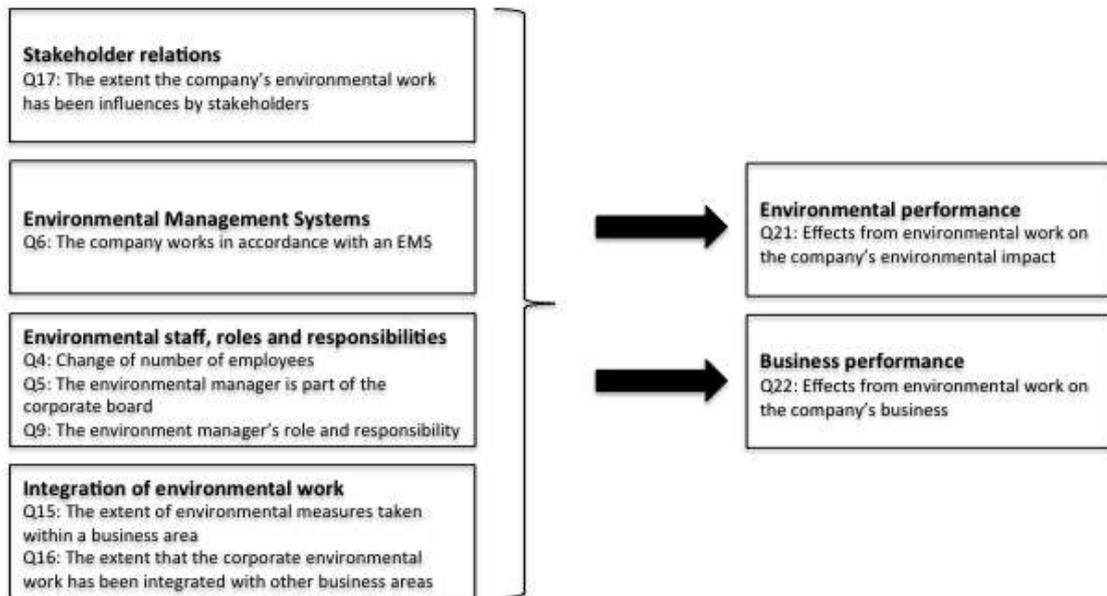


Figure 2 Interrelation between environmental strategies and measures and environmental and business performance.

In the analyses we regressed stakeholder relations (Q17), the degree of environmental measures undertaken in other business areas (Q15), degree environmental work has been organizationally integration with measures taken in other areas (Q16), the presence of environmental management systems (Q6), changes in environmental department staff numbers (Q4), whether the environmental officer were part of the company's management group (Q5) and finally the environmental manager's role and responsibility (Q9) on environmental performance (Q21) and business performance respectively (Q22). Due to space limitations we are unable to present all individual items in the paper and we only present the items (Table 2 and 3) from the two predictors that came out significant in the regression analyses.

When it comes to business performance we found that only the degree of environmental measures undertaken in other business areas were a significant predictor ( $b=.38$ ,  $p=.003$ ,  $R^2=.44$ ,  $F(7,109) = 11.34$ ,  $p<.00001$ ), thus the more measures undertaken the higher perceived level of business performance.

<sup>1</sup> All index variables had alpha coefficients exceeding .80 thus all being reliable measures.

When it comes to reported environmental performance the only significant predictor were degree of organizational integration of environmental activities ( $b=.38$ ,  $p=.009$ ,  $R^2=.21$ ,  $F(7,110) = 3.90$ ,  $p<.001$ ), thus the higher degree of reported integration the higher perceived environmental impact.

## DISCUSSION AND CONCLUSIONS

Based on a longitudinal empirically based analysis of the sectors environmental work this study has identified trends over time. Four areas were investigated: 1) stakeholder relations, 2) management systems, 3) environmental staff, roles and responsibilities and 4) integration of environmental work. These areas were further explored regarding their correlation with environmental and business performance.

Respondents perceive that stakeholder pressure is getting stronger over time. Over the studied period, it becomes clear that opinions of stakeholders are increasingly recognized and heard. The pressure is now also perceived as more contextual and to a higher degree driven by local stakeholders. Work related to EMS is getting intensified and we could also see that over the years there has been a change of the environmental managers' responsibilities and positions. A higher number of responding environmental managers perceive having increased influence on their companies' strategic decisions. Effects from this will be focus in another paper.

Even if environmental managers now are part of companies' top management organization and although a higher number of environmental managers perceive having increased influence on their companies' strategic decisions, we could in our data not see that this had led to improved environmental performance or greater business advantages. Neither could we in our data find a relationship between stakeholder relations and EMS with these two parameters. The only factor that we found to be influencing environmental performance was the degree of integration of environmental work into the functional organizations of a company. Similarly the degree of environmental measures undertaken in different business areas was predictor for improved business performance. As such this study partly aligns with the results of Lee and Rhee (2007), showing a lack of direct relation between environmental strategies and performance, with the exception that we have found a relationship between performance and environmental strategies of integrative kind. Integration can most certainly not happen without personnel working with the issue (Gluch, 2009, Gluch et al., 2009, Ludvig et al., 2013) neither can it be isolated from stakeholder demands (Cole, 2011, Heiskanen and Lovio, 2010) nor from management systems and practice (Gluch and Räsänen, 2012, Brunklaus, 2009, Guy and Shove, 2001), so these types of strategies must not be disregarded just based on these results. Thus, the relative lack of observations explaining perceived business performance demands further analysis to better understand the business justifications for environmental efforts that are now quite extensive in the Swedish construction sector.

Based on this study we conclude that companies nor internal environmental units can carry out environmental work in an isolated bubble; both are dependable on and must cooperate and interrelate closely with others (Bansal and Clelland, 2004, Gluch et al., 2013). It is also clear from this study that a key to positive environmental as well as business performance is that environmental work is integrated within the organization. This is in line with previous research which holds collaborative and interdisciplinary actions within the field of sustainable development as crucial for the development and implementation of proactive, holistic and innovative green solutions (Brown et al., 2003, Vergragt and Brown, 2007, Quist et al., 2011, Bossink, 2007). The same logic

applies to the field of sustainable building (Brown and Vergragt, 2008, Cole, 2011, Glad, 2012, Heiskanen and Lovio, 2010, Hartenberger et al., 2013). Consequently, to address increased and more diverged pressure there will be a need for new types of organizational logics that enables integrative actions as well as cooperation between various actors involved in construction; cross-disciplinary as well as inter-organisational. This focus on change in complex multi-actor organizational environments is an interesting and under-researched area (Whyte and Sexton, 2011, Cole, 2011, Phua, 2013, Summerfield and Lowe, 2012) deserving more attention in future research.

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# RECONCEPTUALISING HOSPITAL FACILITY RESILIENCE TO EXTREME WEATHER EVENTS USING A PANARCHY MODEL

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Hospitals represent critical social infrastructure assets that are essential for the effective functioning of any society and economy. The increasing incidence of climate-related extreme weather provides major challenges for hospitals and there is increasing evidence of hospital services being disrupted during such events. Given the vulnerability of hospitals to extreme weather and the significance of their service delivery to social and economic wellbeing, there is an urgent need for research into the factors that contribute towards hospital resilience in these situations. Using a panarchy model to integrate theories of ecological resilience, adaptation and learning, a new conceptual framework is presented to inform future research in this area and the way that hospital buildings are managed, used and adapted to make them more resilient to EWEs.

Keywords: hospital, panarchy, resilience, learning, adaptation

## INTRODUCTION

It is essential to community health and wellbeing that hospitals are designed and constructed to remain operational both during and after extreme weather events (EWEs). EWEs are defined as “rare and severe occurrences of a climate variable above (or below) a threshold” [that is at] “either end of the continuum of the observed climate variable” (Field et al.,2012:7, Linnenluecke and Griffiths, 2010:2). EWEs include major flooding events, severe storms, prolonged heat waves, hurricanes and cyclones and the inability to prevent or predict such events creates a major challenge for many organisations (Chapman and Arbon 2008; Field et al 2012). In particular, in planning how to design and construct hospitals to enable users to respond to EWEs managers are faced with the dilemma of allocating limited resources to plan for future EWEs when they have no certainty of being directly affected by them (Winn et al. 2010). Given the low probability-high impact nature of EWEs, research indicates that the normal human response is to gamble on an event not happening and defer any response to the future, reacting to any event that may potentially occur rather than

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planning for it in advance (Taleb 2007). This is especially likely to happen in a resource-constrained environment like healthcare, despite the impact of EWEs on hospital infrastructure being potentially significant and widespread. These impacts range from direct damage to physical hospital infrastructure to changes in patient admissions which affects the way that hospital users interact with their built environment.

While research into the impact of EWEs on human health and hospital admissions is well advanced, research on built infrastructure impacts has just begun and there are no conceptual frameworks yet developed to guide it. However, we do know that in practice, hospital service delivery is increasingly being disrupted during such events (Loosemore et al 2010). Recent studies from a resilience perspective have focused on the physical capacity of a hospital to deal with disasters (Bruneau and Reinhorn 2007; Boshier 2008; Cimellaro et al. 2010). While valuable, when viewed from a socio-ecological perspective, there is a need for a wider focus on human capacity to adapt to improve the performance of the overall system. A better understanding of how people adapt to their hospital built environments during times of stress imposed by an EWE has important implications for the way that hospital buildings are designed, managed, used and adapted to make them more resilient. To address this need, the aim of this paper is to advance the theoretical notion of socio-ecological resilience as a new way to better conceptualise an understanding of hospital facility resilience to EWEs. Without a theory there is no basis for empirical research, so this paper presents an essential theoretical contribution to knowledge in this area rather than an empirical one.

## **RESILIENCE**

In recent years, the terms ‘resilience’ and ‘adaptation’ have started to appear in the disaster management literature. Resilience literally means ‘to bounce back’ (Holling 1996) and has long been used to describe the elastic property of materials. This physical view has been applied as a metaphor to humans and communities. Despite widespread adoption of the term in the organisational literature, ‘resilience’ has different meanings to different people. So to clarify the perspective of this paper, in considering how hospitals respond to EWEs we are interested in resilience associated with the dynamic nature of systems, and their ability to react and to respond to shocks and keep delivering necessary healthcare services to the community (Holling 2001).

Importantly, in the field of ecology, a resilient ecosystem can ‘bounce back’ and maintain physical equilibrium in the face of a disturbance, or it can ‘step forward’ to a new state (Folke et al. 2004). The ecology literature differentiates between these two different types of resilience as: engineering and ecological resilience (Holling (1973, 1996). Holling (1973) defines engineering resilience as: the ability of a system to return to an equilibrium or steady-state after a disturbance [such as an EWE]. In contrast, ecological resilience is defined as the magnitude of disturbance that can be absorbed before the system changes its structure in order to remain within critical thresholds. Hence, engineering resilience differs from ecological resilience where the former relates to stability and the speed of return, the latter relates to flexibility and instability with a tendency to change into new states (McDaniel et al., 2008). Despite these differences which are rooted in different disciplinary traditions, what underpins both perspectives is the belief in the existence of equilibrium in systems, be it a pre-existing one to which a resilient system bounces back (engineering) or a new one to which it bounces forth (ecological). This common principle is now incorporated into

contemporary definitions of resilience which see it as the potential of systems to change state or bounce back, and has been defined as “the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions” (Hollnagel et al., 2011:xxxvi).

Research has shown that the resilience of physical and social systems is determined by four main properties: robustness, rapidity, resourcefulness and redundancy (Bruneau et al. 2003). Robustness is about the inherent strength or resistance in a system to withstand stress without losing its functionality. Rapidity refers to the speed at which disruptions can be overcome in a timely manner and avoid future losses.

Resourcefulness indicates the diversity of options and redundancy reflects the ability to mobilise available resources efficiently. In a hospital context, resourcefulness can be described as the availability of back-up medical supplies as well as utilities services such as power generator, water supplier, and communication systems to maintain hospital service delivery during EWEs. Redundancy is the hospital system properties that allow for alternative options and choices to maintain their services such as using other health facilities (such as other community buildings and outpatient centres), back-up generators (to supply electricity), alternative travel routes (to get patients in and out) and alternative suppliers of drugs and equipment to deliver healthcare to the community. Robustness is provided by the physical strength of the building materials (strengthened shatter-proof glass, windows that are not blown-out by high winds, drains that prevent flooding to basements where services tend to be located, roofing materials that do not get torn off by winds etc.) Lastly, rapidity signifies the ability to re-build the hospital infrastructure and return quickly to ‘normal’ or ‘new normal’ (improved) system functions. From a built environment perspective this is provided by flexible designs and demountable or prefabricated materials that can be bolted back together after an EWE.

It is interesting, although not surprising, that research into infrastructure resilience adopts the engineering resilience perspective which focuses on the robustness of the built facility and the recovery time for the facility to return to normal service delivery (McDaniels et al., 2008). Hence, from an engineering perspective, Figure 1 presents a graphical illustration showing how infrastructure form and function can vary over time in the presence of an EWE. The graph illustrates the patterns of response in relation to EWEs and the slopes/scales may vary depending on the magnitude and duration of EWEs and the properties of the facility. The rate at which the infrastructure functions are lost indicates their susceptibility to EWEs as well as the magnitude of EWEs. As noted above, the extent of this loss depends on the robustness of the facility. Alternately, the rate at which the infrastructure recovers and returns to a ‘business as usual’ state indicates rapidity.

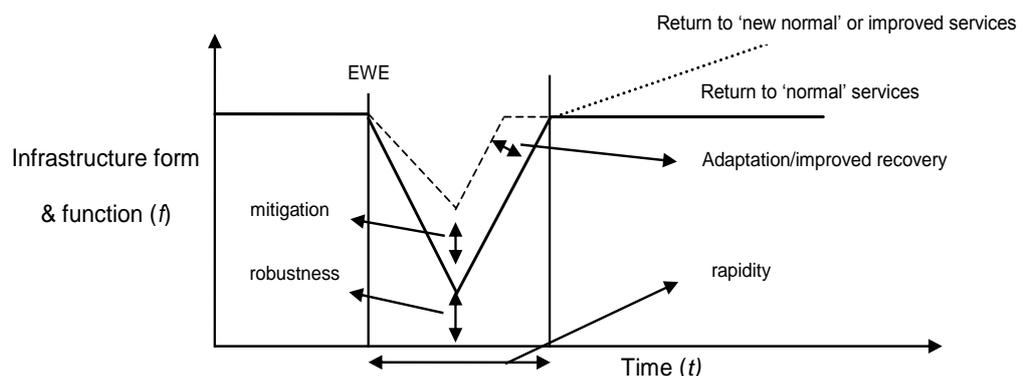


Figure 5: Quantitative measure of hospital facility resilience (source: McDaniels et al., (2008))

delivery. Hence, both perspectives of resilience highlight the significance of change in informing the performance of a system such as a hospital facility. Acknowledging change in improving resilience is demonstrated through a process called ‘panarchy’.

## PANARCHY

The term ‘panarchy’ emerged from the field of ecological resilience to describe the process by which evolving hierarchical systems with multiple interrelated elements have to constantly interact with, and adapt to, their ever changing environments to remain stable (Gunderson and Holling 2002). Gunderson and Holling (2002) have developed the ‘adaptive cycle’ as a conceptual illustration of this process. The cycle is represented by four phases: exploitation/rapid growth, conservation, release, and reorganisation (Figure 2) (Gunderson and Holling 2002). Rapid growth ( $r$ ) occurs during post-disturbance periods as a system’s environment stabilises. As resources are built up, the system also enters into a mature and stable state ( $K$ ). Stored resources are released when faced with a new disturbance ( $\Omega$ ) and the system begins to reorganise ( $\alpha$ ) as resources are made available, leading to a new period of stability and so-on. The adaptive cycle has been applied to many complex systems such as human and environment to assist in conceptualising and understanding resilience. However, its value has never been explored in the context of how hospitals (or indeed any other type of built infrastructure) can respond effectively to threats such as EWEs.

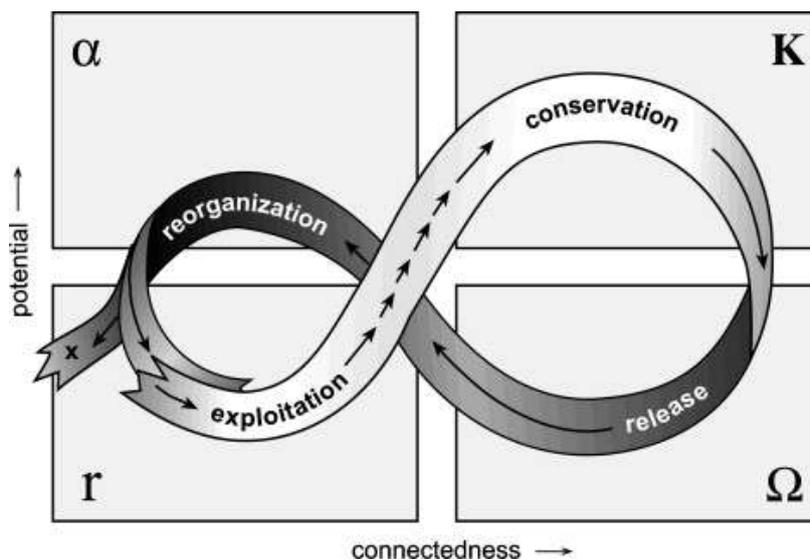


Figure 6: The panarchy adaptive cycle model (Source: Gunderson and Holling 2002)

Although a hospital facility is a complex multi-level system that is embedded within other complex multi-level systems (such as emergency services) in the community, we can demonstrate the value of the model by looking at the adaptive cycle at the level of the hospital as a single entity and in an idealised situation (Figure 3).

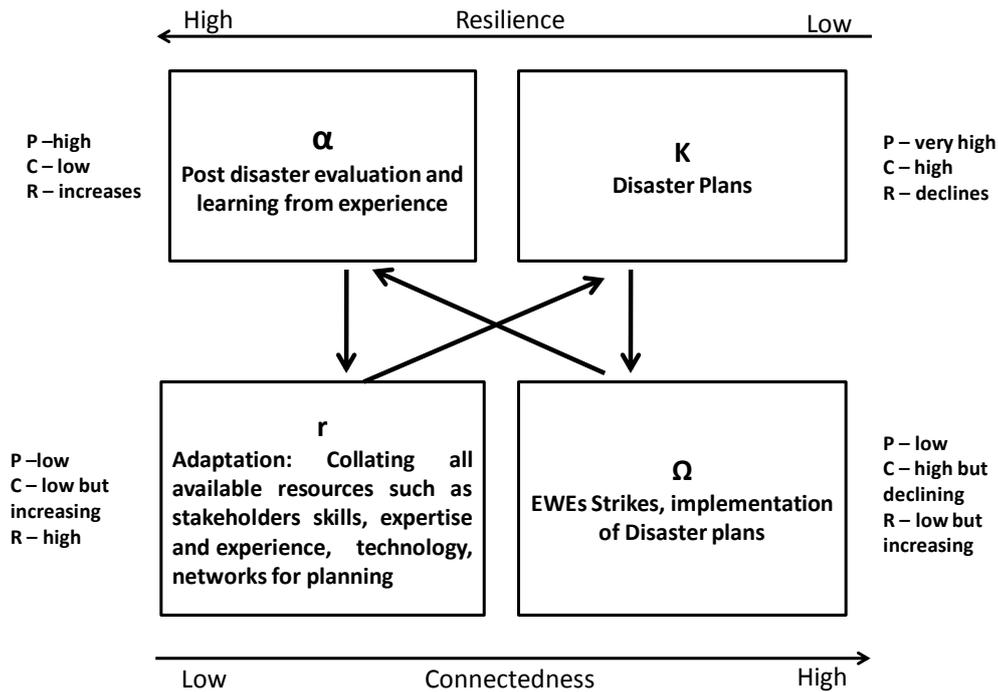


Figure 7: Hospital Facility Resilience Adaptive Cycle in normal scenario

In Figure 3, hospitals develop and store their disaster plans to deal with future disasters (K) which are then used to guide and coordinate actions when an EWE strikes ( $\Omega$ ). These disaster plans have many dimensions and including the way that the building is managed, used and adapted during an EWE to ensure that healthcare services can continue to be delivered to the community. In reality, no matter how thorough the planning, disaster plans are never perfect and in an ideal world hospital stakeholders learn from this experience and re-organise themselves to better cope with the on-going situation ( $\alpha$ ). While the connectedness is low, the potential to create new directions and pathways is high with individual learning thus increasing the resilience potential. The lessons learnt encourage the re-organisation of disaster planning structures and processes (including facilities management and building adaptation) enabling greater resilience to future EWEs (r). But as adaptation process draws closer to policy development, the connectedness between the hospital stakeholders on the structure increases, and pattern of disaster planning becomes increasingly rigid. Hence the hospital's resilience to EWE shock declines. The cycle continues as these new planning structures are stored as organisational knowledge and become imbedded once again leading to a new round of learning and adaptation. Recent research calls the type of resilience which is generated in this way (through learning from adverse events) 'evolutionary resilience' (Davoudi 2012).

It is also important to note that in Figure 3, each of the four phases are characterised by different levels of change in three dimensions: 1) the potential for accumulated resources available to the system which in context relates to appropriate policy plans (P); 2) the internal connectedness of the system components such as the hospital stakeholders dependence on the disaster planning structure and the pattern of developing the plans (C); 3) resilience, a measure of system's ability to deal with shocks which in this context related to collective learning and reasoning amongst

hospital stakeholder during disaster planning that is associated with creativity and flexibility of disaster responses (R) (Gunderson and Holling 2002).

Another feature of the adaptive cycle is that the pathway between the four phases is not fixed but can vary subject to circumstances. For example, in Figure 4, after the disaster plans are prepared, the hospital carries out regular disaster drills and disaster education. In contrast to Figure 3, the cycle moves from 'disaster plan' (K) phase directly into 'post disaster evaluation' ( $\alpha$ ) phase, rather than waiting for an EWE to determine the way forward. Hence even in the absence of an EWE there is continuous learning and adaptation which prepares the hospital to deal with the challenges posed by EWEs more effectively and efficiently.

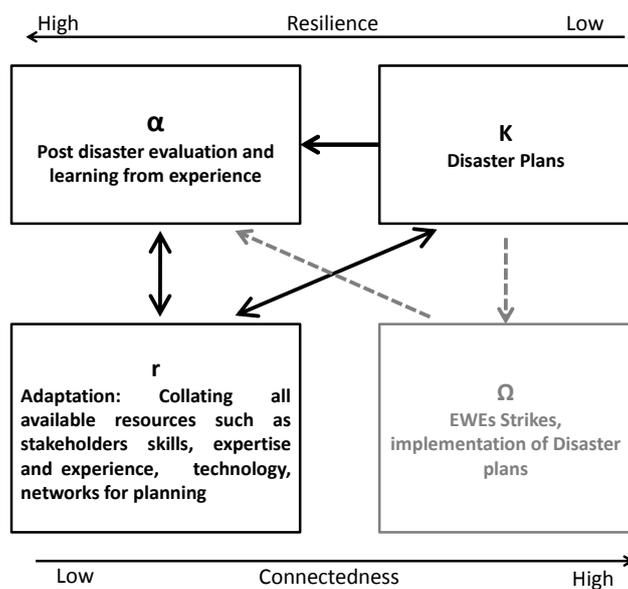


Figure 8: Hospital Facility Resilience Adaptive Cycle with continuous learning

The adaptive cycle also interacts across scales which indicate the interaction between various health sub systems at different levels. For example, Loosemore et al.'s (2012) analysis of hospital sub system interdependencies during an EWE using rich picture diagrams highlighted that the resilience of a single hospital system is also dependent on the resilience of other linked or interdependent systems in the wider community. For instance, cross scale interactions can occur with other healthcare infrastructure such as aged care facilities, or primary care (GP) centres. In other words, the resilience of hospital buildings cannot be treated in isolation but must be seen as part of a much bigger interdependent health infrastructure system. The necessity of engaging at multiple scales requires greater participation, open communication and networking, and these are critical in establishing trust and collective decision making amongst the hospital stakeholders who manage the resources for disaster response (Lebel et al. 2006). The key to the successful adaptation of an organisation to a changing environment is to recognise and leverage the various sub-systems associated with that organisation (Barabasi and Crandall 2003). The interconnectedness across scale and networks can encourage greater flexibility in planning and better coordinated response during disaster (Schein 1996). It also helps in identifying the gaps and redundancies in the wider community, such as facilities that can be utilized

to continue hospital service delivery despite failure of the primary hospital building due to structural damages.

The above analysis illustrates that organisational learning amongst various hospital stakeholders is necessary for effective adaptation. As hospital stakeholders' knowledge, skills and understanding of EWE vulnerabilities increase, it facilitates interactions, collective reasoning and decision making for disaster response. As Field et al. (2012) point out, inter and intra organisational learning is central to adaptation and pivotal to improving organisational resilience to EWEs.

## LEARNING

The Panarchy model is useful to understand how systems such as hospitals adapt and respond to EWEs. However, this model is limited in explaining the process of learning that facilitates adaptation. Hence, we draw from Nonaka and Takeuchi's knowledge creation SECI model (Figure 5) to help elaborate on this process.

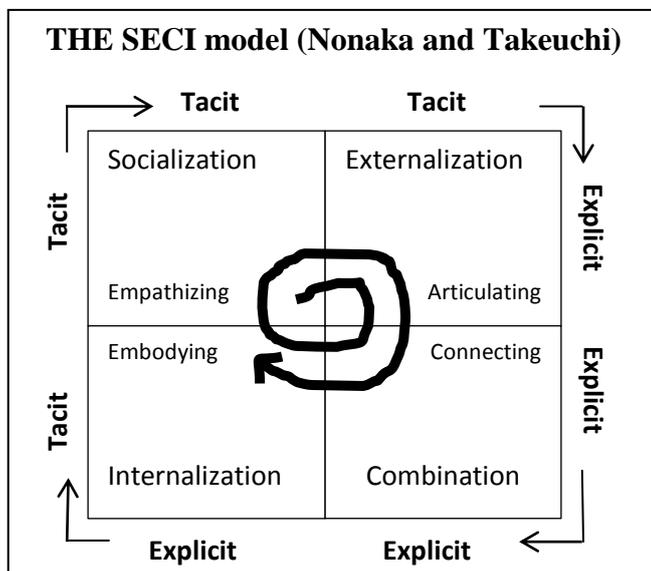


Figure 9: The SECI knowledge conversion model (Source: Nonaka and Takeuchi 1995)

Like the Adaptive Cycle, the SECI model consists of four phases that can help conceptualise the process of learning and knowledge transfer in hospitals during an EWE. In the SECI model, socialisation is the process of articulating tacit knowledge (lessons of past EWEs). Externalisation occurs when tacit knowledge is made explicit (people record the lessons in the form of disaster procedures). Combination is the process of connecting discrete elements of explicit knowledge into an explicit knowledge set that is more complex and systematic than any of its parts. In the context of responding to EWE's, this process involves the formulation of 'disaster management plans' which seek to bring disaster procedures together into a unified system of response. Finally, internalisation is the process of embodying this explicit knowledge as tacit knowledge to create a shared mental model between all stakeholders involved in responding to an EWE. When this embodied tacit knowledge is shared with other individuals it sets off a new spiral of knowledge creation through socialisation etc. In the context of responding to EWEs, this process may involve amendments to the disaster policy or procedure in responding to EWEs that is shared and accepted across the hospital.

## RECONCEPTUALISING HOSPITAL FACILITY RESILIENCE

We can combine the resilience and learning theories discussed above to propose a new conceptual framework of hospital resilience which is focussed on the process of 'adaptive learning'. This new framework is called the Hospital Resilience Learning Cycle (HRLC) (Figure 6). The HRLC model is a dynamic model and illustrates that the process of learning and adaptation are inextricably linked in enhancing hospital facility resilience to EWEs. Since it combines both the adaptive cycle and SECI model it also has four phases: develop disaster plans, implement disaster plans, behavioural learning and social learning.

The HRLC model is a continuous cycle and in a practical sense it begins with phase one (develop disaster plan).

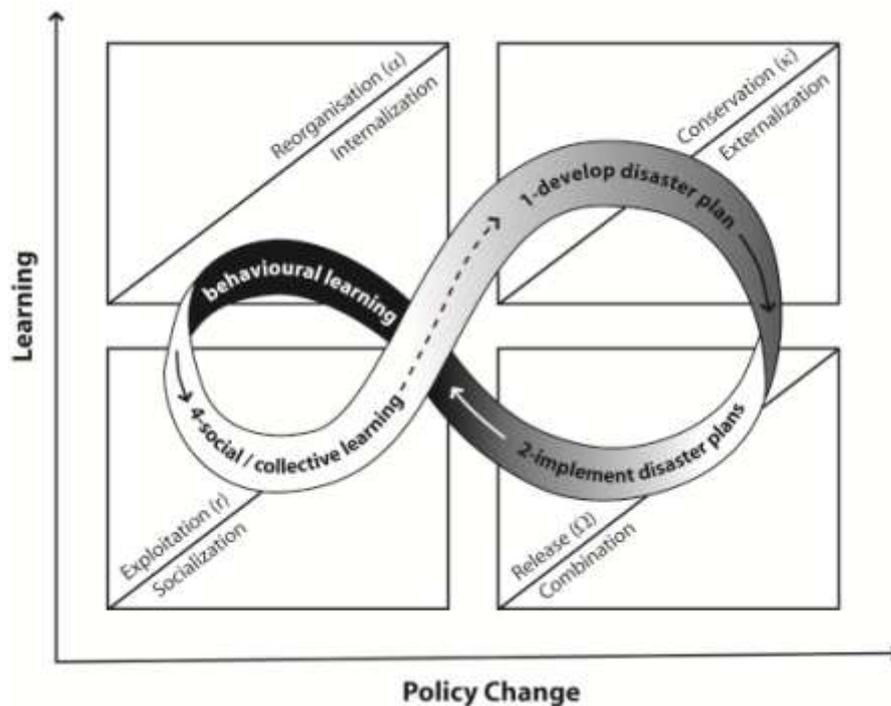


Figure 10: Hospital Resilience Learning Cycle

Phase 1 (Develop Disaster Plan) is the conservation phase of the adaptive cycle where the hospital develops an organisational memory in the form of disaster management plans. This phase relates to the externalisation phase of the SECI model where tacit knowledge from stakeholders' experience of EWEs is made explicit and recorded in the form of written procedures such as disaster plans. As pointed out above, this includes plans relating to how the building will be managed, used and adapted during an EWE.

Phase 2 (Implement Disaster Plan) relates to the release phase of the adaptive cycle and represents the deployment of resources through the implementation or activation of disaster plans developed in the conservation phase to deal with an EWE. It also relates to the combination phase of the SECI model since it involves integrating individual expertise from different parts of the organisation which are required to work together to manage, use or adapt the building to collectively deal with an EWE.

Phase 3 (Behavioural learning) is equivalent to the reorganisation phase in the adaptive cycle and the internalisation phase in the SECI model. It involves the re-

structuring of the organisation post disaster as the lessons learnt from the implementation phase are shared between the stakeholders (including those involved in managing, using and adapting the building) and absorbed to instinctively inform future responses.

Phase 4 (Social and collective learning) relates to the exploitation phase in the adaptive cycle and the socialisation phase in the SECI model. Here there is a rapid accumulation of new tacit knowledge as hospital stakeholders involved in a disaster response come together and share their experiences (including about how the building is managed, used and adapted). This accumulation of tacit knowledge is converted to explicit knowledge in the form of changes in the existing policy or development of new policies and plans in the first phase of the HRLC model (develop disaster plans) which continues the on-going adaptation over the life of a hospital to maintain its resilience.

## CONCLUSIONS

The aim of this paper was to reconceptualise hospital facility resilience to EWEs using a Panarchy model which emerged out of ecological resilience theory. The HRLC model provides new behavioural insights into hospital resilience and has important implications for designing, facilities management and adapting hospitals to make them more resilient. It shows that EWEs provide an opportunity for learning amongst and between different hospital stakeholder groups and individuals, better preparing them to deal with disaster situations and informing future disaster planning. While pre-disaster knowledge is critical in initial disaster planning and design, post-disaster learning provides feedback on the effectiveness of the existing designs and facilities management enabling learning (about design performance and how people adapt to their built environment) which allows improvements to be made in the future. The implications for facilities managers and hospital designers is that they must be included in this learning process so that they can, like other hospital stakeholders, have the same opportunity to learn any lessons which may influence the way in which hospital buildings are managed, used and adapted to ensure that healthcare continues to be delivered to the community during an EWE. Given the traditional disempowerment and exclusion of health facilities managers from hospital planning and management processes, on-going research is exploring, not only the extent to which hospital building issues are incorporated into the initial disaster management plans in the conservation/externalisation stage of the HRLC model but to what extent facilities managers and designers are included in subsequent stages of the cycle to enable them to learn and adapt their facility to EWEs.

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# STAKEHOLDERS PERSPECTIVE ON SUSTAINABLE TECHNOLOGY SELECTION TO ACHIEVE ZERO CARBON RETAIL BUILDINGS

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In the design and construction of sustainable retail buildings, there are various stakeholders involved with the overall aim of selecting appropriate sustainable technologies to reduce energy consumption and carbon emissions. Previous studies and literature review indicate there is no comprehensive selection process to assist stakeholders. This can be classified as a complex multi-criteria decision problem due to the high number of alternatives, potential solutions and variety of stakeholders (e.g. clients, professional advisors, end-users) with multiple, often conflicting, objectives leading in turn to the slow take-up of sustainable technologies. There is a demand for a systematic and effective evaluation tool for the selection of sustainable technologies based on the needs of stakeholders. This paper is part of an on-going study to develop a decision making system to assist stakeholders in the selection process and aims to establish the decision criteria for the selection of sustainable technologies for existing retail buildings based on the clients' (retailers') perspective. The arguments are informed by a combination of literature review and an in-depth case study with a leading construction company in the UK. The data collected was both qualitative (establishing and verifying decision criteria) and quantitative (establishing weightings and priorities). Five broad decision criteria currently used by clients in the selection of sustainable technologies to achieve reductions in energy and carbon were established (i.e. cost, time, proven success of technology, risk and sustainability). Using AHP survey and expert opinions, the identified criteria were weighted and ranked, with risk (37%) being the most important, followed by cost (22%), proven success (20%) and time (12%), and sustainability (9%) the least important factor. Although the established criteria would be most relevant for the selection of sustainable technologies for existing retail buildings, it will also be beneficial for new build retail buildings and be transferable to other types of buildings.

Keywords: criteria selection, decision making, stakeholders, sustainable technologies, zero carbon, retail buildings.

## INTRODUCTION

There are several simple and cost effective sustainable technologies (STs) that exist today and the integrated use of such technologies could enhance energy efficiency and

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reduce emissions in the construction industry (IEA 2012). Carbon Trust (2009) estimates that using simple and cost effective technologies that already exist could result in a net cost saving to the UK economy of more than £4.5bn and could reduce carbon emissions from the UK's non-domestic buildings by 35% by 2020. However, despite the economic and environmental benefits of STs, there has been a slow uptake; with nine out of ten technologies that hold the potential for energy and carbon emissions savings not selected by construction professionals (Carbon Trust 2009, BRC 2012, IEA 2012). Designers and clients face significant challenges in the selection of appropriate sustainable technologies (Akadiri et al. 2013, Pan et al. 2012, Dangana 2012). This is due to the fact that the selection of sustainable technologies is a complex task, with the rapid development of technological alternatives, lack of skills and knowledge, uncertainties, risks and a large number of technological alternatives and decision criteria all needing to be considered (Dangana 2013, Pan et al. 2012, Wang 2009). The selection of STs can have significant implications on building performance and stakeholders' satisfaction, creating long-term problems and hindering the adoption of such technologies (IEA 2012, BRC 2012). It is therefore necessary to base sustainable technology selection decisions on a clear understanding and a proper evaluation.

The study on which this paper reports is part of an on-going research project which aims to optimise the process, energy and carbon efficiency in retail construction by capitalising on sustainable technology. Preliminary literature review and exploratory studies indicate there is a slow uptake of sustainable technologies by stakeholders in the retail construction industry in the UK (Dangana et al. 2012). Currently, designers, constructors and retailers interested in adopting sustainable technologies in the retail construction industry have no comprehensive evaluation approach to review and select technologies (Catalina et al. 2011, Akadiri et al. 2013). There is thus a demand for a systematic and effective evaluation tool for the selection of such sustainable technologies (Pan et al. 2012, Devoudpour et al. 2012, Akadiri et al. 2013). This presents a big challenge for stakeholders in the retail construction industry in relation to implementation strategies that will support sustainable retail buildings and overcome the barriers which influence the slow uptake of sustainable technologies.

An earlier study (Dangana 2013) explored the composition of the main stakeholders involved in the selection process. The study developed a set of criteria predominantly from the perspective of a main contractor and their clients/supply chains. The criteria were clustered in such a way that they contribute to each stakeholder's objectives and are brought together into an overall multi-actor perspective (Brucker 2013).

This paper aims to focus on the client (retailer) in the selection of STs for retail buildings. Based on expert opinions the study involved clarifying the decision context; establishing decision objectives; identifying, clustering and assessing decision criteria; and, finally, quantifying the relative significance of the clients' criteria using the analytical hierarchy process (AHP) technique.

## **STAKEHOLDER MANAGEMENT**

Freeman (1984) defines a "stakeholder" as an individual or group of individuals who can influence the objectives of an organization or can be influenced themselves by these objectives while Banville et al. (1998) describes a stakeholder as everyone with a vested interest in a problem that can either affect, be affected by, or is both being affected by and affecting the problem. There are various classifications of stakeholders; Mainardes et al. (2012) proposed a new model of stakeholder

classification with six stakeholder types (regulator, controller, partner, passive, dependent and non-stakeholder), which is similar to the classification made by Roloff (2008) in which the stakeholders can be categorized into stakeholder groups of regulators, customers, workforce, political actors, social environmental etc.. Freeman's (1984) proposed model includes a broader spectrum of stakeholders, not only the traditional ones (clients, shareholders, members of staff, suppliers and competitors). This creates the issue of how to deal with all the stakeholders simultaneously, which is simply not possible. However the utilization of criteria prioritizing stakeholders can overcome this problem (Macharis et al 2012) by focussing on certain specific groups. It is thus necessary to first analyse who the stakeholders are and what are their respective interests (Mainardes et. al 2012).

Stakeholder management is the process of systematically gathering and analysing qualitative information to determine whose interests should be taken into account when developing and/or implementing a policy or programme (Chinyo et al 2010, Mainardes 2012, Macharis 2012). Stakeholders' needs can provide an indication of concerns, problems and the stakeholder requirements of the projects. It is thus important to identify stakeholders' interests, and this can be achieved by exploring their needs and constraints which will enable a satisfactory and realistic solution to be found to meet the needs of the stakeholders (Macharis et al. 2012). The stakeholder circle methodology can be used to identify key stakeholders', develop an engagement strategy and communication plan to satisfy the needs and objectives of the stakeholders' (Chinyo et al 2010).

### **Stakeholder management in construction projects**

The importance of stakeholder management has been identified in several studies (Newcombe 2003, Macharis 2012, Brucker et. al. 2013). However, there has been a poor record of stakeholder management in the construction industry, due to the complexity and uncertainty of construction projects and the vast number of stakeholders involved. This is due to inadequate engagement, unclear objectives and inadequate communication with the stakeholders (Loosemore 2006).

Yang et al. (2009) explored the critical success factors for stakeholder management in construction projects in Hong Kong. The study identified 15 critical success factors which were verified and ranked by professionals in the construction industry. The top three factors were: (1) managing stakeholders with social responsibilities (economic, legal, environmental and ethical), (2) exploring the stakeholders' needs and constraints to the project, and (3) communicating with and engaging stakeholders properly and frequently. The study clarifies the highly prioritised factors and can be used as an assessment tool to evaluate the performance of stakeholder management.

### **Stakeholders' perspective on the selection of sustainable technologies**

There are various stakeholders involved with the overall aim of selecting the appropriate sustainable technologies to reduce energy and carbon emissions and achieve sustainable retail buildings. However, this is complex multi-criteria decision problem due to the high number of alternatives, potential solutions and various stakeholders (e.g. clients, professional advisors, end-users) leading to the slow take-up of sustainable technologies. Also, due to the lack of formal available measurement criteria or strategies, selection is currently based on knowledge-based techniques (Wang et al. 2009, Catalina et al. 2011). These methods do not provide adequate solutions to prioritise and assign weights to the relevant selection criteria based on the needs of stakeholders (Akadiri et al. 2013). It is therefore important to have an in-

depth understanding of each stakeholder's objective (Macharis et al. 2012) and develop a systematic selection process to identify and prioritise relevant criteria based on the needs of stakeholders (Catalina 2011). Due to the complicated nature of the selection of STs, the multiple criteria decision analysis methodology would be adopted and the analytical hierarchy process (AHP) technique would be used to prioritise the criteria for the selection of STs.

### **AHP for the selection of sustainable technologies**

Analytical Hierarchy Process (AHP) is a well-known multi-criterion decision making technique. It was developed by Saaty in the 70s as a theory of measurement concerned with deriving dominant priorities from paired comparisons of homogeneous elements with respect to a common criterion or attribute (Macharis et al. 2012). It has found widespread application in complex decision-making problems involving various stakeholders and alternatives with conflicting criteria, to arrive at a consensus decision (Wang 2009, Pan et al. 2012, Akadiri et al 2013).

AHP is a well-known technique that breaks down a decision-making problem into several levels in such a way that they form a hierarchy with uni-directional hierarchical relationships between levels. The top level of the hierarchy is the main goal of the decision problem. The lower levels are the tangible and/or intangible criteria and sub-criteria that contribute to the goal. The bottom level is formed by the alternatives to evaluate in terms of the criteria. AHP uses pairwise comparison to allocate weights to the elements of each level, measuring their relative importance with Saaty's 1-to-9 scale, and finally calculates overall weights for evaluation at the bottom level. If A and B are the elements to be compared, then "1" defines that A and B are equal in importance, and "9" defines that A is extremely more important. The method also calculates a consistency ratio (CR) to verify the coherence of the judgements, which must be about 0.10 (10%) or less to be acceptable.

Considering the current problem of selecting the appropriate ST to achieve sustainable retail buildings and the lack of a process to prioritise and assign weights to relevant criteria for the selection process (Akadiri et al. 2013), the AHP method is recommended. The AHP process transforms comparisons which are mostly empirical into numerical values and this is the distinctive feature of AHP when compared to other comparing techniques which allow the elicitation of both qualitative and quantitative data to arrive at a desired goal (Pan et al. 2012, Wong et al. 2008). The problem is broken down into a hierarchy of criteria that can be easily analysed and compared in an independent manner. The five main steps of AHP are: (1) Define the problem and determine the objective, (2) Structure decision problem into a hierarchical model, (3) Perform a pairwise comparison for the lower levels, (4) Undertake a consistency test and (5) Estimate relative weights of the components at each level.

## **METHODOLOGY**

The research presented in this paper is part of an on-going research study employing an action research approach within a broad case-study based design (Yin 2007). The research will lead to the development of a decision-making system that will promote the uptake of sustainable technologies in the retail construction industry and assist retail construction stakeholders (e.g. retailers, contractors, architects and construction professionals) in evaluating and selecting the appropriate sustainable technologies. The system is based on the concept of multiple criteria decision analysis (MCDA)

with due regard to sustainable development. Within the system technologies can be analysed, evaluated and finally compared to allow the selection of the optimal variant according to a set of criteria (Huang et al. 2011) based on stakeholder objectives. This study builds on the findings from an earlier exploratory study by the researcher (Dangana 2012, Dangana 2013), which identified the key stakeholders and their selection criteria for the selection of STs for retail buildings.

The survey-based approach is currently used by researchers for examining decision criteria for the selection of sustainable technologies (Chen et al. 2010, Wong et al. 2008). This is useful in identifying the broad decision criteria but does not provide an in-depth exploration of the underlying considerations for the decision (Pan et al. 2012). To overcome this problem and address the value-laden and context-specific issues of technology decision making; this study consisted of two surveys; an initial general survey followed by an analytical hierarchy process survey (AHP) using the action-research approach with a leading construction company in the UK (Company A). The data collected was both qualitative (establishing and verifying decision criteria) and quantitative (establishing weightings and priorities).

### **General Survey**

The general survey consisted of interactive discussions using semi-structured interviews with the identified stakeholder groups to evaluate and validate the pre-defined criteria identified from literature review and previous research. The study was also used to select professionals with relevant qualifications and experience to participate in the AHP survey. The interviews were conducted with 20 senior management personnel from Company A involved in the roles of technical, commercial, retail construction, sustainability, procurement, marketing and customer services and three sustainability managers of retail clients of Company A. The established decision criteria was presented and explained to the participants in the general survey. Some participants provided more criteria or sub-criteria for consideration, while some suggested minor modifications to the criteria. As this was a pilot study to check the success and usefulness of the developed decision making systems, the study was limited to five broad criteria which were approved by the participants as most relevant to use in the AHP survey and illustrate the current industry concerns over the use of sustainable technologies.

### **AHP Survey**

This was followed by a one-day workshop to conduct the AHP survey with Company A at an organizational level with ten senior managers predominantly involved in sustainable retail construction, client facing and job winning roles. The workshop was set up in an interactive and constructive way, allowing ample space for the participants to contribute to the real problems at stake. The value tree of five decision criteria to be used for the AHP questionnaire survey was explained and participants then performed pairwise comparisons using the scale developed by Saaty (2006).

The first phase of the questionnaire asked for the criteria to be ranked in a given context and second phase asked for a pairwise ratio/importance response for each of those ranked factors. The comparisons were made using a scale of absolute judgements that represented how much more one element dominated another with respect to a given attribute. The results relied on the judgements of experts to derive priority scales and it is these scales that measure intangibles in relative terms (DCLG 2009).

## RESULTS AND DISCUSSION

There are several methods currently available for selection of STs; however they are inadequate as they overemphasise the quantitative and financial criteria, but overlook qualitative factors such as improved human comfort and environmental sustainability (Wong et al. 2008, Pan et al. 2012). Secondly they do not provide a process for prioritising and assigning weights to the relevant selection criteria (Akadiri et al. 2013). This study has generated a set of both qualitative and quantitative key criteria currently used by clients in the selection of STs as explained below. These are consistent with the criteria identified from literature review and reflect the five broad issues which affect the selection of STs by clients.

### General survey

The results of the general survey indicate five broad criteria currently used by clients in the selection of STs as explained below.

- Proven success of technology (Success)

A carbon saving of 75% by 2050 is achievable at no net cost (Carbon Trust 2009); however, it will be difficult to realise these savings and additional savings from new technologies without innovation (Carbon Trust 2010, IEA, 2012). Innovation in the non-domestic building sector represents a significant opportunity to help meet the UK's GHG emissions targets. Similarly, a study by Aberdeen Group (2008) identified the need for innovation as one of the top five pressures driving the green retail enterprise. Leading retailers are keen to use innovative products and processes in their construction processes to achieve reductions in energy and carbon emissions. However, due to the newness of several innovative sustainable technologies and lack of skills, with most of the technologies not performing as expected, there is a preference for technologies with evidence of proven success in reducing the energy and carbon emissions. This could be based on the fact that the technology has been used on other building types (schools, hospitals, houses, etc.), by other retailers or even trialled or piloted by organisations such as the British Research Institute or Energy Trust. There is a need for innovative sustainable technologies to be fully endorsed and supported (Pan et al 2012) and to create the right framework to encourage both development and deployment by stakeholders (IEA 2012).

- Time and ease to install sustainable technology (Time)

Refurbishing and retrofitting existing buildings can improve the energy efficiency and environmental performance and will be a crucial step in making significant inroads toward tackling climate change. In many cases, an existing building is either vacated or partially closed as it is refurbished. A participant from the general survey mentions 'The closure of a retail store (such as grocery) even for a day can be a great loss to the owner, with busier stores losing up to £500,000 in sales'. The use of technologies which require extended periods of closure of the store is particularly challenging when they impact on store trading and sales. Hence, retailers/clients prefer to install those technologies which have the least impact on occupiers and involve little or no disruption to store trading, such as the use of off-site technologies. Clients using off-site production technologies benefit from faster construction times, less waste, less noise and disruption to neighbours, and lower site accident rates as well as improved health and safety.

- Cost of the technology (Cost)

The use of energy efficient technologies in retail buildings can reduce the energy costs by 20% and this represents the same bottom line benefit as a 5% increase in sales (Carbon Trust 2010). However, cost is one of the major barriers when implementing sustainable technologies, due to higher upfront cost and the lack of financial benefits and incentives for stakeholders (Wong et al 2008, Dangana 2012, Pan et al 2012). Also, many sustainable technologies do not yet offer an acceptable payback period for clients which is critical to environmental and energy efficiency. A simple payback method is most often used by clients looking to recoup costs and determine how long it will take to break even on the investment. This is achieved by dividing the incremental cost by the net annual operational savings (energy savings and maintenance impact). Due to the frequency with which a retail store needs to be refurbished, the acceptable payback period of 2-5 years is preferred by clients rather than the average 8-10 years for most technologies.

- Sustainability

There are various new sustainable technologies, with a potential for saving energy and improving efficiency for retail buildings. However, due to the newness of the technologies there is little or no evidence to prove how effective they are. Clients are becoming increasingly conscious of sustainability; in terms of what the energy and carbon saving would be. Although this is difficult to prove for immature technologies, data might be available in different forms such as BRE testing, accreditations by well-known organizations, or data from a pilot study, all of which could increase the confidence of the client when selecting such technologies.

- Impact of technology on customers (Risks)

Sustainable technologies can have an effect on the end-users of the buildings, such as the customers. Retailers recognise that a greater understanding of customers is needed to enhance customer satisfaction and retail performance. They are mindful of the impact a technology would have on the customers as this could either increase or reduce their sales and profits. Some retailers would not install a sustainable technology, no matter how energy efficient it might be, if it might have a negative impact on customers. For instance, in grocery and convenience stores, refrigerators and freezers make up a significant portion of total energy use, with the selection of freezing and refrigeration systems playing an important role in energy efficiency (Evans et al. 2007) and the extent to which such technologies are positively perceived by customers most probably hinges around functionality. A report from Consumer Focus recommended that supermarkets should achieve efficiency savings by putting doors on all freezer units and explore and progress consumer acceptance to doors on chillers (Allder & Yates 2009). However, some retailers are still not making use of such technologies as customers do not like the idea of doors on fridge-freezers. Thus the positive or negative impact of the technology on customers is a key factor in the selection of STs.

### **AHP Survey**

The aim of the AHP survey was to evaluate the comparability of the established decision criteria currently used by retailers for the selection of STs.

The results were first analysed for each participant to establish the weighting and ranking (Figure 1) for the five broad criteria (cost, sustainability, time, proven success, and risks). The results highlight the different view of the participants, however, the CR for each participant was within the acceptable range, and was reliable and consistent to establish the combined weighting and ranking for the stakeholder group.

All the results were combined to provide a consensus ranking and weighting for the group using the AHP technique (Table 1). The risk criterion was found to be the most important attribute for the group with a score of 34%. followed by cost (22%), proven success (20%) time (12%) and sustainability as the least important (9%).

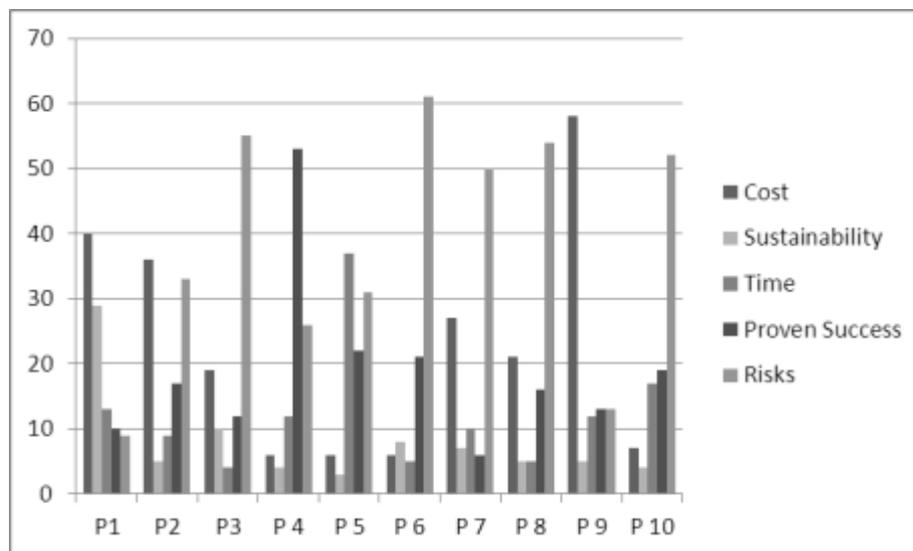


Figure 1: Ranking and weighting of criteria by all participants.

The scores for the various attributes in Table 1 clearly denote that the group under study places much emphasis on the risk posed by the technologies and the effect it would have on the end-users of the building. The sustainable features of the ST (sustainability), was considered the least important criteria, this could be due to the fact that it is difficult for clients to quantify the energy and carbon saving compared to the other factors.

Table 1: Combined comparison matrix of selection criteria used by clients

	Cost	Sustainability	Time	Success	Risks	Weights	Ranking
Cost	1	2 7/8	1 5/7	1 1/7	1/2	22%	2
Sustainability	1/3	1	7/9	4/9	2/7	9%	5
Time	4/7	1 2/7	1	4/7	3/8	12%	4
Success	7/8	2 2/9	1 3/4	1	1/2	20%	3
Risks	1 8/9	3 2/3	2 2/3	2	1	37%	1

An essential feature of AHP is the consistency test, which aims to eliminate the possibility of inconsistencies by providing a consistency ratio (CR). Saaty's suggests that a CR equal to 10% is acceptable. If the CR value is lower than 10%, the established weight results are valid and consistent, but if larger than 10% the matrix is considered inconsistent. The CR was thus used to determine and justify the inconsistency in the pairwise comparison made by the participants. The results of this study indicate a CR of 0.3% which is within the acceptable range of 10% and the established weights are thus reasonably consistent.

The sample size of 10 participants for AHP survey might seem limited. However, AHP is a subjective method and with a large sample size there is a tendency for respondents to provide arbitrary answers which can result in inconsistencies (Wong et al 2008).

## CONCLUSIONS

There has been a slow uptake of STs by stakeholders in the retail construction industry. Previous studies have indicated the lack of a decision making system for the selection of appropriate sustainable technological innovations (Akadiri et al. 2013, Catalina 2011, Pan et al. 2012, Dangana et al. 2012) to optimise the process, energy and carbon efficiency for retail buildings. This can be classified as a complex multi-criteria decision problem due to the high number of alternatives, potential solutions and various stakeholders involved. It is important to have an in-depth understanding of each stakeholder's aspiration to arrive at a consensus decision to select the appropriate technology.

The study reported in this paper established five broad decision criteria (cost, time, proven success of technology, risk and sustainability) currently used by clients in the selection of STs to achieve reductions in energy consumption and carbon emissions. The established criteria were selected and approved as most relevant by the participants and illustrate the current industry concerns over the selection of STs. Using AHP survey and expert opinions, the identified criteria were weighted and ranked in the following order with risk being the most important and sustainability the least important factor: risk (37%), cost (22%), proven success (20%), time (12%) and sustainability (9%). The established weights and ranking are considered to be reliable and consistent as the CR was 0.3% and within the acceptable value of 10%.

The findings contribute to widening the understanding of selection criteria as well as their degree of importance based on stakeholders' needs; improving the quality of the decision by making informed decisions that are more explicit, rational and efficient. The study has focused on the objectives of the client (retailer) but, the process can be applicable to other stakeholders. The various stakeholders' objectives can be visualised in a value-tree to assist stakeholders in making a more informed decision to achieve sustainable retail buildings.

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# **PRESERVING CONTINUITY IN WHOLE-LIFE COST MODELS FOR NET-ZERO CARBON BUILDINGS**

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Investment in net-zero carbon buildings requires comprehensive evaluation especially with regards to economic viability. Mathematical modelling of whole-life costing provides a relevant framework to assess the investment potential of net-zero carbon buildings. Previous studies in investment analysis have suggested insufficiency in the discounting mechanism of cash flows leading to unrealistic estimation, and in some instances, incorrect decisions. There is a growing body of evidence that conceptual adjustments to cost models could facilitate improvements in the costing of zero carbon buildings. This study, - which is part of a PhD investigation on cost studies in zero carbon buildings, presents an approach to preserving continuity in whole-life cost models using the binomial theorem. The work builds on the New Generation whole-life costing developed in Ellingham and Fawcett (2006) by extending the period under consideration and concurrently providing for other elements of time, uncertainty and irrevocability. The study also highlights the conceptual importance of continuity in decision-models. An illustrative costing exercise is carried out, over a 25-year period, on a conventional and net-zero carbon building using three different whole-life cost procedures. Results from the study suggest that continuous whole-life cost models provide a realistic template for representing cost variables especially in comparative studies. Future research will examine the implications of continuous whole-life costing for a generic net-zero carbon building. This will provide construction professionals with clear aspirational objectives on the economic performance of net-zero carbon buildings.

Keywords: continuity, cost models, present-value, whole-life costing, zero-carbon

## **INTRODUCTION**

In December 2006, the UK Government announced zero-carbon compliance for new housing and schools by 2016; public sector buildings from 2018 and commercial buildings from 2019. It is expected that the zero-carbon agenda would induce changes in the supply chain of the construction industry. Some of the anticipated changes in the supply network might include the “change in role(s)” for existing parts, displacement of vestigial units as well as admittance of new members. These changes should present an opportunity for the construction industry to re-strategize and re-position itself towards becoming a more efficient sector in the delivery of modern sustainable buildings. It is not unreasonable to expect the costing of housing units to play a pivotal role in this drive. Moreover, there are marked indications that benefits

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from an improved costing framework are likely to be far-reaching in this developmental epoch (Smit 2012). A number of notable industry reports have previously mentioned poor performance of the housing and construction sector resulting in unprofitability, unpredictability and poor client satisfaction (Egan 1998; Barker 2004). It is anticipated that these trends will be improved upon as momentum gathers in the advance towards a net-zero carbon built environment.

Investment in net-zero carbon buildings requires comprehensive evaluation in order to ascertain economic viability. Many published studies have already hinted at higher capital cost implications for net-zero carbon buildings compared to conventional buildings (Clarkson & Deyes 2002; Catto 2008; Williams 2012). CLG (2008) reported that an additional construction cost of 25-37% was needed to achieve “level 6” of the Code for Sustainable Homes (also known as zero-carbon standard), in new buildings. This figure closely tallied with the findings of Holden and Twinn (2011) that net-zero carbon houses could be about 40% more expensive in the build-cost requirement. A later study by Williams (2012) contends that the additional capital investment cost in net-zero carbon houses might not exceed 10%, given the competence and aptness in the scale of operation of the house developer. Considering the propositions in these disparate accounts and especially in the current economic climate, analytical costing of zero-carbon buildings could play a germane role in identifying the relevant cost drivers. Analytical approach to costing could also aid an appreciation and understanding of the entire process relating to delivery of net-zero carbon buildings. This paper presents an innovative and analytical approach to costing net-zero carbon homes. Critical reflections on the mathematical modelling of costing as well as the binomial theorem, constitute the background literature for the investigation. An overview of the distinct variants of whole-life cost techniques are stated and appraised. A comparative illustration employing the procedures of the whole-life cost techniques is also presented. The results obtained are collated and reported upon in the final section of the paper. Implications of the results from the cost models are discussed and employed in suggesting future research directions.

## **MATHEMATICAL COST MODELS**

A mathematical cost model is a unit of analysis which consists of sets of relationships, systematically arranged to handle inputs and methodologically translate them into outputs (Smit 2012). According to Farr (2011), represented in *Figure 1* below, the paths to mathematical modelling are essentially a choice between closed-form or finite elements methods. Ross (2009) suggested that closed-form mathematical expressions provide precise descriptions for systems with little complexity and hence assume little uncertainty. Current trends in cost estimation however suggest increasing complexity, heightened uncertainties and relative noisiness of data (Boussabaine & Kirkham 2008). In cost estimation, an alternative to building mathematical models is the use of simulation which could be in the form of system-dynamics or Monte Carlo (Farr 2011). Simulations can provide a cheaper way to conduct a simplified analysis of a system over a specified period of time (Farr 2011). Simulations are highly beneficial in simplifying the characteristics of a system and obtaining reasonable expectancies on system performance. One demerit of simulation is that it is not an optimizer, but provides satisfactory solutions (Wayne 1996; Boussabaine & Kirkham 2008). It is also quite evident that simulation experiments seldom tend to establish fundamental relationships; rather they juggle an array of input variables in order to determine the impact of their possible combinations on one or more output variables. Wayne (1996)

equally acknowledged the advantages of mathematical models in place of simulation experiments but contends that for many a system, a true mathematical model does not exist. Arguably, this claim does not seem to have been empirically substantiated.

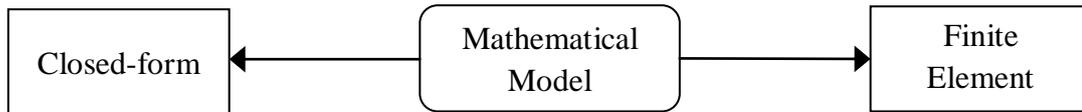


Figure 1: Paths to Mathematical Modelling. (Source: adapted from Farr 2011)

Existing trends however point at an increasing and persistent gap between the predictions of cost models and eventual economic realities (Boussabaine & Kirkham 2008). Ellingham and Fawcett (2006) reasoned that many managers understand that numerous cost models are flawed and often make informal adjustments to compensate for the deficiencies in cost estimates. The demerit of such an approach is the arbitrariness in the magnitude and impact of adjustments made. Ellingham and Fawcett (2006) further expressed that flawed cost models resulted from a consistent lack of recognition of life-cycle options embedded or acquired in decision choices. Clarkson and Deyes (2002) had also earlier noted that cost studies were often conducted in a limited intertemporal optimization framework. Georgiadou and Hacking (2011) pointed out that many of the existing cost figures are based on deterministic projections of historical data which can only provide “steady-state” models; and thus have little bearing on reality. These accounts sufficiently suggest a growing body of evidence seeking to establish the analytical underpinnings of contemporary cost models. Mathematical modelling provides a robust means of implementing and facilitating analytical significances in costing (Ellingham & Fawcett 2006; Farr 2011; Smit 2012).

## CONTEMPORARY ISSUES IN COST MODELLING

For costing to be carried out it is important to understand the objectives and requirements of the particular system, as well as its constraints and assumptions (Smit 2012). In cost modelling, like every other physical and engineering system analysis; evaluation needs to be conducted across a robust frame of reference. In many cost modelling exercise, time is perhaps the most prevalent frame of reference, especially in life-cycle scenarios. Ayyub (1999) added that the development of a cost model also results in introducing and defining uncertainties. Uncertainties, on the one hand consist of lack of information which could emerge from cognitive or non-cognitive sources (Ayyub *ibid*). Core areas of uncertainty in estimating cost across a product’s lifecycle include cash flow data, building-life, investor’s commitment, component service life and future decisions (Ellingham & Fawcett 2006). On the other hand, recent research has also presented a case for the existence of a significant degree of economic and/or physical irrevocability in projects; evidence of this, is seen in some literature on housing (Verbruggen *et al.* 2011; Smit *ibid*). In the context of buildings, irrevocability can be termed a “lock-in” syndrome (CLG 2011). This implies that once built, a certain level of efficiency or inefficiency is locked into a building which cannot be dramatically altered without significant and disruptive costs. Irrevocability therefore connotes the difficulty and/or impossibility associated with withdrawing resources already committed to a course of action for an alternative use. Verbruggen *et al.* (2011) represented a four-degree irrevocable process in buildings; very strong, strong, medium and weak. Very strong connote situations where the cost of reversal increases over time. Strong refers to those where reversal cost in the future is above the reference initial cost but decays over time; medium refers to reversal cost being

higher than initial cost at current time and for some years but falling below initial cost in later periods; Weak refers to reversal cost being equal to or less than the initial cost.

Supposing time, uncertainty and irrevocability are attributes worthy of being represented in cost models, the analytical underpinnings of such procedures are not very straight-forward. . The discounting process is the widely-accepted mechanism of deriving the equivalent value today of a future expenditure (Park & Sharp-Bette 1990). Previous studies in investment analysis have however suggested insufficiency in the discounting mechanism of cash flows leading to unrealistic estimation and in some instances, incorrect decisions (Gluch & Baumann 2004). Korpi and Ala-Risku (2008) have also questioned the discounting convention which invariably elevates the place of running cost over initial capital cost. Chan (2012) hinted that the problem with the conventional discounting mechanism might be embedded in the cultural perception of time as a homogeneous numerical order. Kishk and Al-Hajj (1999) have reportedly cautioned that costing does not completely fit into the framework of probability and statistical theories. Hence, there is need to expand the purview of modelling in order to augment the needed robustness and flexibility in cost evaluation.

Perceptibly, ZCH (2011) has expressed that cost modelling could assist in benchmarking the occurrences in a housing project which could then serve as a proxy for feasibility assessments. One effort which also appears promising especially in the containment of irrevocability is recognising the continuity attribute in cost models. The principle of continuity is a methodical approach underlying the conceptual notion that reality is a dynamic sequence of events and decisions (Verbruggen *et al.* 2011). By and large, the principle of continuity models progressive and successive events as being intrinsically interlinked. Continuity, an age-long mathematical principle, can be considered as an aspect in finite element (FE) algebraic analysis of cost models.

## **BINOMIAL COST MODELLING**

Analytical costing presupposes the existence of a representative cost function for a costing process. Whilst there may be differing opinions on the existence of a true cost function, such assumption is fundamental to employing mathematical models in costing. In many costing situations, data is known only at discrete points. However, the value of a function at a non-discrete point may be required to better understand the behaviour of a cost system (Hoffman 2001). In such situations, one pragmatic endeavour becomes fitting an approximate function to the set of discrete data. For the purposes of simplicity and ease of manipulation, polynomials are often an excellent choice in fitting an approximate function (Hoffman *ibid*). Furthermore, the binomial model is the simplest form of polynomial in any given probabilistic sample space. The binomial model shown in Fig 2b below is a mathematical representation of the rate of change of cost with respect to time ( $\delta C / \delta t$ ) and explicitly recognizes a stream of possible values within a sample space. The binomial model also specifies probability coefficients for respective cost values based on the differentiation calculus. In obtaining the empirically derived cost projections, this work builds on the binomial model developed by Ellingham and Fawcett (*ibid*). In the binomial model, the normalized coefficients of each term follow the sequence as shown in Figure 2a:

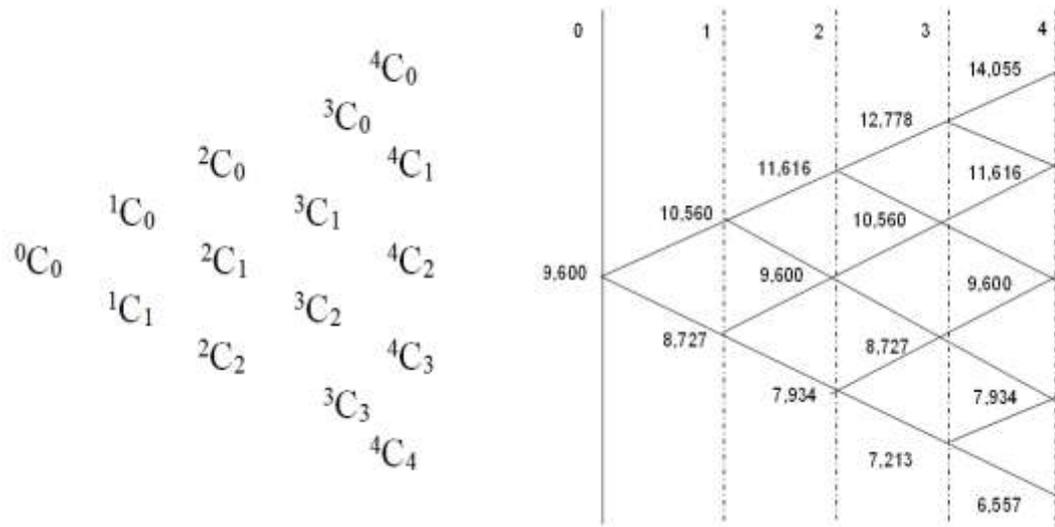


Figure 2: [a] Coefficients of a Binomial Model [b] Binomial Cashflow Model

The equation below is a general binomial series and can be represented as:

$${}^nC_0 + {}^nC_1 + {}^nC_2 + \dots + {}^nC_{n-r} \quad (\text{Eqn. 1})$$

Also for any term,  $r$  and column,  $n$ , the general equation can therefore be expressed as:

$${}^nC_r = \frac{n!}{(n-r)! r!} = \frac{{}^nC_{r-1}}{{}^nC_0 + {}^nC_1 + {}^nC_2 + \dots + {}^nC_{n-r}} \quad (\text{Eqn.2})$$

According to Ellingham and Fawcett (*ibid*), the binomial theorem can be used to forecast, rather than predict future uncertainties. In the binomial model in Figure 2a (Pascal's triangle), the  $r^{\text{th}}$  term,  $n^{\text{th}}$  column as well as the number of binomial coefficients,  $k$  on the sample space, is used to deduce the normalized coefficient of the binomial model. The mathematical formulation employed in deriving the individual probability equivalent for each cost index is deducible by the formula given as:

$$\frac{{}^{n-1}C_{r-1}}{\sum_{k=0}^{n-1} {}^{n-1}C_k}$$

One obvious benefit in mathematical-based binomial cost models is the consistent and explicit calculus used for evaluating risks over a specified period of time. This permits the effects of inflation and discounting to be separately and comprehensively dealt with; and also facilitates robust and procedural evaluation of each mechanism.

## STANDARD WHOLE-LIFE COSTING (WLC)

Over the last few decades, there has been a significant appeal for costing to be extended across the entire life time of projects (Gluch and Baumann 2004; Kishk 2005; Smit 2012). Mathematical modelling of whole-life costing provides a relevant framework for assessing the investment potentials in constructed built facilities. According to the CIFPA (2011), whole-life costing is simply the systematic consideration of all relevant costs and revenues associated with acquisition and ownership. The Net Present-Value (NPV) is the common metric for assessing the whole-life cost of construction projects, and is sometimes regarded as the whole-life cost of a building (Kishk 2005). In mathematical terms, WLC can be represented as:

$$WLC = \sum_{t=0}^T \frac{C_t^i}{(1+d)^t} \quad (Eqn. 4)$$

Where  $C_t^i$  = Equivalent cash flow,  $d$  = discount rate and  $t$  = time

Conceptually, the whole-life costing mechanism compares a range of existing options, leading to a “choose” or “lose” situation, in which, one of the evaluated options often translate into overall better investment based on the estimation of future revenues and costs. The predominant elements in whole-life costing procedures are initial capital costs, running costs, interest rates and inflation rates. Other specialized models further separate cost elements into procurement, maintenance, repair and operational costs (Kishk *ibid*). Usually - for purposes of ease and convenience, many whole-life costing exercises separates costs into just “initial capital” and “running” cost categories. Kishk and Al-Hajj (1999) expressed that by separating costs into capital and running categories, a peculiarity has been established. Some researchers have however criticised such simplistic approach. Tietz (1987) illustrated a situation in which the running cost of a building estimated over a 50-year period is likely to be 0.8 – 1.3 times the capital cost, assuming a discount rate of 2% above inflation. Assaf *et al.* (2002) also contends that the relationship between “capital cost” and “running cost” is essentially unknown. Ferry *et al.* (1999) stated that it is inappropriate to attempt to equate initial and running cost, since the circumstances and benefactors of both costing elements are often different. Other variants of the standard whole-life cost formula have been well documented by Kishk (*ibid*). Kishk (*ibid*) conjectured they were based on the same closed-form expression. Park and Sharp-Bette (1990) earlier inferred that closed-form expressions typically converge to a particular value.

There have however been a number of concerns on the appropriateness of the standard whole-life cost framework in providing accurate long term forecast of all associated costs since it is based on the discounting mechanism (Kirkpatrick 2000; Kishk *ibid*). Perhaps in recognition of such concerns on the performance of WLC models, a UK Government report issued by the Building Research Establishment and reported in Clift and Bourke (1999) identified several barriers to applying whole-life costing, namely: its lack of universal methods and standard format of computations; the absence of a stipulated methodology for integration of operation and maintenance strategies at the design phase, as well as the large scale of the data collection exercise. The CIFPA (*ibid*) however expressed that the ultimate value of whole-life costing lies in improving the understanding of the key links and drivers between the initial purchase decision and future costs and benefits.

### **NEW GENERATION WHOLE-LIFE COSTING (NWLC)**

The New Generation whole-life costing introduced by Ellingham and Fawcett (2006) is an experimental departure from the standard whole-life costing procedures. One crucial motivation behind this new-generation whole-life cost methodology is the incongruence in the outcome of whole-life costing analysis and the gut-feeling of decision-makers. Ellingham and Fawcett (*ibid*) argued that by relaxing the rigid assumptions of standard whole-life costing - that all decisions are made in year 0, and are irrevocable - increases the whole-life value. According to Verbruggen *et al.* (2011) this brand of costing is an application of the “wait and learn” scenario of the real option literature. “Options-thinking” is basically a conceptual idea that certain decisions can be taken in the future with better information. The life-cycle option described here is analogous to financial options and derives directly from the Black-

Scholes equation for establishing the fair price of an option (Ellingham & Fawcett *ibid*). Life-cycle options are basically the opportunities to respond to future change.

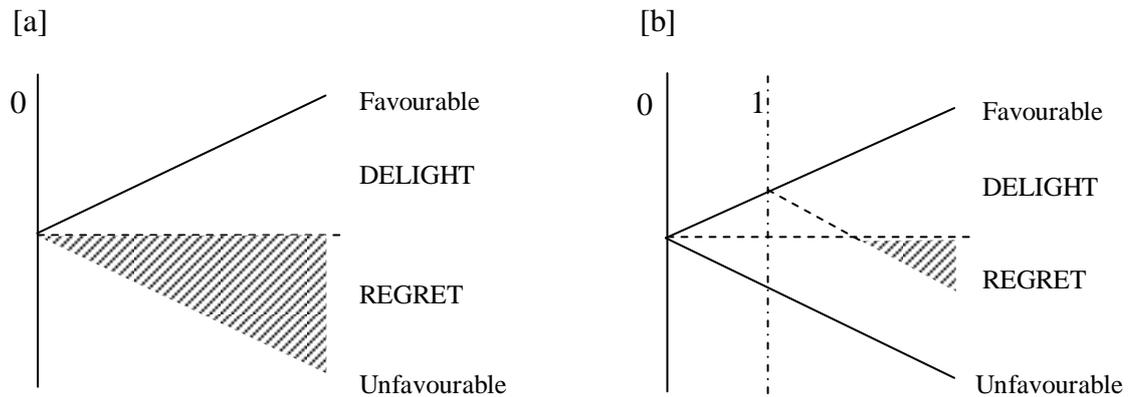


Figure 3: [a] Standard Whole-life Cost profile [b] New Generation Whole-life Cost profile  
(Source: Ellingham & Fawcett 2006).

The present-value (PV) of the entries in the binomial cost model is the discounted weighted average of all the entries. The procedures for deducing the present values for each respective year have been described in Ellingham & Fawcett (2006). As an illustration, the formula employed to evaluate the binomial tree for year 1 in Fig 3b is:

$$PV = v + P_u \times \frac{V_u}{(1 + d)} + P_d \times \frac{V_d}{(1 + d)} \quad (\text{Eqn. 5})$$

Where,

PV = Cumulative value at particular node ; v = Income at the particular node,  
 $V_u$  = Cumulative value at the upward parent node;  $P_u$  = Upward probability  
 $V_d$  = Cumulative value at downward parent node;  $P_d$  = Downward probability  
 d = discount rate

The present-value tree, NPV of the development tree and option tree are then computed. To calculate the NPV of development and option value for the model, a roll-back mechanism similar to a decision-tree analysis is carried out. The New Generation whole-life cost is perhaps most relevant in situations where there is a choice to expand, refurbish, sell, switch use, or include new technologies over a long period of time (Ellingham & Fawcett *ibid*). The New Generation whole-life cost approach is beneficial in its intellectual stimulation and assists clients to explicitly visualise the rationale behind costing decisions. It also encourages systematic consideration of cost information. Also, the procedures could be implemented on a spreadsheet package

Some of the limitations with the new generation whole-life costing model are that its procedures are more rigorous than standard whole-life cost mechanisms and might require expert guidance to be properly implemented. Also, the data across the estimated years are adjusted through the roll-back mechanism, but the model itself is neither dynamic nor adjustable in the decision framework.

## CONTINUOUS WHOLE-LIFE COSTING (CWLC)

There has been a growing proclivity towards continuity in evaluation models in the literature on engineering and construction economics (Park & Sharp-Bette 1990; Chan 2012). The extent and methodology however remains a technical difficulty to be subdued. An earlier work exploring continuity in cash flows was reported by Park &

Sharp-Bette (*ibid*). Park and Sharp-Bette (*ibid*) reckoned that continuity could occur in two main areas namely: continuous compounding of cash flows and representation of cash flows as proceeding at a given rate continuously, as opposed to discrete periods. The procedures reported by Park and Sharp-Bette (*ibid*) however tacitly stereotypes and adopts the exponential growth profile typical with the conventional discounting function and as such provides a somewhat analogous logic to the WLC mechanism. In following an exponential pattern without providing for other possible alterations, cost values are not open to being adjusted based on emergent market realities. The binomial theorem calculus, though not without its limitations, provides a platform for adjusting the continuous compounding of cash flow projections.

The CWLC framework introduced here aims to build on the template of the new-generation whole-life costing through preserving continuity in the NWLC equation. In contrast to Verbruggen *et al.* (2011) the authors reckon that the decision criterion of a (net-zero carbon) building are not always a stiff choice between a “choose or lose” and the “wait and learn” scenario. Essentially, a feasible continuum exists between the expenditure choices at the disposal of clients and the timing of making such decisions. It is possible to propose the existence of a progressive rate of change of cost with time (Park & Sharp-Bette *ibid*). In many established economies, the rate of change of cost is assumed linearly progressive with time. The stream of potential revenues can be derived using the binomial-based cost model template. In this CWLC model, components of the initial capital and running cost categories are retained. The linearity assumption aids analytical ease and facilitates compatibility with the binomial theorem framework. In modifying the binomial cost structure developed by Ellingham and Fawcett (2006), continuity is infused over the estimated life; in this case, 25 years. The CWLC equation in the proposed approach is presented as:

$$CWLC \text{ Equation} = C_0 + \int_{t=0}^{n=25} C_k(t) dt \quad (\text{Eqn. 6})$$

By expanding the integral we obtain the equation:

$$C_0 + [tC_k]_{t=0}^{n=25} + \sum_{t=0}^{n=25} \delta c \delta t = C_0 + [tC_k]_{t=0}^{n=25} + \delta t \times \sum_{t=0}^{n=25} \delta c \quad (\text{Eqn. 7})$$

In traditional integral expansion, the term,  $\sum_{t=0}^{n=25} \delta t \delta c$ , in eqn 7 is a constant ( $K$ ).

This constant,  $K$ , is often considered infinitesimal in most mathematical integration procedures and often approximated to zero or simply considered non-existent. It should however be noted that such approximations, where applicable, are admissible in say, distance-to-time measurements, where the dimensional quantities are in metres and seconds respectively. However in cost models, the dimensional equivalent of time is in years and sums of money are in local currencies; which often have significant digits. Such approximation might be rather inimical to robust model development. The CWLC proposed here intends to dynamically evaluate the cost mechanism through a procedure that obtains the exact difference in the average binomial value computations for each successive year ( $\delta c_n$ ) as the project progresses through its life cycle. The first step in this procedure involves the estimation of a stream of binomially generated revenues across the estimated number of years ( $n$ ) and averaging its value to yield each incremental cost value. The incremental cost is progressively summed over the specified number of years to attain the cost difference,  $\delta c$ , which is

multiplied to  $\delta t$ . This summation is cumulatively added to the initial capital cost and the average running cost for the estimated period. The continuous whole-life cost figure is basically the cumulative summation of the incremental running costs, the initial capital cost and the average running cost for the estimated number of years.

## NUMERICAL ILLUSTRATION AND DISCUSSION

For the purposes of practical illustration, this study evaluated the initial capital and running cost data of a net-zero carbon house (*Lighthouse*) and conventional house over a period of 25 years using variants of three different whole-life cost equations. According to Cook (2011), the build cost of the *Lighthouse* was £75,000, excluding the cost of foundations and utility service connection. Catto (2008) earlier hinted that possibility abounds for a net-zero carbon house to be constructed at a cost of £120,000. Holden and Twinn (2011) have also found that the running cost of the first zero carbon house (*Lighthouse*) in the UK is £30 per year, in contrast to the £500 per year that will be incurred with a conventional house, of similar capacity; which complies with the previous part L, Building Regulation, 2006. Catto (*ibid*) expressed that such conventional building could cost about £85,000, which roughly represents an approximate 40% reduction from the approximate cost of a zero carbon house. Juxtaposing these accounts, this study adopts a capital cost of £120,000 and running cost of £30 per year for a zero-carbon house and a corresponding capital cost of £85,000 and running cost of £500 per year for a conventional house. Table 1 compares the present-value cost figures of the house-types using standard whole-life cost, new generation whole-life cost and continuous whole-life cost techniques respectively. The inflation rate and interest rate of 2.5% and 8.0% respectively is employed in all cases, in line with the work of Ellingham & Fawcett (2006). In effect, a risk-adjusted discount rate of 5.5% was applied in the standard whole-life costing computation.

*Table 1: Comparative Present-value figures for different Whole-life Cost Techniques*

	WLC	NWLC	CWLC
<b>Zero Carbon House</b>	£120,402.44	£120,321.18	£120,758.79
<b>Conventional House</b>	£91,707.06	£90,352.43	£97,646.54

The CWLC technique introduced here could be beneficial because it does not require a prohibitive amount of data. Unlike in WLC models, the continuous whole life cost model is sensitive to the estimated life time of the building. The CWLC model is also helpful in identifying the exact point where the combined effect of inflation and interest rate has an optimal impact. This awareness could assist in providing a more realistic and dynamic pay-back period in the evaluation of emerging technologies. In addition, assumptions could be varied for successive years which allows for dynamic visualization of cost drivers. Also, cost factors over the lifetime of a building could be based on more recent market realities without recourse to back-casting. Lastly, the continuous whole life costing described here provides a conceptually simple and mathematically tractable approach to rational investment evaluation.

## CONCLUSIONS

This study promotes consideration of the issues and approaches available for costing net-zero carbon buildings. The continuous whole-life cost is a novel and innovative approach in financial appraisal and costing. Preserving continuity partly explains the gut-feelings of housing clients that have been hesitant to embrace zero carbon homes based on the leanings from some existing cost models. Given current indications, the

UK Government might need to consider a capital subsidy exceeding £23, 112. 25 (present-value cost difference between CWLC estimates of the net-zero carbon and conventional house) or its equivalent, in order to promote widespread patronage for a house like the *Lighthouse*, based on a 25-year product life. The initiative of the UK Government in granting a stamp duty exemption of £15,000, for zero carbon housing which costs below £500,000 proves inadequate in this respect. It can also be observed that the values in the continuous whole-life cost technique are considerably higher than the other two whole-life cost techniques. This might suggest that previous cost over-runs could be partly due to a persistent case of methodological oversights leading to underestimation in housing projects. The results also suggest that continuous whole-life cost models provide a comparable and realistic template for representing cost variables. The limitations in the study are that, only one property type has been considered for the illustration; cost figures are also indicative rather than definitive and have been assumed to be longitudinal data. This work however proposes an analytical basis to costing, which equips construction professionals with clear aspirational objectives on the economic performance of net-zero carbon buildings.

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# GREEN MARKETING IN HOUSING: REALITY OR RHETORIC?

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All new homes in the UK will be required to be zero carbon from 2016. Housing sector bodies and individual housing developers are championing a transition from traditional marketing to green marketing approaches to raise consumer awareness of the benefits of low and zero carbon homes. On-site sales teams on housing developments form a central interface between the developer and potential buyers. These teams, then, have a critical role in the success or otherwise of the developers' green marketing strategies. However, there is a dearth of empirical research that explores the actual attitudes and practices of these teams. An exploratory case study approach was adopted. The data collection consisted of reviewing relevant company documentation and semi-structure interviews with the on-site sales teams from six housing developments. The findings from two case studies suggest that the sales teams do have potential to forge a bridge between the design / production and consumption spheres in the way that consumers understand and appreciate, but further work is required. The sales teams' practices were constrained by the incumbent, traditional marketing logic that rotates around issues such as location and selling price. The sales teams appeared to adopt a strategy of a restriction of information about the benefits of low and zero carbon homes to not disturb the prevailing logic. Further, the sales teams justify this insulating mechanism by the argument that consumers are not interested in those benefits. This rhetoric may be driving a real wedge between the design / production and consumption spheres to the detriment of the consumer and, in the longer term, the house builder itself.

Keywords: zero carbon homes, green marketing, on-site sales.

## INTRODUCTION

The United Kingdom (UK) Government has set out in the Code for the Sustainable Homes (hereafter the Code) that all new homes should be 'zero carbon' from 2016 (CLG, 2010). This requirement will, it is anticipated, be reflected in the 2016 Building Regulations Part L 'Conservation of Fuel and Power.' This ambitious 'zero-carbon target' potentially poses many challenges for both the new build housing industry and consumers (e.g. NHBC Foundation, 2012b; ZCH, 2010). For the industry, the target may significantly alter the way homes are built (e.g. NHBC Foundation, 2012b). For the consumers, the zero-carbon agenda may change "the design of the homes they will buy and in the way they will live day-to-day in these homes" (ZCH, 2010: 4).

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The industry and academic engagement in the zero-carbon agenda has followed a broad chronology of enquiry: design / production and consumption. In terms of design / production, research provides ample evidence of the implications of the zero carbon target for housing developers' business models, design and production templates (e.g. Lees and Sexton, forthcoming). In terms of consumption - a number of studies conclude that it is vital to engage with consumers in order to better understand their appetite for low and zero-carbon housing and the impact of occupant behaviour on the energy efficiency of a home (NHBC Foundation, 2012c; 2012a; 2011b; ZCH, 2010).

The proposition we make in this paper is twofold. First, we argue that the extant literature treats design/production and consumption as discrete spheres of logics and interests. The separation of these spheres has resulted in a lack of systemic understanding of their connectiveness and mutual shaping. Second, we suggest that a fruitful conduit to bring these spheres together is the discourse of green marketing. Anecdotal evidence suggests that consumers are not receptive to current 'green' marketing approaches being deployed by housing developers and that consumers' purchasing decisions are still driven by traditional criteria, for example, location (e.g. NHBC Foundation, 2012c; Kriese, 2009). The prescription to overcome this malaise that appears to be advocated by housing developers and academics is either carry on as before, under the assumption that the louder the marketing message of low and zero carbon homes the greater the chance that potential buyers will hear (e.g. NHBC Foundation, 2012c; ZCH, 2010; NESTA, 2008); or, to modify the marketing message to emphasise hedonistic benefits, especially lower energy bills (e.g. ZCH, 2010). Both prescriptions appear not to be working. We argue that if green marketing is to be effective in closing the gap between production and consumption, there needs to be a shift from generic corporate approaches to a more local, nuanced understanding of the complex 'interaction spaces' of house builders and potential buyers on specific housing developments.

Reframed in this problematic, a new actor group that takes central importance is the on-site marketing and sales teams on housing developments. Empirical research into the interests and practices of this actor group is surprisingly quiet in the relevant literature. Research conducted by the NHBC Foundation (2011a: 18) into the handover practices of home builders show that 43 % of site sales staff undertakes / are involved in the handover process, followed by 31% of the site manager or someone in the build team, 11 % of customer care or after sales staff, 4 % contractors and 10 % others (project managers or surveyors). The results indicate that the on-site marketing and sales teams have a critical role in communicating (or failing to communicate) the benefits of low and zero carbon homes to consumers. The sales teams also form a potentially powerful feedback mechanism to convey to consumers' low-carbon requirements and preferences back to the design teams within housing developers.

This paper presents case study findings that give insight into "do on-site sales and marketing teams have a role in bridging the design / production and consumption spheres in the way that consumers understand and appreciate?" The structure of this paper is as follows. First, key literature will be reviewed which illuminates, to iterate the polarised treatment that renders design / production and consumption as discrete spheres, and that the conduit between the two takes the form of new corporate 'green marketing' approaches. Second, the research methodology for the case studies is presented. Third, interim findings from these studies are given. Finally, conclusions are drawn.

## LITERATURE REVIEW

### **Design / production and consumption perspectives**

There is growing body of literature that emphasises the potential impact of low and zero carbon homes on house builders. The Energy Saving Trust (2011), for example, identify that the biggest challenge faced by housing developers in the construction of ten zero carbon homes was to reduce heat loss from the properties and that the housing developers needed to change their standard designs and construction methods, such as increasing the levels of insulation and the use of different materials [1]. Lees and Sexton (forthcoming), for instance, provide survey data that show the selection of low and zero carbon (LZC) technologies [2] by volume house builders to meet the desired Code level is based on a logic of minimisation of disruption to their standard design and production templates.

The limitations of such a design / production loci are beginning to be noted by a broad range of commentators that concentrate on a variety of perspectives and levels of resolution. Boardman et al. (2005) provide a normative context that consumers have become more environmentally aware and have a desire for more energy efficient / low carbon homes. The precise form of this consumer awareness and motivation is given hedonistic shape by the work of commentators such as Caird et al. (2007) and Ginsberg and Bloom (2004) that emphasise that consumers are driven by the allure of energy savings and enhanced comfort levels.

This part of the literature landscape, then, is cleaved by two loci: the commercial and technical considerations of the house builders and the potential hedonistic benefits to the consumers. The gulf between the two loci is eluded to, and given substance by, a number of different concerns. Research has stressed the role of occupant behaviour in determining whether or not the potentiality of energy efficient homes are realised. Gill et al. (2011), for example, lay bare the reality that all consumers are different in terms of energy use and, as a consequence, occupant behaviour may undermine overall building performance. Similarly, Bell et al. (2010) report findings that where LZC technologies were installed, residents did not understand and were unable to use the system. Further, case study research has stressed that house builders are not adequately engaging with consumers to understand their interests and behaviours. A study by Lees and Sexton (2012) indicate that a lack of engagement with consumers around the LZC technologies installed in new build developments caused tensions and misunderstandings of the system. The vagaries of consumer behaviours has led to a growing call by housing sector bodies, in particular, for house builders to recognise the significant impact on the 'as designed' energy performance of new homes (NHBC Foundation, 2012a; 2011b).

The need to knit together the design / production and consumption aspects of low and zero carbon homes is coming into the focus in the relevant literature. The means to achieve this integration is not so clear, but one growing solution being driven by the house builders themselves is to deploy effective green marketing strategies.

### **Marketing of low and zero carbon homes**

Green marketing of low and zero carbon homes to consumers has recently taken centre stage in the eyes of the housing development sector itself. We understand green marketing as “the application of marketing tools to facilitate exchanges that satisfy organisational and individual goals in such a way that the preservation, protection and conservation of the natural environment is upheld” (Mintu and Lozada,

1993: 2); and, “the holistic management process responsible for identifying, anticipating and satisfying the requirements of customers and society, in a profitable and sustainable way” (Peattie, 1995: 28).

There are two key publications that set out the general terrain and characteristics of this gathering interest. The first one is the ‘marketing tomorrow’s new homes’ report which aims to explore marketing opportunities for low and zero home homes, and by doing so, offers to “inform the development of marketing plans and help accelerate the generation of the market for low and zero home homes” (ZCH, 2010: 3). The polarisation between the developer and consumer view on low and zero home homes in the current marketing context was highlighted, stating that: “developers will currently engage if it’s right for their business. Consumers will only engage if it’s right for their lifestyle” (ZCH, 2010: 3). This report further argues that “the re-framing of the argument towards a customer-centric perspective in which there is clear, beneficial and recognisably secure sales proposition, reflecting innovation rather than risk, is considered central to successful market development” (ZCH, 2010: 3). The second one is ‘today’s attitudes to low and carbon zero homes’ report which reveals the current thoughts, awareness and understanding towards issues such as climate change, the Code, the 2016 zero carbon definition, airtightness and renewable technologies” (NHBC Foundation, 2012c). Underpinning these two reports, the key theme that can be discerned is that low and zero carbon home marketing endeavours made by housing developers need to be directly relevant to individuals’ concerns / interests.

These influential reports begin to sketch out the need for more effective green marketing but also detail some of the significant problems that need to be addressed to deliver against this goal; particularly the polarised design / production perspective of the house builders and the consumption interest of consumers.

To reiterate, the prescription to overcome this malaise that appears to be advocated by housing developers and academics is to either carry on as before, under the assumption that the louder the marketing message of low and zero carbon homes the greater the chance that potential buyers will hear; or, to modify the marketing message to emphasise hedonistic benefits, especially lower energy bills. Both prescriptions appear not to be working. To further iterate, the proposition that guides the research reported in this paper is whether or not on-site sales and marketing teams have a role in green marketing that mobilises and brings together both the design / production and consumption spheres of interest. More specifically, the research question for this paper is "do on-site sales and marketing teams have a role in bridging the design / production and consumption spheres in the way that consumers understand and appreciate?"

## **RESEARCH METHOD**

An exploratory case study approach was adopted (Yin, 2009). As the new housing is a concentrated sector and is dominated by a number of volume house builders, six housing developments from one large volume house builder were selected. Selection criteria for each of the case studies included type of unit (housing, apartments, mixed), type of housing (social, private, mixed housing), type of site (greenfield, brownfield, mixed), the desired code level being achieved (e.g. Code level 3), type of low and zero carbon technology (e.g. solar thermal) and project progress (e.g. completed).

The data collection consisted of the review of relevant company documentation (e.g. site plans) and semi-structured interviews. The interviews were carried out through face-to-face with the on-site sales and marketing team representatives from each of the six new housing developments. Before starting the interviews, a generic semi-structured interview protocol was prepared and pretested. All of the interviews were carried out at site offices and by doing so, giving the researcher a direct insight into each development. Each interview was around one hour in length. The interview data was captured by note-taking and audio-tape recording and then was transcribed verbatim. The transcripts were made anonymous before being analysed.

Interview transcripts were analysed using the 'pattern matching technique' (Yin, 2009: 136). We looked for similar or contrasting discussions of the theoretical propositions. Our pattern matching started with the notion of interest / no interest of customers in the benefits of low and zero carbon homes. We further explored the different rationales of their interests (e.g. consumers are more interested in location or budget of the house).

## **INTERIM FINDINGS**

### **Corporate green marketing messages**

One large volume house builder was selected for this research. The central corporate green marketing messages that the house builder conveys are as follows. First, the developer recognises that building homes has a significant impact on the environment. In response, the company has implemented a number of initiatives to minimise waste and reduce energy and to ensure their homes meet Level 4 of the Code. Second, the developer advertises its new homes as being more eco-friendly than older properties and this is through the installation of the latest energy saving devices and insulation. Finally, the developer emphasises that their homes will reduce consumers' energy bills.

### **Description of the case studies**

This paper will report on the interim results emerging from two out of the six case studies. The first chosen case study (Case 1) is a large urban mixed used redevelopment located within a city in Southern England. The site consists of 129 houses and apartments. The site is brownfield and has achieved a Code Level 4 standard. The low and zero carbon (LZC) technologies being installed are air source heat pumps (ASHP), solar photovoltaics (PV), mechanical ventilation heat recovery (MVHR) and solar thermal. One sales advisor was interviewed and his job was to offer information to potential buyers and sell the apartments. The second chosen case study (Case 2), sitting in a greenfield site, is a large two phased development for both private and social housing, located in a county in the East of England. The development consists of 59 social houses and apartments, and 90 private houses. The development is built to a Code Level 3 standard and is expected to be completed in June 2013. The LZC technologies adopted include solar thermal (private and social units), solar PV (social units only) and MVHR (social units only). One sales manager was interviewed and her responsibility was to oversee the development and put together the specification brochures.

### **Are consumers interested in low and zero carbon homes?**

A recurring theme from the on-site sales and marketing teams was that consumers were not interested in the benefits of low and zero carbon homes. The sales manager of Case 2 expressed the view that:

"... very, very rarely does anybody actually ask us about energy efficiency ... Not at the point of viewing the houses, even at the point of actually going through the legal process with solicitors ... solicitors don't even actually ask questions ... about anything energy efficient ... Nobody ever actually comes in and says to us, oh, we're so pleased with how the solar water panel's working. It's not something anybody actually ever mentions ... I mean, realistically they do save money on their gas bills because of it..."

The rationale for this position expounded by the sales manager of Case 2 was that consumers took the energy efficient benefits as a 'given' and were more interested in other features:

"... I think in general, people who are coming to look at a new house appreciate that a new house is going to be more energy efficient than an old house. I think that's why a lot of people want to buy new, because they know they haven't got any work to do, they won't have any maintenance to do for quite some time. And I think they appreciate, I think they do realise that as builders we're obviously using all the latest technology and everything we need to use to make it as energy efficient as possible ... I don't think that's maybe why they actually raise it as a particular question. I think they already take onboard that it's a new house, it's going to be warmer, it's all built with modern technology, so it's going to be as it should be. And I think maybe that's why people don't question it maybe."

When consumers were interested in the benefits of the low and zero carbon homes, the interest tended to be narrowly defined in terms of saving money, but, again, were not interested in the detail of the technologies to achieve this. The sales advisor of Case 1, for example, pointed out that they did not believe that the buyers wanted to know about the technologies incorporated, but instead their primary interest was the money saving potential of the new homes by stating that:

"... especially with what's happening in the press where all the energy companies have just put their prices up, and of course customers have spent a lot of money on their new home, if we've already incorporated it [the technology] the customer is much more happy to have that rather than pay extra in years to come to have solar panels installed or to have, specific installation installed, we've already got it in situ... They [customers] are pleased, they've got it as a peace of mind and it's all in their new home without an initial expense from them"

The 'peace of mind' (but technology out of mind!) benefit was further pushed by the sales teams by using the five year warranty as a means to pacify potential concerns. The sales manager of Case 2, for example, expressed that:

"... low maintenance is probably the biggest selling point that most people would latch onto that we talk about. Because it is, I mean, if you move into a new home, there is no maintenance, it's all, you've obviously got a five year warranty with HD42's [the developer], so they have peace of mind with that."

### **So what are consumers more interested in according to the sales teams?**

The results indicate that the sales team believed that the consumers' principal interest was in house price (budget), followed by location - not in energy efficiency. The observation of 'budget' being the most crucial thing for potential buyers is captured by the sales manager of Case 2 who noted that:

"... obviously what happens is, when we launch a development ... People would come into the office, or they'll phone up to make an appointment. We would sit them down, go through their details, find out what they were looking for, size, type, whether they wanted terraced, semi-detached, detached, an apartment, depending on what their budgets were. Budget is obviously the most important thing, and the most crucial thing. And that's really which is the, probably the most important thing that leads all our purchasers. In the main, it's budget."

Further, it was found that the location of a new housing development (in particular its proximity to services and facilities) influence consumer choice. The sales manager of Case 2, for example, explained that:

"... Location, without a doubt has been here because of the schools. We've had a very good mix of properties here, we've got everything from a two bedroom apartment up to a five bedroom house. So it has been about location, it's been about a particular property type. And it's been about budget ... what they can buy for their money ... What was included in the price, in terms of incentives? Who was next door? Was it next to affordable? Could you hear the train station? All that sort of thing. But, there was no mention of energy efficiency."

### **Consumer differentiation?**

It was found that the sale teams 'classified' consumers and altered the message depending on the consumer-type: those that were receptive to technology (the minority of people) and those that were not interested / resisted technology (the majority of people). This observation was captured by the sales advisor of Case 1 who noted that:

"It's split in to two categories. Yes, you've got the scientist type of person that wants to fiddle with everything and see how it works, wants to know the ins and outs of it and then you've got the other people that are technophobes that haven't got a clue how it works."

## **DISCUSSION AND CONCLUSIONS**

The results can be read in two different ways. On the surface, the on-site sales and marketing teams appear to be justifying not communicating and translating the benefits of low and zero carbon homes with the argument that the consumers themselves were not interested in these features. But is this justification warranted or a convenient rhetoric to insulate the sales teams themselves from having to actively engage with the consumers on this topic? This is an empirical question that requires on-going fieldwork.

What is clear, though, is that there is a definite gap between the rhetoric of the corporate green marketing advocating the benefits of low and zero carbon homes and the translation of this message by on-site sales teams. In reality, there is evidence that the sales teams are reproducing the divide between the design / production benefits and the consumption benefits from the perspective of the consumer. Indeed, the sales

teams are implicitly placing the responsibility on the consumer to seek and calibrate the benefits. The ZCH (2010) lament a polarisation between the developer's and consumer's view of low and zero carbon homes is evident.

The underpinning research question for this paper was: "do on-site sales and marketing teams have a role in bridging the design / production and consumption spheres in the way that consumers understand and appreciate?" The interim findings from two case studies suggest that the sales teams do have potential to forge a bridge, but further work is required. We can speculate that their practices were constrained by the incumbent, traditional marketing logic that rotates around issues such as location and selling price. The results indicate that the sales teams adopt a strategy of a restriction of information about the benefits of low and zero carbon homes to not disturb the prevailing logic. Further, the sales teams justify this insulating mechanism by the argument that consumers are not interested in those benefits. This rhetoric may be driving a real wedge between the design / production and consumption spheres to the detriment of the consumer and, in the longer term, the house builder itself.

## NOTES

[1] In the UK, Building Regulations Part L on energy efficiency requires housing developers to meet certain standard which covers energy used in home for heating, hot water and lighting (Broer and Titheridge, 2010). There is significant potential for achieving such requirement through technological measures such as fabric solution (ZCH, 2009), use of high-performance glazing, efficient heating systems and low and zero carbon technologies (CLG, 2010; Boardman, 2007).

[2] A LZC technology is defined as "a technology that can provide heating, cooling or power (or a combination of outputs) and will be powered solely by renewable energy (zero carbon) or powered in part by fossil fuels (low carbon)" (Bevan and Lu, 2012). Examples of LZC technologies include, but are not strictly limited to: solar PV, solar thermal, wind power, hydro power, heat pumps (ground/air/water), combined heat and power, biomass boiler, MVHR and fuel cells.

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# AN APPRECIATION OF BREEAM RELATIVE TO THE COSMONOMIC IDEA OF REALITY

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Sustainability assessment schemes risk the institutionalisation of a limited definition of sustainable construction. New, broader structures of knowledge and thinking relating to sustainability in the built environment are required. The 'Cosmonomic Idea of Reality' has been advanced as such a structure. The notional basis of the cosmonomic framework was explored and was shown to accord with six previously identified dimensions of sustainability. Using the mind-mapping technique and a set of mapping rules, the framework was compared with an established BREEAM scheme, to allow the shortcomings of this assessment method to be exposed. It was found that the BREEAM scheme neither sufficiently accommodated the sustainability dimensions nor each and every modality of the framework. In order to address the complexities of the sustainability challenge the BREEAM scheme must fully accord with a framework that more appropriately encapsulates the sustainability concept. Moreover, it should be better informed by project-specific concerns.

Keywords: assessment, framework, sustainability.

## INTRODUCTION

In recent years attempts have been made to broaden the scope of building environmental assessment to encompass the concept of sustainability (Cole 2005). This notion seeks to balance the inherently interrelated yet frequently opposing aspects of environment, society and economy. These aspects interact over space and time and, in accordance with the idealised tenets of the related concept of sustainable development (WCED, 1987) should be shaped and influenced by participation in associated decision-making (Moir and Carter 2012). However, many schemes which claim to assess sustainability in the built environment continue to inadequately address the social and economic impacts of construction (Todd *et al.* 2001). Context-related spatial, temporal and participatory concerns are similarly ill-considered (Moir and Carter 2012). Building performance determined through such schemes often acts as a proxy for the achievement of built environment sustainability goals. Consequently, there is a risk that a limited definition of sustainable construction, misaligned to the notional essence of sustainability, will become institutionalised (Moir and Carter 2012). Therefore, it is evident that progress towards a sustainable future through construction theory and practice will require new, more extensive

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structures of knowledge and thinking than those offered by contemporary building performance assessment.

In response to this demand, Brandon and Lombardi (2011) advance the ‘Cosmonomic Idea of Reality’, a ‘weltanschauung’ (world view) conceived by the Dutch philosopher Herman Dooyeweerd (1894-1977), as a suitable framework. An appreciation of an established building assessment methodology, specifically an instance of the Building Research Establishment Environmental Assessment Method (BREEAM), relative to Dooyeweerd’s cosmology was undertaken with a view to exposing the shortcomings of the methodology. The identified aspects of sustainability, namely environment, society, economy, space, time and participation (Moir & Carter, 2012) were shown to be encompassed by the cosmonomic framework. The analysis conducted sought to determine if the BREEAM scheme offers a similar level of correspondence. The scheme BREEAM New Construction 2011 (Non-Domestic Buildings) (BRE Global 2011) was selected as the comparator based on its anticipated common usage. The mind-mapping technique was used to establish associations between the framework and the scheme.

## **THE COSMONOMIC IDEA OF REALITY**

The ‘Cosmonomic Idea of Reality’ (Dooyeweerd 1953-58) is a pluralist ontology. It is a universal conception founded on the theocentric premise that “nothing, not even theoretical thought, is absolute: it is all relative to the Creator God who, by the action of creation, gave everything meaning” (Brandon and Lombardi 2011: 218). Despite its ostensibly transcendental aspirations Dooyeweerd’s cosmology can be readily applied in secular contexts. It is concerned with the notion of an independent external reality (i.e. cosmology) which influences and is influenced by those who are subject to it. This reality is composed of two ‘sides’, an entity side and a law side. The former pertains to systems and ‘things’ (i.e. all perceptible objects in the macrocosm) while the latter relates to the ‘modalities’ (i.e. essential characteristics) of these entities.

Where applied in the context of the built environment, cosmonomic theory is not intended to supplant existing sustainability rating systems, which are but one element of a development process which considers sustainability. Rather, it seeks to “bring together the diversity of interests necessary to assess the impact of the built environment and urban design on urban sustainable development” (Brandon and Lombardi 2011: 124). Nijkamp (2007) concurs, and highlights its explicit transdisciplinary and integrationist nature together with its suitability for comprehending the complexity of the city archetype (Lombardi and Basden 1997). The cosmonomic framework has been successfully used for the prospective and retrospective evaluation of built environment sustainability in a number of case studies (Lombardi 2009, Brandon and Lombardi 2011: 151-167).

### **Modalities**

A modality is “an irreducible area of the functioning of the system [or entity]” characterised by its own internal order and unique laws (Brandon and Lombardi 2011: 219). These laws guide and enable the operation of the entity. For example, the laws of biology, associated with the ‘biological’ modality, govern the patent functioning of all living creatures. Laws which relate to lower-order modalities, and therefore the modalities themselves, tend to be determinative (‘hard’) whereas higher-order modality laws are more likely to be normative (‘soft’). The framework upon which the theory of Dooyeweerd is based consists of fifteen ordered and interrelated modalities,

“derived by taking every large-scale kind of property that has been distinguished in the history of philosophy and science” (Brandon and Lombardi 2011: 221). Brandon and Lombardi (2011: 127) list these modalities, their general meanings and their proposed meanings within the context of sustainable development (Table 1). The modalities appeal to the identified dimensions of sustainability. The economic, social and spatial dimensions are (eponymously) accounted for, as is environment via the ‘biological’ through to the ‘numerical’ modalities. The dimensions of time and participation are implicit considerations of each modality (Brandon and Lombardi 2011: 139-145). Participation is an explicit feature of the ‘juridical’ modality (Brandon and Lombardi 2011: 130).

*Table 9: The cosmomic modalities, their meanings and sustainable development definitions (Brandon and Lombardi, 2011: 127)*

Modality	Meaning	Sustainable Development definition
Numerical	Quantity	Numerical accounting
Spatial	Continuous extension	Spaces, shape and extension
Kinematics	Movement	Transport and mobility
Physical	Energy, mass	Physical environment, mass and energy
Biological	Life function	Health, biodiversity and eco-protection
Sensitive	Senses, feelings	People’s perception towards the environment
Analytical	Discernment of entities	Analysis and formal knowledge
Historical	Formative power	Creativity and cultural development
Communicative	Information	Communications and the media
Social	Social intercourse	Social climate and social cohesion
Economic	Frugality	Efficiency and economic appraisal
Aesthetic	Harmony, beauty	Visual appeal and architectural style
Juridical	Retribution, fairness	Rights and responsibilities
Ethical	Love, morality	Ethical issues
Credal	Faith, trustworthiness	Commitment, interest and vision

### **Inter-modality relationships**

Three types of relationships exist between the modalities (Brandon and Lombardi 2011: 220-221), of which two are directly relevant to this study. The first relationship is that laws associated with higher-order modalities are dependent on and require those of lower-order modalities. This is the dependency relation. It means that each modality (with the obvious exception of the lowest order ‘numerical’ modality) is founded on each of the lower-order modalities relative to it. Alternatively, each modality (with the obvious exception of the highest order ‘credal’ modality) anticipates in some respects those modalities above it. Thus, the modalities are arranged in a non-arbitrary nested progression, the so-called ‘cosmomic order of time’ (Kalsbeek 1975). This relation serves to reinforce the applicability of all the modalities to the identified dimensions of sustainability.

The second relationship is that, as a subject, an entity can be simultaneously characterised by multiple modalities, depending on its operation. In other modalities it functions passively as an object. For example, animals have populations (‘numerical’), occupy space (‘spatial’), can move (‘kinematics’), have form (‘physical’), etc. and in many cases exhibit quite complex inter-species bonds and relationships (‘social’). Across this range of modalities they are active as subjects. However, animals cannot perform financial transactions (‘economic’), have no formal discernment of visual merit (‘aesthetical’) nor conception of fairness (‘juridical’), etc. and are not influenced by aspirations or beliefs (‘credal’). In this range they are the object of the modalities.

Therefore, for such entities the qualifying modality, or the highest subject (active) modality that endows the entity with its ultimate character and uniqueness (Nijkamp 2007), is the ‘social’ modality. Humans and the extended configurations in which they occur (e.g. communities), as more complex entities, are able to function as subjects in all fifteen modalities of the cosmonomic framework. They are distinguished by the ‘credal’ modality. The built environment is qualified by the ‘physical’ modality (Brandon & Lombardi 2011: 128-129).

## **MAPPING BREEAM TO THE COSMONOMIC FRAMEWORK**

BREEAM New Construction 2011 (Non-Domestic Buildings) consists of nine essential categories and a further innovation category, each of which is comprised of a number of assessment areas, or ‘issues’. These issues were mapped to the modalities in order to appreciate the scheme relative to the cosmonomic framework.

### **Qualifying and dependency modalities**

The principle of the qualifying modality presents a legitimate means of mapping each issue to a modality of the cosmonomic framework. The qualifying modality for an issue can be readily determined from an examination of that issue’s general aim and specific evaluation features. These latter attributes are assessment criteria, evidence requirements, and supplementary information (e.g. compliance notes, relevant definitions and calculation procedures). Where the qualifying modality has been established for an issue so, by virtue of the ‘cosmonomic order of time’, its lower-order dependency modalities are revealed. These modalities similarly apply to the issue. For the purposes of mapping, whether they are referenced explicitly or implicitly (if at all) by the issue is immaterial. The structure and logic of the cosmonomic framework dictates that these founding modalities are inherent in any entity distinguished by a qualifying modality (i.e. all entities). Thus, the dependency modalities can also be mapped to the issue, by default and without exception.

### **Higher-order modalities**

Modalities of an order higher than that of the qualifying modality manifest invariably in all issues. However, in contrast to the intrinsic dependency modalities, the explicit or implicit nature of these higher-order modalities is more critical from a mapping perspective. This is because certain modalities that do not qualify any of the issues are sufficiently referenced, expressly or otherwise, across a significant number of issues to merit consideration when evaluating the modality coverage of the BREEAM scheme. These higher-order modalities, regardless of their disposition, are problematic. Enabled by the nested structure of the cosmonomic framework, they imply additional underlying modalities relative to them. These implied founding modalities in turn further infer comparatively lower-order modalities, and so on. This situation hinders the isolation of the higher-order modalities that are pertinent to an issue and imperils the relevance and manageability of the mapping process. Explicit associations between issues and modalities are unequivocally mapped. However, for the purposes of this mapping exercise there is a need to limit the obfuscating inference of additional higher-order modalities associated with an issue.

Therefore, implicitly referenced higher-order modalities relative to the qualifying modality are only mapped to an issue where they pertain to so-called ‘directly implied’ modalities (i.e. modalities whose inference is obvious). Modalities that can be successively inferred from these directly implied modalities are disregarded in the mapping protocol. In effect, only the ‘qualifying modality of the implied entity’ is

considered. As the process of implication can be subjective it is possible that implied higher-order modalities that defy this axiom are presented in the issue mind-maps. The innate integrating character of the cosmonomic framework makes such admittances almost unavoidable. However, if kept to a minimum they should not tangibly affect the mapping intent. Thus, a mind-map fragment for an issue identifies and presents that issue's qualifying modality, dependency modalities (either explicitly stated within the issue or inferred from the qualifying modality), and higher-order (relative to the qualifying modality) explicit and 'directly implied' modalities.

### **Mapping method**

The BREEAM issues were mapped to the modalities of the cosmonomic framework using the software FreeMind (v0.0.9). Initially, the complete BREEAM scheme was transposed as a mind-map, organised in terms of the categories and their associated issues, with each identifiable assessment feature occupying a separate branch of the mind-map. Thereafter, associations between these features and the modalities of the cosmonomic framework were denoted by the application of an identifying label to each feature. A list of example built environment characteristics associated with the modalities (Brandon and Lombardi 2011: 130) was used as the basis for deciding whether or not an assessment feature could be mapped to a particular modality. This list was supplemented by further attributes identified from a review of pertinent literature. The mapping exercise was conducted from the perspective of an office building evaluation and therefore certain issues (specifically, 'Ene 07 – Energy efficient laboratory systems' and 'Ene 09 – Drying space') were out of scope. A summary of the detailed mapping of the BREEAM issues to the modalities of the cosmonomic framework is presented in Tables 2 and 3. In these digests 'D' denotes an association between an issue and a dependency modality, 'H' links an issue and a higher-order modality and Q' indicates an issue's qualifying modality.

### **ANALYSIS**

The BREEAM scheme was analysed relative to the cosmonomic framework. It was found that the scheme appealed to each modality of the Dooyeweerd's cosmology, with some modalities having greater prominence than others. Every feature of each issue was found to map to modality of the cosmonomic framework. However, crucially, relationships between the issues and all modalities, most notably the social, economic and aesthetic modalities, were found to be incomplete. (A consummate association between each issue and each modality would have resulted in a value in each of the cells in Tables 1 and 2). Full consideration of temporal and participatory concerns was also found to be lacking in the scheme.

### **Qualifying modalities**

Qualifying modality coverage for the issues tended towards the harder end of the modality range, with a concentration on the 'physical' and the 'biological' modalities. This would seem to support previous conclusions that contemporary sustainability assessment is rooted in environmental considerations and performs weakly with respect to the social and economic aspects (Todd *et al.* 2001). Issues within each category were (perhaps unsurprisingly) found to have the same qualifying modality, although limited exceptions to this maxim were evident. For example, 'Hea 04 – Water quality' differs from the other issues within its associated category by being distinguished by the 'biological' modality rather than the 'sensitive' modality.

### **Credal, ethical and juridical modalities**

The ‘credal’ modality is evident only in the issue ‘Man 01 – Sustainable procurement’, where assessment criteria seek to engender accord among key stakeholders through contractual agreements and the transparency of information.

Table 2: Summary of mapping of assessment issues (Management to Transport) to cosmomic modalities

BREEAM		Cosmomic Modalities														
Categories	Issues	Numerical	Spatial	Kinematics	Physical	Biological	Sensitive	Analytical	Historical	Comm.	Social	Economic	Aesthetic	Juridical	Ethical	Credal
Management	Ma	D	D	D	D	D	D	D	D	Q	H	H		H	H	
	Ma	D	D	D	D	D	D	D	D	Q	H	H	H	H	H	H
	Ma	D	D	D	D	D	D	D	D	Q		H		H		
	Ma	D	D	D	D	D	D	D	D	D	Q	H	H	H	H	
	Ma	D	D	D	D	D	D	D	D	D	D	Q		H		
Health and Wellbeing	He	D	D	D	D	D	Q	H	H	H				H		
	He	D	D	D	D	D	Q	H	H	H				H		
	He	D	D	D	D	D	Q	H	H	H				H		
	He	D	D	D	D	Q	H							H		
	He	D	D	D	D	D	Q	H		H				H	H	
	He	D	D	D	D	D	Q			H				H		
Energy	En	D	D	D	Q	H		H	H	H		H		H		
	En	D	D	D	Q	H		H	H	H		H		H		
	En	D	D	D	Q	H	H			H	H			H		
	En	D	D	D	Q	H	H	H	H	H		H		H		
	En	D	D	D	Q	H		H	H			H		H		
	En	D	D	D	Q	H	H	H				H		H		
	En	D	D	D	Q	H	H	H				H		H		
Transport	Tra	D	D	Q	H	H						H		H		
	Tra	D	D	Q	H	H						H		H		
	Tra	D	D	Q	H	H	H					H		H		
	Tra	D	D	Q	H	H						H		H		
	Tra	D	D	Q	H	H	H	H		H	H	H	H	H		

*D* = dependency modality, *Q* = qualifying modality, *H* = higher-order modality

Although it could be argued that commitment, interest and vision are reflected in the choice of issues to be assessed, gaming and strategies that seek to attain the most credits for the lowest possible cost may act to subvert this. Ethical deliberations within the scheme are largely anthropocentric. They are primarily expressed through issues relating to the appropriate sourcing of building components and aggregates within the Materials category and implied by the issues of the Waste category. The application of impartiality also extends to non-human species and non-living entities (e.g. landscapes) via the issues of the Land Use and Ecology category. However, these latter considerations are not overtly grounded in any manner of cogent egalitarian moral philosophy, such as Deep Ecology (Naess 1973), nor significantly extend beyond mere legislative duty. The juridical modality features strongly in the scheme. Indeed every issue has at least one feature that can be associated with this modality. This reflects the extent of technical and planning legislation applicable to contemporary construction practice within the built environment.

**Aesthetic modality**

Although much of building design is concerned with the appearance of constructed assets, the aesthetic modality does not feature strongly in the scheme. Where beauty and visual amenity have been considered by the scheme this is restricted to: a demand

Table 3: Summary of mapping of assessment issues (Water to Pollution) to cosmomic modalities

BREEAM		Cosmomic Modalities														
Categories	Issues	Numerical	Spatial	Kinematics	Physical	Biological	Sensitive	Analytical	Historical	Comm.	Social	Economic	Aesthetic	Juridical	Ethical	Credal
Water	Wa	D	D	D	D	Q						H		H		
	Wa	D	D	D	D	Q			H	H		H		H		
	Wa	D	D	D	D	Q			H	H		H		H		
	Wa	D	D	D	D	Q			H	H		H		H		
Materials	Ma	D	D	D	Q	H			H	H		H		H	H	
	Ma	D	D	D	Q	H			H	H				H	H	
	Ma	D	D	D	Q			H	H	H				H	H	
	Ma	D	D	D	Q	H				H				H	H	
	Ma	D	D	D	Q	H						H		H		
Waste	Ws	D	D	D	Q	H		H	H	H		H		H	H	
	Ws	D	D	D	Q							H		H	H	
	Ws	D	D	D	Q	H						H		H	H	
	Ws	D	D	D	Q							H		H	H	
Land Use and Ecoc	LE	D	D	D	D	Q			H	H		H		H		
	LE	D	D	D	D	Q				H		H	H	H	H	
	LE	D	D	D	D	Q	H	H	H	H		H	H	H	H	
	LE	D	D	D	D	Q	H		H	H		H	H	H	H	
	LE	D	D	D	D	Q	H			H	H	H	H	H	H	
Pollution	Pol	D	D	D	D	Q			H	H				H		
	Pol	D	D	D	D	Q								H		
	Pol	D	D	D	D	Q		H	H	H				H		
	Pol	D	D	D	D	Q	H			H				H		
	Pol	D	D	D	D	Q	H		H					H		

*D* = dependency modality, *Q* = qualifying modality, *H* = higher-order modality

within the Considerate Contractor scheme relating to the appearance of the construction site ('Man 02 – Responsible construction practices'); non-specific direction that the consultation process associated with the development must consider aesthetic impacts ('Man 04 – Stakeholder participation'); the provision of pleasant external waiting areas for transport users ('Tra 05 – Travel plan'); and the notion of ecological harmony and balance implied by the issues of the Land Use and Ecology category. These somewhat insubstantial requirements are polarised, existing as either defined but relatively trivial or important but abstract imperatives, with the latter mode being particularly subjective and difficult to meaningfully encourage and assess. However, visual considerations are an important facet of sustainability. The ephemerality of high fashion can lead to the perceived obsolescence of buildings prior to the end of their technical, functional, economic and/or physical life. This is at odds with need for an enduring built environment. More optimistically, high quality design has the potential to instil wellbeing among building users and may facilitate social integration. This in turn can attract people and investment to an area and yield economic benefits (Brandon and Lombardi 2011: 136).

It has been suggested that innovative design, a perceived requirement of a sustainable built environment, flounders where excessively regulated. Thus de facto sustainability standards in the form of assessment schemes have been resisted by some sections of the building design community. While such an apprehension may be true, at the very least this mapping exercise draws attention to that fact that dialogue concerning aesthetics and their relation to sustainability needs to take place as part of the building design process, if not necessarily within the confines of a specific assessment scheme.

### **Economic and social modalities**

The 'economic' modality implicitly maps to issues across a number of categories. These issues relate to rather oblique budgetary exigencies and attitudes towards finance (Management); the consumption of non-renewable resources, principally fossil-based fuels (Energy and Transport); indirect financial benefits realised through efficiencies and recycling schemes (Water, Waste and to a lesser extent Materials); and the use of land for non-development purposes (Land Use and Ecology). The 'social' modality is directly evident through specific requirements that encourage plurality, social relationships and interaction through consultation ('Man 04') and the Considerate Contractor scheme ('Man 02'). Moreover, this modality is implied through cohesion, competitiveness and collaboration that shape building development processes ('Man 01'). However, only issues 'Man 04' and 'Man 05' are characterised by the social and economic modalities respectively, thus reinforcing previous declarations regarding the need to improve how BREEAM assesses these aspects.

### **Communicative, historical, analytical and sensitive modalities**

All of the scheme categories contain issues that relate to the 'communicative' modality. This is to be expected as the effective delivery of high quality information is a hallmark of successful construction practice, something that BREEAM seeks to encourage and augment. The 'historical' modality is principally evident where technology, an application of cognition that builds on previous discoveries and learning, is harnessed. The substance of the 'analytical' modality is logic and distinction, which is practically applied as analysis and formal knowledge (Brandon and Lombardi 2011: 133). Associations with this modality can be found throughout the scheme, conspicuously in issues of the Management category. This modality is also represented by issues dealing with, for example, modelling software and the data associated with designing for visual and thermal comfort ('Hea 01 – Visual comfort' and 'Hea 02 – Indoor air quality' respectively). These issues and others, including those relating to the provision of peaceful surroundings (e.g. 'Man 03 – Construction site impacts'), security and noise (Health and Wellbeing), also appeal to the 'sensitive' modality.

### **Biological, physical and other lower-order modalities**

The 'biological', 'physical' and other lower-order modalities are well-represented throughout the BREEAM scheme. The 'biological' modality characterises each issue in the Water, Land Use and Ecology, and Pollution categories. The 'physical' modality qualifies the Energy, Materials and Waste category issues. All issues of the Transport category are distinguished by the 'kinematics' modality. The 'kinematics', 'spatial' and 'numerical' modalities are evident, both explicitly and through the modality dependency relation, in all issues in all categories of the scheme.

### **Time**

Considerations within the scheme relating to time appear primarily within the Management category. For instance, 'Man 01' specifies that seasonal commissioning activities are to be completed over a minimum 12-month period following occupation of the building. Similarly, 'Man 04' directs the client to commit to a post occupancy evaluation one year after the building commences its intended function. Although time is explicitly acknowledged in the issues of other categories (e.g. 'LE 05 – Long term impact of biodiversity') the temporal impacts of each and every modality are not addressed by the scheme. Even in the issue 'Man 05 – Life cycle cost and service life planning', where a clear attempt is made to consider financial requirements over time, this effort is limited to the option comparison of only two from four specific building elements (i.e. envelope, services, finishes and external spaces) rather than a comprehensive analysis of each and every building element and significant component, and indeed the building as a whole, over a range of envisaged life-spans. Importantly, the scheme does not require the prospective re-assessment of a building to determine if it is still functioning per its immediate post-construction assessment status. This deficiency represents a lost 'analytical' opportunity to work towards closing the gap between design intent and the realised artefact.

### **Participation**

Allowing impacted parties to bring their faculties to bear on just what makes a development sustainable is another key attribute of sustainability. However, stakeholder participation is constrained within BREEAM to only a single issue ('Man 04'). Here, consultation is specified with a range of stakeholders, including actual and potential building users, community representatives and other relevant bodies depending on the function of the development. There is a requirement to demonstrate that feedback from these parties has influenced the design. Ostensibly, this affords bodies that are peripheral to the development process but still impacted by it with a say in the achievement of the associated building. However, the intended extent of this influence is not defined and thus may be marginalised. Where projects are driven by high costs and/or are technologically complex the tangible inclusion of feedback in the final design from this latter type of stakeholder is likely to be limited.

### **CONCLUSIONS**

Sustainability, as interpreted by Moir and Carter (2012), consists of the aspects of environment, society, and economy, which interact over space and time and require participation in their context-specific definition. The 'Cosmomic Idea of Reality' offers a suitable lens through which to perceive this conception of sustainability in a built environment context. It provides a framework to further expose the deficiencies of building sustainability assessment, specifically those of a BREEAM scheme. A de novo set of mapping rules were formulated to allow the framework and the scheme to be compared. An analysis of the resultant mind-map revealed that although each and every issue feature of the scheme could be associated with a modality of framework considerable gaps in the BREEAM scheme were apparent when scrutinised relative to the cosmomic structure.

Despite its aspiration as a means to assess sustainability and notwithstanding the intrinsic interrelatedness of the conventional sustainability dimensions, the environmental aspect dominates within the scheme. The qualitative and diffuse nature of social benefits is an extant problem of sustainability assessment that remains to be resolved. In particular, aesthetics are underrepresented. Furthermore, the lack of attention given to the quantitative economic dimension, particularly the rather trite

approach taken to life-cycle costing, is disappointing, especially when considering the emphatically econocentric views on sustainable development of Pearce (2005). The notion of space is partially addressed by the scheme, as evidenced by assessment issues which deal with impacts occurring within the development site boundary and beyond. However, the full extent of spatial coverage (from local to global) is limited to the environmental dimension. Temporal considerations fare little better. Although the future is inherently uncertain impacts over time are insufficiently considered by all issues. Moreover, participatory deliberations are poorly conceived and unenforceable. It is this last dimension of sustainability that the BREEAM scheme critically fails to address. Perhaps, analogous to the approach taken by Ding (2008), the weighting of BREEAM assessment categories and issues by stakeholders and other interested parties presents a possible solution to this problem. This activity could be facilitated by the mapping of the scheme to the cosmonomic framework, as applying weights to fifteen mapped modalities would be an ostensibly more manageable activity. However, as demonstrated through comparison with the cosmonomic framework, BREEAM New Construction 2011 (Non-Domestic Buildings), and by sensible extrapolation other related BREEAM schemes and similar rating systems, still has some way to go to fully address the complexities of the sustainability challenge.

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# DEVELOPMENT OF A MEASURE TO ASSESS ATTITUDES TOWARDS SUSTAINABLE DEVELOPMENT IN THE BUILT ENVIRONMENT: A PILOT STUDY

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The recognition of the importance of the construction industry for the three dimensions of sustainable development, the environmental, economic and social has gained widespread momentum in recent years. Yet despite policy drives and regulations from government as well as efforts from higher education institutions, progress towards implementation of sustainable practices within industry remains slow. The literature evidences that attitudes towards sustainable development are a major barrier to implementation of such practices. At present no measure exists to quantify attitudes towards all three dimensions of sustainability within a construction context. This paper describes the steps taken to develop such a measure, the Sustainable Development Attitudes Measure (SDAM). Once developed, in order to test the questionnaire and validate for dissemination in industry the SDAM was piloted amongst built environment students (n=230). Results indicated that the measure was both valid and reliable ( $\alpha=.87$ ). The resulting measurement tool will allow a broad range of practitioners working across the construction industry and higher education to assess which aspects of sustainable development are favoured over others and target less favourable aspects through increasing awareness, training and curriculum design. Validation processes are described along with directions for future work in relation to further validation of the measure and its usage.

Keywords: attitude, psychology, psychometrics, scale development, sustainable development.

## INTRODUCTION

Since the publication of the Brundtland report (WCED 1987), sustainability has become an important topic on many agendas locally, nationally and globally. In more recent years, the recognition of the importance of the construction industry for sustainability through sustainable development has gained widespread momentum as whilst a built environment is necessary for us to live work and socialise, the construction of the facilities that allow us to do so have detrimental impacts on the environment.

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The construction industry is one of the largest employers in the world. It is Europe's largest industrial employer, accounting for 7% of total employment and 28% of industrial employment in the EU and employs over 2 million people in the UK alone (BERR 2006).

Socially and economically, the industry is a major source of employment and an area of significant financial investment with around £910 billion euros invested in construction in 2003, representing 10% of the gross domestic product (GDP) (European Commission 2006 cited in Ortiz et al. 2009) and the UK turning over in excess of £100 billion annually (Tsai & Chang 2012). However by contrast, environmentally the sector is responsible for high-energy consumption (50% of worldwide energy usage), solid waste generation, global greenhouse gas emissions, external/internal pollution and resource depletion (Ortiz et al. 2009) with construction consuming 40% of raw materials extracted (Bribian et al. 2011).

Organisations such as the UK's Building Research Establishment (BRE) and the Construction Industry Research and Information Association (CIRIA) have spent decades researching and documenting such impacts of the building industry (Murray & Cotgrave 2007) yet despite growing awareness of these issues, progress towards sustainable practice in the construction industry continues to be slow compared to other sectors. The construction industry is renowned for being resistant to change which has been attributed as one of the main reasons for not implementing sustainable strategies (Yang et al. 2005). A growing body of literature however evidences that certain barriers preclude the implementation of sustainable practices. The literature indicates that the main barriers are cost, responsibility, understanding and issues regarding policy and legislation. These are discussed in the following headings.

#### *Cost*

Cost is a major barrier to adopting sustainable approaches. In studies carried out by Cotgrave (2008) and Pitt et al. (2009), when asked what the key barriers to the industry for sustainable construction are, respondents indicated that cost/affordability was the main barrier. Such perceptions are however unfounded based on the pure assumption that, if the building is green, it must cost more (Hoffman & Hen 2008). A survey by the World Business Council on Sustainable Development (WBCSD) found that people tend to overestimate the cost premium of green building to be between 11% and 28% more than a normal building, with an average overestimation of 17% (WBCSD 2008). This is worrying given there appears to be a common consensus that unless adopting sustainable practices and use of sustainable materials achieves costs savings, the same will not be widely implemented (Constructing Excellence 2008; Baker Associates 2006). Professional bodies such as the Chartered Institute of Building (CIOB 2001) however report how industry can move sustainable development forward while still making a profit. Such claims are evidenced by reports from companies such as McGraw Hill Construction (2006) who found that clients opting for sustainable buildings expect greener buildings to achieve an average increase in value of 7.5% over comparable standard buildings, together with a 6.6% improved return on investment.

#### *Policy and Legislation*

In the UK, sustainable construction is still primarily a policy imperative driven by the public sector (central and local government) rather than by private sector market and client demand (Cooper et al. 2005). More government legislation, regulations and 'positive' incentives are seen by some as one of the main drivers for promoting

sustainability (Cooper et al. 2005). However as Cotgrave (2008) points out, it is unlikely that government will introduce such legislation as to do so would risk alienating industry by impeding their ability to make profits, a move likely to be hugely unpopular and ultimately a vote loser. Government ultimately rely on co-operation so even if they do impose more policies and regulations, their effectiveness relies on the response of industry (Murray 2011). In addition, whilst sustainability legislation has been shown to be a corporate driver for change the extent to which legislation changes attitudes is debatable (Meehan & Bryde 2013). This is illustrated by the fact that despite strong policy drives by UK government in recent years, many new developments in the UK still incorporate few sustainability features (Williams & Dair 2006) with much of industry unwilling to go above and beyond ‘minimum requirements’. Industry needs to adopt sustainability of its own accord and thus there is an imperative need to change attitudes and perceptions so that they are able to ‘create’ a market demand for sustainability. Firms within industry that do so, will not only help to protect the environment but give themselves a competitive edge in an ever growing sustainability focused market but will also.

#### *Understanding*

Leal Filho (2000) states there are various reasons why the concept of sustainability may be hard to understand namely that sustainability: -

is not a subject per se since it is not classified as being of the domain of any given science but rather a component which may be incorporated into all disciplines and thus there tends to be a trend towards perceiving it as an abstract concept

- is too recent a field for its urgency to be seen as important
- is a fashion and will eventually go out of date
- is too theoretical
- is too broad a concept and therefore impossible too handle and thus achieve

The fact that nearly over 60 definitions of sustainability now exist (Hartshorn et al. 2005) adds to the confusion with many claiming that some definitions of sustainable development are too broad giving a wide ranging set of guiding making it very difficult to draw conclusions on how successful current practice is in achieving such wide remit of aims (Baker and Associates 2006).

#### *Responsibility*

There are mixed views as to where responsibility for sustainable practices lie particularly in relation to waste minimisation. Saunders and Wynn (2004) assessed subcontractors’ attitudes towards waste minimisation, and found that eighty-five per cent of all respondents felt that the main contractor should bear the full responsibility of waste minimisation. Osmani et al. (2006) report that poorly defined responsibilities are leading to confusion as to who should control and monitor waste management finding that architects argued that waste was an issue for contractors, while contractors countered that a failure to address waste generation in design and poor waste management by subcontractors were the consequences of a lack of definition regarding roles and responsibilities in a contract. Construction professionals are not aware of the environmental damage they are causing and due to deferred responsibility no responsibility can be assumed (Lo et al. 2006). This uncertainty of and shifting of responsibility is clearly a barrier towards the adoption of sustainable practice.

Many professionals are aware of and are willing to undertake green building but due to the above barriers, a level of consternation permeates the industry with many

remaining sceptical and unenthusiastic as a result. This coupled with fear of the unknown and fear of risk pertaining to costs all have an adverse effect against progress towards sustainable practices in the industry. We now need to move from the rhetoric that permeates industry to action. At present no standardised measure exists to capture and quantify the above attitudes identified in the literature. It is important that such a tool be created if we are to find and develop ways of changing these attitudes. The rest of this paper describes the validation processes undertaken to develop such a measure, the Sustainable Development Attitudes Measure (SDAM). Initial validation results are presented along with future validation objectives and the practical considerations for use of the measure.

## **DEVELOPMENT OF THE SUSTAINABLE DEVELOPMENT ATTITUDE MEASURE (SDAM)**

Attitudes are a latent construct and cannot be observed directly (Milfont & Duckitt 2010). Thus, rather than being measured directly, attitudes have to be inferred from overt responses (Himmelfarb 1993). Methods of attitude measurement can be broadly organized into direct self-report methods (such as questionnaires/interviews) and implicit measurement techniques (Krosnick, et al. 2005). For the purposes of the current research a questionnaire approach was deemed the best method to capture the data required.

In order to ensure a strong theoretical grounding, items were developed from the literature and existing measures. Existing measures tend to cover the environmental aspect only and items for the social and economic subscales were developed from the literature. A total of 70 items were pooled from the literature and placed into subscales representing the three dimensions of sustainability i.e. environmental, social and economic. A fourth scale 'other' was created to encompass important political issues pertaining to sustainable development.

### *Scale Response*

When measuring attitudes, Likert-type scales are most commonly used which measure levels of agreement/disagreement. Such scales assume that the strength/intensity of experience is linear, i.e. on a continuum from strongly agree to strongly disagree, and makes the assumption that attitudes can be measured. Respondents may be offered a choice of five to seven or even nine pre-coded responses with the neutral point being neither agree nor disagree (Ratray & Jones 2007). A 5 point Likert scale was chosen for the current scale.

### *Content validity*

Content validity is a non-statistical type of validity that involves "the systematic examination of the test content to determine whether it covers a representative sample of the domain to be measured" (Anastasi & Urbina 1997: 114). In order to ensure content validity, only items that were deemed to be relevant to sustainable development were considered. Content validity is usually conducted via a panel of experts in the domain being investigated (Ratray & Jones 2007). As such, the list was emailed to 10 experts, 5 from LJMU and 5 professionals in industry currently undertaking the MA in Sustainability at LJMU. Experts were asked to assess the content, relevance and clarity of the statements and provide their comments on the same. They were advised that the aim of the validation was to choose items they thought were worded in a way that would elicit strong attitudinal responses and if a question was too arbitrary, abstract, too obvious or too ambiguous to provide their

comments on the same. In addition they were asked to rate the item on a scale of 1-5 with 1 being weak and 5 being strong. After initial consideration of items, a number of meetings took place online via WIMBA classroom and face to face for further discussion and clarification of the validation process.

All ten experts provided verbal feedback with seven out of the ten experts providing ratings for the items. The 70 questions were then whittled down to 28 based on the ratings, feedback and comments for each item. To ensure students were engaging with the questionnaire and not just ‘ticking boxes’, three of the statements were given an opposing statement. These were statement numbers 3/15, 6/21 and 12/23. Items 18, 24, and 28 were negatively phrased and reverse scored in an effort to reduce response bias. A sample of questions is provided in Table 1 below.

*Table 1: Example Questionnaire Statements Classified by Sub-scale*

<i>Environment</i>
Global climate change will be a major problem for future generations unless the construction industry adopts sustainable practices.
Modern science and technological advancements will solve our environmental problems
Refurbishment of existing buildings should always be considered before new build is undertaken
<i>Social</i>
Using more resources than we need for the built environment is a serious threat to the health and welfare of future generations
Communities can significantly benefit from sustainable development
Sustainable development should create and provide jobs at a local level
<i>Economic</i>
Companies that are environmentally sustainable are more likely to be profitable over the long run
Acting sustainably is only worthwhile if it reduces costs.
It is all right for humans to use nature as a resource for economic purposes
<i>Other</i>
The Government should be leaders in sustainability and the environment
Corporate social responsibility is irrelevant to sustainable development
The construction industry is of vital important to sustainable development

### *Sampling*

When piloting a questionnaire, a sample size of 300 is generally deemed best however sample sizes of 200 plus are acceptable (Rattray & Jones 2007). The SDAM was piloted to 230 built environment students across the UK through opportunity sampling. After removing questionnaires with uncompleted questions, there were a total of 226 useable questionnaires giving a response rate of 98.5%. Unfortunately the demographic section was only partially or not completed at all in some cases and so figures for age and gender are not accurate. Descriptive statistics indicate that of those who did complete demographics, 178 were male and 29 female (n = 207) with ages ranging from 18 to 48 and a mean age of 23 years (sd = 5.7, n = 170). Participants were instructed prior to completing the measures that it was important if possible to avoid ticking middle boxes and that if they were veering towards a more negative or positive response to tick boxes demonstrating this.

*Inter-item Correlations*

Items should inter-correlate at a significant level if they are measuring aspects of the same thing, in this case sustainable development. Any items that do not correlate at a 5% or 1% significance level should be excluded. Correlations for the SDAM revealed that all individual items correlate significantly with each other as do the subscales. Correlations for the subscales are reported here only (Table 2).

Table 2. Correlations between subscales of the SDAM

	Environmental Subscale	Social Subscale	Economic Subscale	Other Subscale	SDAM Total
Environmental Subscale	1				.738
Social Subscale	.543	1			.861
Economic Subscale	.372	.516	1		.743
Other Subscale	.454	.675	.530	1	.846

\*Correlation is significant at <0.05 level \*\*correlation is significant at <0.01 level (two-tailed)

*Reliability*

An important aspect of a psychometrically developed measure is the reliability of the scale and its subscales. Chronbach's alpha is used to test for internal consistency of scales. Different authors have differing views on what are acceptable alpha levels for measures. Bryman & Cramer (2001) posit that if items show good internal consistency, Cronbach's alpha should exceed .7 for a developing questionnaire and .8 for a more established questionnaire. Hair and Anderson (2010) however posit that for exploratory research, levels of .6 are acceptable.

Reliability for the SDAM was .87 overall indicating that the scale has excellent reliability. Alpha scores for the subscales were all acceptable except the economic subscale (.529). which was below the acceptable level required (see Table 3). Item total statistics indicated that if item 10 was dropped this would bring the subscale to a reliable level of .605. The mean score for the SDAM total 103.10 was with a standard deviation of 13.47 indicating a good variance across responses.

Table 3. Reliability Coefficients for the SDAM and subscales with Means and Standard Deviations

	Chronbach's Alpha ( $\alpha$ )	Mean	sd
SDAM Total	.87	103.10	13.47
Environmental Subscale	.60	25.00	4.11
Social Subscale	.74	26.61	4.31
Economic Subscale	.60	23.74	3.84
Other Subscale	.78	27.77	4.58

**CONCLUSIONS**

Adverse attitudes preclude implementation of sustainable practices within the construction industry. The construction industry faces many challenges in relation to sustainable development yet many of these challenges are not as problematic as industry perceives them to be. It is imperative that the construction industry change its outlook and attitudes towards sustainable development in order to move the agenda

along. In light of the current economic climate and the diminishing government emphasis on sustainable development and education for sustainable development policy (Martin et al. 2013) this is more important now than ever. The focus on achieving sustainability must not be lost as this will undoubtedly impede progress. The development of a standardised measure to assess attitudes to pinpoint areas for improvement in the context of sustainable development within the construction industry and in higher education is therefore an important step forward to making progress in this field. The findings from the pilot study that the SDAM is a statistically sound measure are very promising. The economic subscale had the lowest reliability and lowest mean indicating that attitudes towards this subscale were less favourable than the others. This finding reflects findings in the literature that attitudes towards costs are the biggest barrier to implementation of sustainable practice and demonstrates how the SDAM can highlight areas for improvement. For example increasing awareness of how industry can still make a profit and more training/education on life cycle costing may help to improve attitudes in this area.

All research is not without its limitations. One limitation of this study was that a lot of participants omitted demographic information which would have allowed for examining differences between age groups and level of study and may have provided some interesting findings. For the purposes of the research however it is not a major drawback as the main aim was to develop a tool to measure attitudes. The main limitation of the study was that data was only conducted at one time point. No test re-test reliability analyses were conducted to assess whether the SDAM holds internal consistency over time. This is not a major issue at this stage in this research however as it is a process which can be addressed later on.

Whilst it could be argued that the sampling population was a limitation, Shepherd et al. (2009) in developing a questionnaire looking at sustainable values noted that using student samples was permissible when looking at psychological phenomena. The results from this exploratory study however provide only a snapshot of built environment students' attitudes towards sustainable development and as with any research, one must take caution when generalising findings to a wider population.

In order to strengthen the rigour of the questionnaire a factor analysis will be undertaken to explore further the theoretical construct of the SDAM and assess the quality of individual items. Once this has been undertaken a further replication study will be undertaken to generalise findings to a wider audience of built environment students from across the UK.

The resulting measurement tool should be of benefit to a broad range of practitioners working across the construction industry and higher education. In using the tool, both will be able to assess which aspects of sustainable development are favoured over others and those less favourable could be targets for increasing awareness, training and curriculum design.

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# REDUCING BUILDING ELECTRICITY USE BY INCREASING OCCUPANT PERCEIVED CONTROL

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This paper demonstrates the impacts of increasing the perceived level of control that building users have over the energy performance of a building. The study was conducted at the Student Services Building at the University of Reading in 2009 – 2011. Building occupant perceived control was influenced by engaging the user with high resolution building energy data. Increasing this perceived level of control contributed to overall savings in the building of 25% in small electrical items and lighting. The majority of a building's carbon emissions are a result of operational activity. Further to this, post occupancy evaluations of new buildings regularly demonstrate that operational energy use and carbon emissions are higher than those quoted during design. A key factor in this design-operation performance gap is the actions of building occupants. Often building occupants are not aware of the level of control they have on the energy performance of the building they occupy. Two behavioural models have been developed that include perceived control as a key factor for enabling and motivating environmental behaviour. Ajzen's 'Theory of Planned Behaviour' and Stern's 'Value-Belief-Norm' model demonstrate increases in the amount of influence an individual believes they have over the outcome of a situation will increase their action to make that change.

Keywords: building users, communication, energy, facilities management, values.

## INTRODUCTION

Buildings are responsible for approximately 40 per cent of the UK's energy use (Perez- Lombard 2008). The majority of a building's carbon emissions are a result of operational activity (Ramesha 2010). Post occupancy evaluations have shown that operational energy use can be up to five times higher than estimates during design. Even in highly automated buildings, occupants can affect their energy use (Menezes 2012). Often building occupants are not aware of the level of control they have on the energy performance of the building they occupy (Clements-Croome 2011).

This new research is designed to explore current advances in construction management research through the quantification of the effects of increasing building occupants' perceived control over electrical energy use in an office environment. It was undertaken in the Student Services Building at the University of Reading: a modern administrative office building. Interventions have been designed within the context of Ajzen's Theory of Planned Behaviour (TPB) (Ajzen 1975). The design of the specific interventions within this theoretical framework is based partially on the literature and adapted according to the practical experience of the authors, as detailed

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in the 'Intervention Design' section below. Results indicate that actions completed as part of the research led to reductions in electricity use of 25% in small electrical items and lighting within the building.

This paper records a pilot study on the use of psychological behavioural change theory to complement traditional construction management techniques. It is the opinion of the authors that much more cross disciplinary research is yet to be completed that will help guide reductions in carbon emissions from our built environment. This paper is part of a Ph.D research program that aims to combine state of the art construction management techniques with psychological theory. As described later in the paper, this is common place in research focussed on energy saving techniques in the domestic context, but much less so in these areas of impact at work (Davis 2009).

## LITERATURE REVIEW

According to the TPB, human behaviour is guided by three kinds of considerations: beliefs about the likely consequences or other attributes of the behaviour (behavioural beliefs), beliefs about the normative expectations of other people (normative beliefs), and beliefs about the presence of factors that may further or hinder performance of the behaviour (control beliefs). It follows that given an actual level of control over their actions, if the criteria above are met, then the individual would change their behaviour (Ajzen 2002). Ajzen designed the TPB by developing his earlier research on the theory of reasoned action (Ajzen and Fishbein 1975, 1980). Bortoleto (2012) summarised the development between the theory of reasoned action and the theory of planned behaviour as the addition of consideration for perceived control. However, it may be that users are in possession of environmental knowledge and environmental awareness, yet do not display pro-environmental behaviour (Kollmuss 2000).

Stern (2000) presents a Coherent Theory of Environmentally Significant Behaviour, suggesting that the gap between environmental attitudes and knowledge, and environmental behaviour is influenced by beliefs that individual actions could alleviate threats to valued persons or things. This may be interpreted as individuals perceiving that their actions, which they have control over, can remove threats, for instance climate change or risks associated with energy security.

This idea, presented by Stern (2000) is part of the wider value-belief-norm theory. The theory links value theory, norm-activation theory, and the New Environmental Paradigm (NEP) (Dunlap 2000) perspective through a causal chain of five variables leading to behaviour: personal values (especially altruistic values), NEP, adverse consequences and ascription of responsibility to self-beliefs about general conditions in the biophysical environment, and personal norms for proenvironmental action (Stern 2000). This theory shares perceived control as a variable with Ajzen's TPB.

The concept of perceived behavioural control can be traced back through research outside of the environmental management and construction management literature. Rosenstock (1966) refers to perceived control ideas as termed barriers, and in the model of interpersonal behaviour (Triandis 1977), it takes the form of facilitating conditions. Rothbaum (1982) goes further and splits perceived control into two perspectives: primary control – the degree to which the subject believes they can control their environment and secondary control – the degree to which they adapt themselves to fall in line with external environmental forces (Rothbaum 1982). However, perceived behavioural control was most fully developed by Bandura in his research on self-efficacy (Bandura, 1977, 1989, 1997). More recently, Bortoleto

(2012) has defined perceived behaviour control as including two factors: (a) the effects of external conditions on the ability of an individual to adopt certain behaviours, and (b) the individual's perceived ability of themselves to adopt a particular behaviour. On this basis, perceived behavioural control predicts specific behaviours directly and indirectly using intentions.

A prevailing theme in the literature is that a level of perceived control must be present in order for people to feel their efforts are worthwhile (Rothbaum 1982, Stern 2000, Ajzen 2002, Poortinga 2012, Bortoleto et al 2012). It follows that this topic presents a valuable opportunity for research, yet relevant literature is limited. The World Business Council for Sustainable Development report (2007) recognised the role of occupant behaviour as having 'as much impact on energy use as the efficiency of equipment', yet little research has been carried out specifically on these behaviours or on potential interventions that address their negative impact on energy conservation (Mindy 2009). Davis (2009) warns of a lack of research undertaken in the areas of environmental impact at work – from a review of 8,595 articles returned from their multiple database search the vast majority looked at green behaviours in the home while the workplace was almost entirely overlooked. Further review of the literature confirms that there is no quantification of cost and carbon savings that could be expected from implementing this theory in administration buildings in the higher education sector. This paper seeks to address that gap.

The review of literature suggests that perceived control is significant in influencing individuals to change their behaviour, yet it has not been applied to energy saving behaviour in an administrative environment.

## **METHODOLOGY**

The Student Services Building at the University of Reading is a three storey office building. The building was finished in 2007. The building is heated by a two ground source heat pumps. It was designed to be environmentally efficient, with additional insulation and efficient lighting beyond the requirements of contemporary legislation. The user population consists of office-based University staff with students coming to the building for various services. The building was specifically chosen following the belief of the Energy Manager that if energy efficiency improvements were possible within this building, they would be easily replicated elsewhere. This is justified as, at the time, the building had the best Display Energy Certificate score on Campus.

### **Monitoring approach and installation**

Monitoring equipment was installed in the Student Services Building during October 2009 to collect high resolution electrical data. Existing sub-meters in the building did not provide sufficient coverage and were supplemented with wireless current transducers.

Metering exclusions include lifts as these were rarely used and the emergency lighting circuit as users did not have control over this. Due to the electrical layout in the building, the monitoring of the main floors combined lighting and small power. The cost of metering these circuits individually was prohibitively costly as a retrofit.

The monitoring equipment is managed by Carnego Systems Limited and was fitted by University of Reading electricians. A team of two completed all works within 2.5 hours. The metering equipment was set up to collect data at 1 or 5 minute intervals and transmitted back to a central database. Data transfer was achieved using a GPRS

connection. All data is stored on a database and accessed by users via a secure online application. Data collection started in October 2009 and is ongoing. Data was separated according to 'occupied' – working days and 'unoccupied' – weekends. A potential improvement to the research could be to include evenings in 'unoccupied' periods.

### **Understanding the building**

Through July 2009 to January 2010, the building was reviewed by the project team. During this period, no interventions other than observational visits were carried out. These visits facilitated a relationship of trust between the project team and building management team (BMT). The building management team consisted of the Building Manager (BM) and Deputy Building Manager (DBM). Additionally, basic information about the structure and operation of the building was gathered. Building user behaviour and 'quick win' observations were also made.

During initial visits to the building, lighting and office equipment (personal computers, photocopiers, etc.) was consistently 'on' in offices and corridors even on bright summer days and out of hours. Conversations with building occupants revealed lighting was switched on when people came into the building and usually turned off when people left in the evening. Little thought was given to energy used by office equipment out of hours.

Some building occupants reported awareness of the 'environmentally friendly' nature of the building. They felt that this removed the need to conserve energy in the building. This was demonstrated when questioned about why lights and other equipment had been left on unnecessarily.

### **Feedback mechanisms**

Full detail of the live high resolution data was available in graphical format to show electricity use. This was primarily used by the building management team. This data was used to communicate data about occupied and unoccupied electrical use.

Live data was more widely presented to building occupants in a star chart format. A star chart was chosen as it provides concrete feedback and reinforcement (PENT n.d.). Each of the six teams had a row on the chart. A daily star was awarded based on how close the unoccupied energy use came to the pre-set electricity use baseline. Unoccupied use within 10% of the baseline was rewarded with a gold star, 10-20% over the baseline received a silver star and more than 20% from the baseload was marked with an exclamation mark. The star chart was communicated via email, and displayed on a live screen in the building foyer.

### **Intervention Design**

For the purposes of this research, interventions were designed and mapped to the three considerations highlighted by Ajzen in his 2002 research. Behavioural beliefs must produce a favourable attitude towards the behaviour. Therefore the individual, their individual beliefs and individual behaviours must be addressed. Normative beliefs are established by demonstrating that behaviour is normal or standard. The research aims to ensure people want to instinctively do things because that's what 'we' do, as a group. Control beliefs are reinforced as the project aims to demonstrate to users that their actions will have an effect in reduced energy use in the building, thus strengthening the belief that they have control over the outcomes. This can be as

simple as a light switch or being able to shut down personal computers or as complex as settings in the building management system.

The project addresses these aims by completing a feedback loop: a/ collect detailed, granular data on energy use; b/ process and analyse this data to produce meaningful information relevant to TPB; c/ present the information to people in ways that promote understanding and prompt action; d/ implement the actions; e/ continue this loop, assessing the impact of the interventions to advance subsequent iterations, improving and reinforcing behaviour change.

Communications were designed to support the TPB by aligning with one or more of these behavioural beliefs. Initiatives focussed on unoccupied behaviour as it was agreed by the project team that this would be less disruptive to the working environment. The following communication principles were adopted:

**Non-directive:** As suggested by Paterson (1985), some clients comply with recommendations more frequently when exposed to nondirective versus directive counselling interventions. Where possible the project team did not provide solutions or interventions but rather facilitated the occupants to self-discover improvements that can be made. Some mediation around technical issues was necessary.

**Outcome based to align priorities:** A principal (project team) can achieve control (i.e., actual impact on agent behaviour) by focusing on its agent's (building user) outcomes so as to co-align their interest (Celly 1996). Based on conversations during the initial building review, the project team recognised that energy use is a low priority for many building users. To align interests of the project team and building users, communications were designed to show whether an outcome had been achieved. This could be meeting a target for 'unoccupied' energy use using a star chart or a very clear change in the energy profile on the online system.

**Information granularity:** Information was provided on a location specific basis to groups of building occupants rather than for the building as a whole. This was designed to highlight small changes, for instance a water heating running for a minute or two, providing feedback specific to individuals and their actions. To facilitate this, information was made as granular as practicable, available at up to one minute intervals.

A selection of interventions is described in Table 1. Each intervention relates to a vertical line in Figure 1. An opportunity to develop the research in the future would be to determine the individual impact and significance of each intervention on overall energy use. However, this is beyond the scope of this project.

*Table 1: Examples of Categorised intervention timeline, interventions are listed by date, with a short description and labelled as one of Ajzen's belief base categories, described above.*

Date	Intervention	Belief Base
24/01/10	Monitor Sunday energy use before any communication	N/A
25/01/10	First detailed discussions with building management team	Belief
27/01/10	First communication with building users by email and 'Sunday switch off'	Control
29/01/10	Email reminder of 'Sunday switch off'	Norm
31/01/10	Monitor Sunday energy use following emails on 27 and 29/01/2010	N/A
01/02/10	Email thank you for participating in 'Sunday switch off'	Control
19/03/10	Email issuing 'Sustainability Matters'	Norm
26/03/10	Email reminder about Earth Day on Saturday 27/03/2010 at 8.30pm.	Norm
30/04/10	Email reminder of the continuation of 'Switch off Sunday'	Norm
07/05/10	Email reminder to switch off as per 'Switch off plan'	Norm
14/05/10	Email reminder to switch off as per 'Switch off plan'	Norm
21/05/10	Email auditors visit and switch off reminder as 'Switch off plan'	Control
11/06/10	Email reminder to switch off as per 'Switch off plan' and close windows	Belief
16/06/10	Information on improvement in People and Planet Green League	Control
24/06/10	Email reminder to switch off as per 'Switch off plan' and close windows	Norm
09/07/10	Email reminder to switch off as per 'Switch off plan' and close windows Completion of new energy efficient lighting installation	Control
20/07/10	Email reminder of 'Big Tidy Up' litter picking 23/07/10	Norm
02/08/10	Email notice of Reading Buses travel ticket offer	Belief
12/08/10	Email: Announcement of Green Impact Award 09/10 – Student Services Building silver award - energy use reduced by 24.8%	Control
20/08/10	Email: Explanation of new energy efficient lighting installation (timed and photocell control to regulate the amount of light) Reminder to switch off as per 'Switch off plan'	Norm Control
01/10/10	Email announcement Green Impact Silver Award	Control
08/11/10	Green Week (generic University wide)	Norm
16/12/10	Email message from the Deputy Vice Chancellor about the University's commitment to reduce carbon emissions targets (generic University wide)	Norm

Interventions were initially focussed on the BMT. The BM was 'on board' from the start; however the DBM was more sceptical. It was understood that this reflected the level of perceived control each member of staff had over operations within the building. Initial interactions focussed on demonstrating how their actions affected energy performance of the building.

The BMT were trained in the use of the energy data. This was achieved by introducing simple concepts, for instance: how to identify a set of water heaters that were on 24 hours per day, 365 days per year; how the unoccupied baseline varied when different equipment was shut down, and; how the operation of vending machines affected electricity use. Presenting the high resolution energy performance data increased support from the BM and DBM.

As building users recognised that their actions affected building energy performance, further suggestions were made. The first addressed suggestion was to remove the vending machines from the building. Building users could see from the data that the vending machines used a disproportionate amount of energy and were outside of their control. Building users decided that they should be removed. Following this, data highlighted a set of water heaters (not for space heating) that were on permanently. These were altered so heat was only provided during the expected hours of building usage. This action was initiated by the BMT, following an increase in their perceived and actual control of the energy use within the building. Finally, the building was visited a number of times during bright days where all lights were found to be on. This behaviour was reported by building users as being consistent throughout the year. Following dissemination of the ‘Switch Off’ emails, lights are used more sparingly and are clearly being turned off at night when the building is not in use.

## RESULTS

Data analysis shows a clear reduction in energy use in the areas targeted (lighting and small power) across the Student Services building. All savings are for lighting and small power only (i.e. the power used across the floors of the building that can be influenced directly by the users). Analysis of the space heating and mechanical load is not within the scope of this research.

To evaluate the savings, daily energy use was calculated between October 2009 and January 2011. The Periods between 14th October and 31st January were compared for the 2009/10 period and 2010/11 period. Savings were then extrapolated for the year. Degree day data was not considered relevant as no heating will have been provided. Seasonal variations, including weather, daylight and occupancy were assumed to be constant across the periods, due to monitoring the same periods each year.

The results outlined in Figure 1 show a consistent pre-intervention baseline with no significant trend, at 5% confidence level, between 14th October 2009 and 31st January 2010. This is followed by a significant downward trend, at a 5% confidence level, during the intervention period between 1st February and 13th October 2010. This, in turn precedes consistent electricity use with no significant trend, at 5% confidence level, between 14th October 2010 and 31st January 2011.

Comparison of the 2010/11 data against the 2009/10 baseline demonstrated an average reduction of 25% in electrical use during unoccupied (weekends and holidays) periods. This is in addition to an average reduction of 20% during occupied periods (working week days). Although outside the scope of this initial research, there is an opportunity for future research to investigate whether interventions aimed at reducing unoccupied electricity use would influence electricity use during occupied periods.

Extrapolation of this saving rate across the year provides calculated savings of £2,570 (based on 2012 prices of £0.11p/kWh) and 14.4 tCO<sub>2</sub>e per annum. The total cost of implementing the works was approximately £7,000. This figure includes capital and revenue costs and is based on consultancy costs, equipment supply and installation plus an estimate for University staff costs. On this basis a simple payback period of 33 months was achieved. This compares favourably with a typical lighting controls upgrade project, implemented at the University of Reading. The lighting controls upgrade project achieved savings of 22 tCO<sub>2</sub>e per annum and £4,295 with a total project cost of £25,374. This lighting upgrade project delivered a simple payback period of 71 months. In order to improve future studies, a more detailed record of

University staff time should be made to provide more accurate data for cost and payback analysis.

Figure 1: Initial energy use results

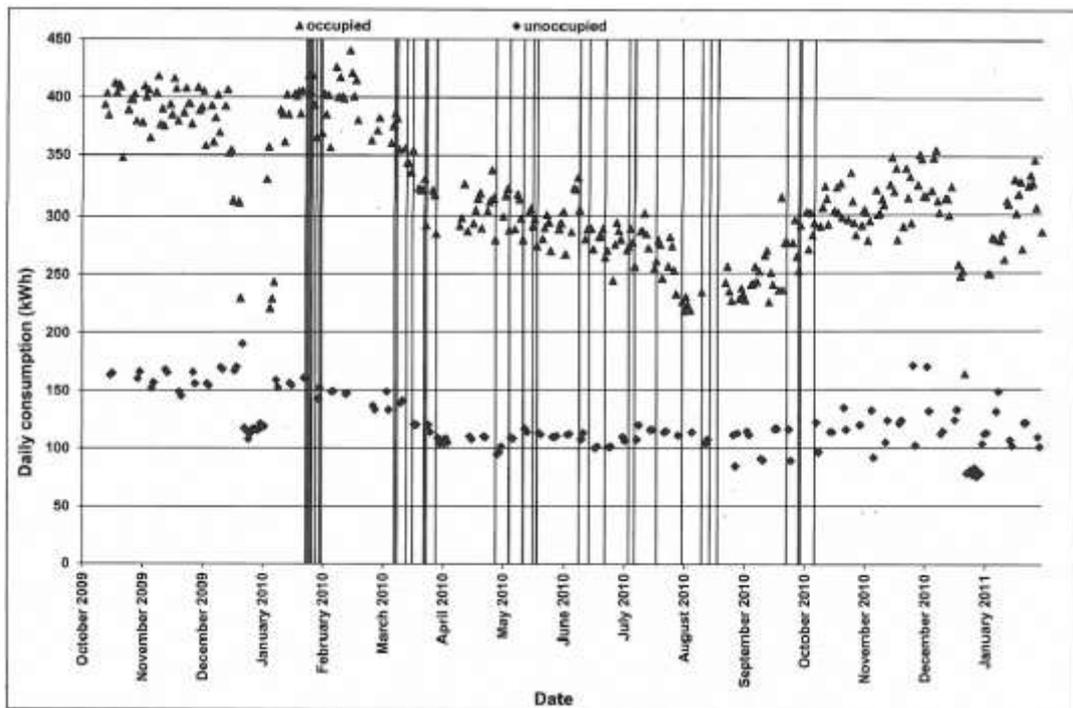


Figure 1 summarises electricity use between October 2009 and January 2011. Triangular marks represent occupied use and diamonds unoccupied use. Vertical lines represent interventions specific to the Student Services Building, with examples listed in Table 1.

An opportunity for future research could include analysis of the implementation costs in future iterations of the project as the team gains experience. Future research may also identify economies of scale that could be recognised should the pilot be extended across the University estate and prove scalable.

The broad specification of the experiment limited the conclusions to general observations. There remains an opportunity for further research into the detail of the degree to which each intervention influenced overall behaviour. There is also further research opportunity to test Stern's Value-Belief-Norm model against the same project. The data could also be refined to separate office hours and out of office hours.

It was not possible to track building user behavioural beliefs at this pre-survey stage. This could be included in future research.

## CONCLUSIONS

In targeted areas, annual savings of £2,570 and 14.4 tCO<sub>2</sub>e per annum have been achieved. Project costs were approximately £7,000 resulting in a simple payback period of 33 months. This human controls project compares favourably to an automated lighting controls project. However, future analysis could be improved by keeping more detailed records of University staff time invested in projects.

Despite the main focus of the project being on unoccupied energy reduction, significant savings were also made during occupied periods. This difference could be investigated further to identify whether the savings made during occupied periods were largely due to evenings as opposed to actual occupied savings.

This paper presents many opportunities to further research in this field, combining construction management and psychology theory. An attitude and behavioural survey could be included in future research to compare energy reductions with reported levels of building user perceived control. Additionally, future research could be conducted to investigate the impact of individual interventions on energy savings. Further research could also be conducted to test the performance of Sterns Value Belief Norm model in comparison to Ajzen's TPB.

It is clear that there is significant potential for research into the use of psychological theory to improve building user perceived control over energy use to contribute to the field of construction management and reduction of atmospheric CO<sub>2</sub> levels.

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# THE INCREASING DEVELOPMENT OF PUBLICATION ON SUSTAINABLE PROCUREMENT AND ISSUES IN PRACTICE

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This paper provides an overview of the developments in relation to sustainable procurement through a review of 63 publications indexed in Scopus and found published between 1996 and 2013. The increasing development of standards, guidance notes and research papers on sustainable procurement offers a means to examine ongoing developments and trends. The research aim was to review studies that contribute to our understanding of sustainable procurement; and critically examine some of the current sustainable procurement trends. The developments since 1996 have culminated in the publication of *Procuring the Future* (2006) which was a UK government Sustainable Procurement National Action Plan; BS8903: 2010 which is a generic standard on sustainable procurement; CIRIA 695: 2011 which is a guide on sustainable procurement in construction; training courses on sustainable procurement offered by the Chartered Institute of Purchasing and Supply (CIPS) for example; and development of policies on sustainable procurement by businesses. ISO 10845: 2010 defines procurement as the process through which contracts are created, managed and fulfilled. However, sustainable procurement requires the use of procurement to achieve wider objectives based on a mix of social, environmental and economic considerations. A content analysis shows the 63 papers from 16 countries are published in 58 different journals which reflect a multidisciplinary subject of growing international interest. More interdisciplinary research is needed to develop a consistent body of knowledge. In practice, the dominance of traditional competitive procurement approaches that focuses heavily on price and lead to wasted resources, exploitation of the “sustainability” label by businesses, and questions relating to the development of a comprehensive method for measuring sustainable procurement reveals significant gaps between theory and practice that should be addressed.

Keywords: literature review, procurement, Scopus, sustainable procurement.

## INTRODUCTION

Procurement has been identified as a primary means through which sustainability and adaptation of the built environment to climate change can be achieved (*Procuring the Future*, 2006). This is because of the stage at which procurement occurs in the construction process including the early occurrence of activities such as specification, contractor selection and award of a contract (EU 2004). For construction procurement

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to be sustainable requires the whole process of how contracts are created, managed and fulfilled need to be fully compliant with considerations of economic, social and environmental factors in a balanced way (CIRIA 695: 2011). The purpose here is to develop a systematic understanding of research papers and standards that have evolved around the subject of sustainable procurement. This was done to identify some of the emergent issues associated with the sustainable procurement concept and trends from the literature particularly in relation to dissemination outlets, countries of origin of the research and issues of investigation by authors. The results flowing from the detailed literature search is summarized in Table 1.

## LITERATURE REVIEW METHOD

A comprehensive method was needed for the literature review aspects of this kind of research. The literature review began with a detailed search for publications on the subject of “sustainable procurement”. In order to be systematic, it was decided to conduct an identification of research papers published on SP through a rigorous bibliographic search in Scopus. Thereafter a further search was conducted through the internet and references of publications to identify other seminal publications and developments in the field. This helped to identify and examine 60+ publications. The reason for opting for Scopus is that it offers the world’s largest abstract and citation database of peer-reviewed literature.

It was decided to conduct an initial search using “sustainable procurement” as the main keyword. An initial search in Scopus for all documents with sustainable procurement in the article title, abstract or keywords of the publication identified 609 papers published between 1990 and 2013 (as at 20<sup>th</sup> April 2013). The reason for searching through “title, abstract and keywords” was based on the assumption that if a paper bears strong connection to the theme of sustainable procurement, then it is likely that phrases such as ‘sustainable procurement’, ‘green procurement’ and ‘responsible procurement’ will be captured in one of these three areas of the paper (i.e. title, abstract or keywords). The 609 papers initially identified show a wide range of general publications in relation to sustainable procurement. For the purpose of conducting a detailed literature review it was further decided to identify the papers within this range that are peer-reviewed research papers on sustainable procurement. This led to identification of 34 papers with “sustainable procurement” as part of the article title and 29 with “green procurement” as part of the article title. The 63 are all published between 1996 and 2013 (see Table 1).

The 63 papers here formed the core of the literature review and they originate from 16 different countries: Belgium (1 paper), Brazil (1), China (2), Finland (2), France (2), Germany (2), Ireland (1), Italy (4), Japan (4), Lithuania (1), Netherlands (2), Norway (1), South Africa (3), Sweden (7), UK (18) and US (8). The UK is the leading source of research papers summarized in Table 1 although the first paper originating from UK (Rimington *et al.*, 2006) was published ten years after the first one by Wentzel (1996) on sustainable energy procurement. A close examination of Table 1 reveals that 12 of the papers have a citation record of more than 10 in Scopus over the period 1996 and 2013 (see Table 1). These may be considered as seminal publications despite the limitation that a paper published for longer is likely to have a higher citation record. The 63 papers published in 58 different journals present sustainable procurement as a multidisciplinary subject of growing international interest in both public and private sector. From the content of the 12 better cited papers in Table 1, the major themes of discussion that provide a context for this research relate to changes

needed to traditional procurement practices, green public procurement of buildings and infrastructure, development of procurement codes and redesign of procurement systems to attain sustainability, actions by firms to become sustainable in purchasing activities, and factors influencing the uptake of green procurement practices.

## **DEFINITION OF SUSTAINABLE PROCUREMENT**

According to the ISO 10845 (2010) series of standards on construction procurement, procurement can be defined as the process through which construction contracts are created, managed and fulfilled. The widely cited Brundtland Report (1987) defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” The concept of sustainable development has often been broken out into three constituent parts, that is, environmental sustainability, economic sustainability and social sustainability.

Therefore, sustainable procurement, referred to in parts of this paper as “SP” may be seen as procurement that helps to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. SP aims to find the best balance between environmental, social and economic factors (BS 8903). A content analysis of the abstracts of 69 papers in Table 1 showed that this is also referred to in various aspects of the literature as responsible procurement, green procurement, low carbon procurement, and good procurement (see for example, BS8903: 2010, Dubey et al., 2013, Palmujoki et al., 2010, Sterner, 2002). The essential feature of SP is that the procurement process should take economic, environmental and social factors into account simultaneously in procurement actions. The UK government report on Procuring the Future (2006: 1) defines SP as “using procurement to support wider social, economic and environmental objectives, in ways that offer real long-term benefits”. The British Standard (BS8903) does not state a definition *per se* for SP but defines its objective as follows: “Procuring sustainably allows organizations to meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organization, but also to society and the economy, whilst minimizing damage to the environment”.

The relationship between procurement and sustainability is complex and research is needed to examine how the best balance between objectives can be achieved. BS8903 summarizes four key aims to address when integrating sustainability into procurement, as follows: minimizing demand for resources; minimizing any negative impacts of goods, works or services across their life cycle and through the supply chain; ensuring that fair contract prices and terms are applied and respected and that minimum ethical, human rights and employment standards are met; and providing opportunities for small and medium businesses, voluntary sector organizations and also supporting jobs, diversity, training and skills development. These broad aims align with prescriptions in the Guide on sustainable procurement in construction (C695: 2011) published by the Construction Industry Research and Information Association (CIRIA). The focus of this study is to develop a systematic understanding of sustainable procurement and discussion of three main issues arising in its practice

## **TRADITIONAL PRACTICES STILL DOMINATE PROCUREMENT PRACTICES**

The EU procurement rules (2004) divides the procurement process into three stages, that is, selection, specification and award. The specification stage refers to how

requirements must be specified including technical and performance specifications. Selection refers to the stage where suppliers are rejected or selected based on evidence of their overall suitability, economic and financial standing and technical capacity. Award stage refers to the use of various specified criteria for determining which offer is the “most economically advantageous” to the procurer or purchaser (i.e. best value for money). Research by Hughes et al. (2006) on procurement in the UK construction industry helps to understand how procurement has been traditionally focused on price and hence economic considerations. The concept of SP requires a balance between economic, environmental and social factors in procurement to enhance the relationship between procurement and sustainability. This has seen significant push in recent years. However, the heavy reliance on traditional techniques like competitive tendering in the procurement process in construction seems to go against the grain of SP theory in some respects. This issue is examined and discussed.

One traditional feature of the construction sector is that price formation and contractor selection takes place as a simultaneous process (Murdoch and Hughes, 2008). This implies that a contractor who is hungry for work needs to address the price aspect of their bid to a significant extent in order to be attractive. Tender evaluation criteria and points are still heavily skewed in favour of a contractor’s financial offer (see for example, Laryea 2013). There is little doubt that many clients of the construction industry use competitive tendering as a mechanism for obtaining bargain bids from contractors (Smith and Bohn, 1999). There is a significant emphasis on economic interests and a genuine desire to achieve SP should seek to balance the triple bottom line factors. There is evidence to prove that many contractors would intentionally pitch a bid lower than cost in order to win work in times when they are desperate (see Rooke et al., 2004). Such commercial behaviours have a tendency to wipe out firms and this may then go on to affect the local economy including job losses. A situation like that will affect the well-being of families and hence goes against the grain of SP.

Second, there is a lot of wasted effort when several companies are bidding for the same work and inevitably some will be wasting resource that could be used elsewhere. This has also been highlighted in the UK Government Construction Strategy (2011) and attempts are ongoing to identify alternative procurement models that help to minimize this kind of wasted resource and effort. A multiplication of the wasted resource throughout the construction industry would reveal the enormous amount of resource and money being wasted. A research project on why clients only feel comfortable in entering into a competitive procurement strategy and awarding on price would be of benefit. The reasons may be many and complex but this procurement process has been shown not to be the most successful often ending in dispute, wasting even more resource. A better understanding of the drivers from the perspective of clients may enable an alternative procurement strategy that reduces bidding cost and contributes to reducing the current wasted effort to be developed. If construction companies were able to reduce their bidding costs their overhead would reduce and the cost of construction could reduce.

The UK Government Construction Strategy (2011: 16) sets out some principles of such an alternative approach towards procurement, designed to eliminate the wastefulness of teams completing and costing a series of alternative designs for a single project, only one of which will be built. This has been the subject of continuing dialogue with the industry, seeking a more collaborative, integrated model that nonetheless maintains competitive tension and the ability to demonstrate value for money. Two propositions have currently been put forward by industry teams, which

offer opportunities for demonstration projects. One effectively pitches framework contractors against a challenging cost benchmark, with the understanding that if no member of the framework can beat the benchmark, then the project will go to tender without the initial framework contractors being permitted to bid. This provides opportunities for new entrants. The other proposition offers a guaranteed maximum price underwritten by insurance, which also extends to protection against defects. Both propositions assume the full engagement of an integrated team – with designers, other professional consultants and constructors offering an integrated proposition, and with key trade contractors and manufacturers involved in developing the design.

This issue was further examined at a seminar marking the 30th Anniversary of the Association of Construction Economists in Finland (RAKI) on 20 March 2013 by Joe Martin, Executive Director of the Building Cost Information Service (BCIS) (RICS). The three main strands in the construction strategy for achieving reduction in carbon emissions are procurement, benchmarking and building information modelling (BIM). Three 'New' methods of procurement at the heart of the strategy are Cost-led procurement, Integrated Project Insurance, and Two stage open-book. Cost-led procurement will be based on four main variables, that is, Cost benchmarks and outline brief, Framework of integrated teams, Programme of work, and Value for money. Integrated project insurance procurement will be based on four variables namely: Cost benchmarks and outline brief, Framework of integrated teams, Third party verification, and Insurance policy – all risks including cost overrun. Two stage open book procurement will be based on five variables namely: Cost benchmarks and outline brief, Framework of integrated teams, First stage – capacity, capability etc. (pre-qualification), Second stage – open book proposal, and Independent stage gate reviews. A detailed examination of these “new” procurement models do not provide much in terms of a framework for achieving SP in construction. The main focus is still on the economic aspects of construction procurement although if the approaches help to minimize wasted resource in procurement, it still will contribute towards the relationship between procurement and sustainability in construction.

## **OBTAINING COMMITMENT FROM ORGANISATIONS**

Observations from the literature and company websites show that nearly all businesses seek to appear “sustainable”. The problem occurs when this is done merely for reason of commercial advantage rather than a true spirit of the need to reduce carbon emissions. It seems that the tag of “sustainability” needs to be attached to almost everything nowadays in order for it to be “acceptable”. There are examples to demonstrate this in industry and even academia. For example, procurement now has the prefix of “sustainable” procurement. Design has the prefix of “sustainable” design. Innovation has the prefix of “sustainable” innovation. Built environment has the prefix of “sustainable” built environment. Construction has the prefix of “sustainable” construction. Architecture has the prefix of “sustainable” architecture and so on. Despite these developments, not much seems to have changed in practice and the quest on the part of some to merely appear “sustainable” is a major problem.

Businesses obviously want to appear green so as to align themselves to be eligible to tenders and business from public agencies that are driven by SP policies imposed on them by central governments. As Correia et al (2013) put it, governments world over are using “the power of procurement” to drive policy change towards global conservation, literary forcing abidance to certain standards using public procurement. Governments, for example, spend significant amounts on public procurement and

therefore can use this massive “carrot” to influence suppliers to be in line with sustainability (Correia et al 2013). Firms are pushing to become “green” as part of their corporate social responsibility with some big firms visibly embarking on policies that are pushing the green agenda (Walker et al., 2008; Andersen and Skjoett-Larsen, 2009; Spence and Bourlakis, 2009). There is no doubt that sustainability has become an essential part of the corporate social responsibility and public relations agenda of most businesses. They want to be on the right side of the public and the sustainability agenda. That in itself is not a problem. The problem occurs when some organisations simply use the image of being “green” to boost their business prospects. Some procurers also pay lip service to the sustainability agenda. On one hand they state policies in favour of SP, and in practice they focus heavily on economic interests. This creates a problem of imbalance that should be addressed. The important milestone here is for firms to be, rather than to seem to be “sustainable”.

## **HOW IS SUSTAINABLE PROCUREMENT MEASURED?**

Correia et al (2013) argue that despite there being a strong drive by governments to push the SP agenda, there are no clear definitions on specific actions that will promote low carbon economies. They put forward that policies are often too broad and vague in terms of providing specific guidance on how SP is to be achieved and how low carbon emissions are to be accounted for. As they put it, “despite a growing political pressure for its implementation, not only is there a problem of lack of clarity over what low carbon procurement (LPC) means, but also lack of strategy and guidance for practice” (ibid).

With most organisations claiming to be doing sustainable procurement, there is a need to be able to measure and assess the progress and challenges of this journey. It seems that the clearest publication to date pertaining to the measurement of SP is by Wilkinson and Kirkup (2009). This publication breaks down the overall measurement of SP into various methodologies used for measuring aspects of sustainability. These comprise of methodologies for measuring the environmental impacts of procurement including carbon measurement technologies; methodologies for measuring the economic impacts of procurement including multipliers, LM3 model and input-output model; and methodologies for measuring the social impacts of procurement including social indicators framework. The key issues around the SP measurement technologies hinge around the gateway criteria, measurement selection and measurement scoring (see explained in Wilkinson and Kirkup, 2009). These techniques do not however provide a means for benchmarking organisational performance in relation to sustainable procurement practices.

A practical technique proposed to businesses and organisations for the measurement of SP is the Flexible Framework (see <http://sd.defra.gov.uk/documents/flexible-framework-guidance.pdf>). The Flexible Framework is a widely used self-assessment mechanism developed by the business-led SP Task Force, which allows organisations to measure and monitor their progress on SP over time. The framework was designed so that it could be used by all organisations: from those with significant levels of procurement expertise and resource to those with very limited resource at their disposal. The recommended approach to implementing the Flexible Framework is to systematically work through each one of five themes (people; policy strategy and communications; procurement process; engaging suppliers; measurement and results) from levels one (foundation), level two (embed), level 3 (practice), level 4 (enhance) and level 5 (lead). This framework is mainly for self-assessment and a comprehensive

framework for assessing and benchmarking the SP performance of organisations is needed.

## **DISCUSSION AND CONCLUSIONS**

Three discussion points emerging from the literature are the need for appropriate incentives to facilitate the diffusion and implementation of SP throughout construction supply chains, developing appropriate measurement techniques for SP, and replacing traditional practices with new approaches that can support the SP concept. Research is needed into some of these emergent issues as part of developing a way forward.

SP has become of great significance within both the public and private sector in recent years particularly since 1996 when research publications started to emerge on the subject (see Table 1). The main focus of research papers has been on the environmental aspects, reduction of carbon emissions and waste and the avoidance of continued depletion of natural resources to combat negative effects of global warming which causes climate change. As a business process, procurement is clearly well positioned to help achieve adaptation of the built environment to sustainability. This will require genuine motivations from society and corporate organisations in particular, appropriate incentives and a suitable institutional framework. Despite having basically the same meaning, several terminologies are used in the literature to refer to “SP” including sustainable sourcing, environmentally preferable purchasing, environmentally preferable procurement, sustainable purchasing, sustainable supply chain management and green procurement and all these are practiced in an effort to achieve sustainable development. Several aspects have to be considered with regards to SP and these are best value for price, lowest price of all life cycle, responsiveness to environmental issues and using of measures of social effects.

In recent years, a wide range of industries have implemented SP strategies including healthcare, agriculture, education as well as construction. For the construction industry, this is a relevant issue as the industry provides social and economic development but it has a negative impact on the environment and consumes large quantities of non-renewable resources. SP therefore provides a primary means for better decision making and more efficient use of resources which results in mitigation of negative environmental effects. These new developments cannot be achieved by the traditional methods of procurement hence the reason a dominance of traditional practice seems to hold back progress.

There is a greater need for both public and private sectors to embed sustainability in their procurement processes and throughout their supply chains. For the private sector, the implementation of sustainable practice in the supply chain proves the corporate social responsibility the organization has and could be used to determine its success in terms of its image and productivity. However, this is sometimes done merely for commercial advantage rather than a genuine effort to reduce carbon emissions.

The table of literature in Table 1 shows countries that are ahead in pushing forward the SP agenda on the basis of published research on the subject. These are less than 20 countries and a clear minority in a global environment of 200+ countries. National institutions ought to provide a leadership through facilitating the availability of guidance documents, training opportunities and better connectivity between published guidance documents and what people actually do in practice. Thus, effective public education is required to adequately support this agenda in various countries. Without adequate policies and education mechanisms in place, the goals of sustainable

development cannot be globally achieved. Where legislation and sustainable regulations exist, it has to be ensured that these are complied with and hence an effective mechanism for monitoring and measurement of SP is required.

The next stage of the research is to examine and analyse the emergent issues from the literature review in greater detail and this will then be used to develop a theoretical framework for empirical investigations into the major issues effecting the successful diffusion and implementation of sustainable procurement throughout the various levels of governance and construction supply chains.

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Table 1: Research papers on “sustainable procurement”

Authors	Title of publication	Year	Source title	Vol.	Iss.	Pages	Citation record	Country of origin of research paper
Wentzel M.	Songai perspective on sustainable energy procurement and small-scale farming: possible applications for South Africa	1996	J Energy South Afr	7	1	11-15		South Africa
Marron D.B.	Buying green: Government procurement as an instrument of environmental policy	1997	Public Financ. Rev.	25	3	285-305	3	US
Helfer L., Daves S.	Investing in sustainable energy: Changing procurement practices at the World Bank	1997	Corp. Environ. Strategy	4	2	73-78	0	-
Ngowi A.B.	Is construction procurement a key to sustainable development?	1998	Build Res Inf	26	6	340-350	7	South Africa
Miller M.E., Sanders P.H.	The Trappers Point site (48SU1006): Early Archaic adaptations and pronghorn procurement in the upper Green River Basin, Wyoming	2000	Plains Anthropologist	45	174	39-52	9	US
Rwelamila P.D., Talukhaba A.A., Ngowi A.B.	<b>Project procurement systems in the attainment of sustainable construction</b>	2000	Sustainable Dev.	8	1	39-50	19	South Africa; Kenya; Botswana
Sterner E.	<b>'Green procurement' of buildings: A study of Swedish clients' considerations</b>	2002	Constr. Manage. Econ.	20	1	21-30	11	Sweden
Da Cunha Lemos A.D., Giacomucci A.	Green procurement activities: Some environmental indicators and practical actions taken by industry and tourism	2002	Int. J. Environ. Sustainable Dev.	1	1	59-72	3	Brazil; Italy
van Calster G.	Green procurement and the WTO - Shades of grey	2002	Rev. Eur. Comm. Int. Envir. Law	11	3	298-305	4	Belgium
Riley D., Pexton K., Drilling J.	Procurement of sustainable construction services in the US: The contractor's role in green buildings	2003	Ind Environ	26	03-Feb	66-69	8	US
Furuta K.	The movement of the environment regulations and green procurement survey standardizing efforts - In Canon. Inc	2004	Kami Pa Gikyoshi	58	11	77-86	0	Japan
Schizzerotto F.	The main European and Italian measures about Green Public Procurement	2004	Riv. Giuridica Ambiente	19	6	967-973	0	Italy
Waugh H.	Paths to sustainable procurement	2004	English	58	10	31-32	0	-
McKenzie C.	Green procurement meets energy targets.	2005	Health Estate	59	3	29-32	0	-
Gunther E., Scheibe L.	The hurdle analysis. A self-evaluation tool for municipalities to identify, analyse and overcome hurdles to green procurement	2006	Corp. Soc. Responsib. Environ. Manage.	13	2	61-77	15	Germany
van Asselt H., van der Grijp N., Oosterhuis F.	Greener public purchasing: Opportunities for climate-friendly government procurement under WTO and EU rules	2006	Clim. Policy	6	2	217-229	8	Netherlands
Byggeth S., Hochschoer E.	Handling trade-offs in Ecodesign tools for sustainable product development and procurement	2006	J. Clean. Prod.	14	15-16	1420-30	48	Sweden
Rimmington M., Smith J.C., Hawkins R.	<b>Corporate social responsibility and sustainable food procurement</b>	2006	Br. Food J.	108	10	824-837	19	UK
Appleby C.	<b>The Mayor's green procurement code</b>	2007	Local Econ.	22	1	98-101	1	UK
Dawson G.F., Probert E.J.	A sustainable product needing a sustainable procurement commitment: The case of green waste in Wales	2007	Sustainable Dev.	15	2	69-82	3	UK
Matsubayashi Y.	Efforts for green procurement of raw materials	2007	Kami Pa Gikyoshi	61	4	24-30	0	Japan
Thomson J., Jackson T.	<b>Sustainable procurement in practice: Lessons from local government</b>	2007	J. Environ. Plann. Manage.	50	3	421-444	15	UK
Gardiner B.	Briefing: Delivering sustainable development through procurement	2007	Proc. Inst. Civ. Eng.:Eng.	160	3	113-114	0	UK
Parikka-Alhola K.	<b>Promoting environmentally sound furniture by green public procurement</b>	2008	Ecol. Econ.	68	02-Jan	472-485	19	Finland
Hosogai M., Tomotani M., Oheda K.	Fujitsu group's activities for green procurement	2009	Fujitsu Sci Tech J	45	1	22-27	0	US
Varnas A., Faith-Ell C., Balfors B.	Linking environmental impact assessment, environmental management systems and green procurement in construction projects: Lessons from the City Tunnel Project in Malmö, Sweden	2009	Impact Assess. Proj. Appraisal	27	1	69-76	2	Sweden
Varnas A., Balfors B., Faith-Ell C.	<b>Environmental consideration in procurement of construction contracts: current practice, problems and opportunities in green procurement in the Swedish construction industry</b>	2009	J. Clean. Prod.	17	13	1214-22	12	Sweden
Michelsen O., de Boer L.	Green procurement in Norway: a survey of practices at the municipal and county level	2009	J. Environ. Manage.	91	1	160-167	7	Norway
Rice S.	Positive procurement for a sustainable future	2009	Offshore Eng.	34	2		0	
Sonnino R.	<b>Quality food, public procurement, and sustainable development: The school meal revolution in Rome</b>	2009	Environ. Plann. A	41	2	425-440	13	UK
Walker H.L., Gough S., Bakker E.F., Knight L.A., McBain D.	<b>Greening operations management: An online sustainable procurement course for practitioners</b>	2009	J. Manage. Educ.	33	3	348-371	11	UK
Harvie J., Mikkelsen L., Shak L.	A new health care prevention Agenda: Sustainable food procurement and agricultural policy	2009	J. Hunger Environ. Nutr.	4	04-Mar	409-429	2	US
Preuss L.	<b>Addressing sustainable development through public procurement: The case of local government</b>	2009	Supply Chain Manage.	14	3	213-223	20	UK
Walker H., Brammer S.	<b>Sustainable procurement in the UK public sector</b>	2009	Supply Chain Manage.	14	2	128-137	23	UK
Haake H., Seuring S.	Sustainable procurement of minor items - Exploring limits to sustainability	2009	Sustainable Dev.	17	5	284-294	8	Germany
Sporrong J., Brochner J.	Public procurement incentives for sustainable design services: Swedish experiences	2009	Arch. Eng. Des.	5	02-Jan	24-35	0	Sweden
Ho L.W., Dickinson N.M., Chan G.Y.	Green procurement in the Asian public sector and the Hong Kong private sector	2010	Nat. Resour. Forum	34	1	24-38	4	UK; Hong Kong
Palmujoki A., Parikka-Alhola K., Ekroos A.	Green public procurement: Analysis on the use of environmental criteria in contracts	2010	Rev. Eur. Comm. Int. Envir. Law	19	2	250-262	0	Finland
Qi B., Yu X., Guo L.	Establishment and application of green procurement model in government incentives based on evolutionary game theory	2010	Shenyang Jianzhu Daxe Xuebao	26	4	813-816	0	China
Willis K.G.	Is all sustainable development sustainable? a cost-benefit analysis of some procurement projects	2010	J. Environ. Assess. Policy Manage.	12	3	311-331	2	UK
Young W., Costelloe P., Kerr L.	Sustainable procurement: Human rights and greenhouse gas emissions	2010	Int. J. Environ. Sustainable Dev.	9	4	364-377	0	UK
Molenaar K.R., Sobin N., Antillon E.I.	A synthesis of best-value procurement practices for sustainable design-build projects in the public sector	2010	J. Green Build.	5	4	148-157	1	US
de Leonardis F.	Green public procurement: From recommendation to obligation	2011	Int. J. Public Adm.	34	02-Jan	110-113		Italy
Tarantini M., Loprieno A.D., Porta P.L.	A life cycle approach to Green Public Procurement of building materials and elements: A case study on windows	2011	Energy	36	5	2473-82	3	Italy
Fet A., Michelsen O., Boer L.	Green public procurement in practice - The case of Norway	2011	Soc. Econ.	33	1	183-198	0	Norway
Otsuki K.	Sustainable partnerships for a green economy: A case study of public procurement for home-grown school feeding	2011	Nat. Resour. Forum	35	3	213-222	1	Japan
Meehan J., Bryde D.	sustainable procurement practice	2011	Bus. Strategy Environ.	20	2	94-106	3	UK
Brammer S., Walker H.	Sustainable procurement in the public sector: An international comparative study	2011	Int. J. Oper. Prod. Manage.	31	4	452-476	6	UK

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Preuss L., Walker H.	Psychological barriers in the road to sustainable development: Evidence from public sector procurement	2011	Public Adm.	89	2	493-521	1	UK
Otsuki K.	Sustainable partnerships for a green economy: A case study of public procurement for home-grown school feeding	2011	Nat. Resour. Forum	35	3	213-222	1	Japan
Ultam K., Faith-Ell C., Balfors B.	EIA and green procurement: Opportunities for strengthening their coordination	2012	Environ. Impact Assess. Rev.	33	1	73-79	0	Sweden
Arvidsson A., Stage J.	Technology-neutral green procurement in practice-an example from Swedish waste management	2012	Waste Manage. Res.	30	5	519-523	0	Sweden
Testa F., Iraldo F., Frey M., Daddi T.	What factors influence the uptake of GPP (green public procurement) practices? New evidence from an Italian survey	2012	Ecol. Econ.	82		88-96	0	Italy
Nijaki L.K., Worrel G.	Procurement for sustainable local economic development	2012	Int. J. Public Sect. Manage.	25	2	133-153	0	US
Melissen F., Reinders H.	A Reflection on the Dutch Sustainable Public Procurement Programme	2012	J. Integr. Environ. Sci.	9	1	27-36	0	Netherlands
Lang A.H., Mendell B.C.	Sustainable wood procurement: What the literature tells us	2012	J. For.	110	3	157-163	0	US
Oruezabala G., Rico J.-C.	The impact of sustainable public procurement on supplier management - The case of French public hospitals	2012	Ind. Mark. Manage.	41	4	573-580	0	France
Oltean-Dumbrava C., Watts G., Miah A.	Procurement of sustainable noise-reducing devices: State-of-the-art review from EU project QUIESST	2012	J Manage Eng	28	3	324-329	1	UK
Tvaronaviciene A.	The possibilities to use public procurement as one of the instruments of implementation of sustainable development concept in Republic of Lithuania	2012	Bus. Theory Pract.	13	3	197-207	0	Lithuania
Erridge A., Hennigan S.	Sustainable procurement in health and social care in Northern Ireland	2012	Pub. Money Manage.	32	5	363-370	0	Ireland
Walker H., Brammer S.	The relationship between sustainable procurement and e-procurement in the public sector	2012	Int J Prod Econ	140	1	256-268	0	UK
Crespin-Mazet F., Dentenwill E.	Sustainable procurement: Building legitimacy in the supply network	2012	J. Purch. Supply Manage.	18	4	207-217	0	France
Cao J., Hu L., Wen H.	The incentive mechanism of green supply chain for raw material procurement	2013	Res. J. Appl. Sci. Eng. Technol.	5	12	3359-63	0	China

Notes: The 63 papers here formed the core of the literature review and they originate from 16 different countries as follows: Belgium (1 paper), Brazil (1), China (2), Finland (2), France (2), Germany (2), Ireland (1), Italy (4), Japan (4), Lithuania (1), Netherlands (2), Norway (1), South Africa (3), Sweden (7), UK (18) and US (8). Most of the publications originate from the UK and 12 of the papers have a citation record of more than 10 in Scopus over the period 1996 and 2013. These are seminal papers although an inherent limitation lies in the fact that papers published for longer are likely to have a higher record of citation.

# SWEDISH POVERTY – AN OXYMORON? TAKING ISSUE WITH SOCIAL SUSTAINABILITY IN URBAN RENEWAL

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Many global cities are struggling to align urban renovation with social sustainability. In particular, solutions to the imbalance between rich and poor neighbourhoods have been difficult to find. This is also the case with the Swedish cities of Gothenburg and Malmö. Recently large contractors have become involved with this issue, claiming they can provide social sustainability on a commercial basis. Many studies have shown that focusing on providing employment, improving social infrastructure and leisure facilities is not enough to rehabilitate the disadvantaged neighbourhoods. A framework for understanding social sustainability is proposed to facilitate further examination of such issues by analysing three biographic accounts of residents of deprived Swedish suburbs. Using critical discourse analysis, the empirical material builds on the three narratives: 1) An account of a childhood and homeless people leaving in a segregated neighbourhood; 2) the biography of an immigrant boy breaking out of the suburb environment and becoming a football star; and 3) an account of adolescence in Gothenburg and the discovery of the city centre in contrast to her home suburb. All the accounts indicate that employment and the presence of functional infrastructures did not prevent the stigmatisation linked to the authors' residential areas. These accounts could therefore help urban developers to better understand the complex and predominantly culturally oriented set of challenges when creating social sustainability. A bottom-up approach is provided by these auto-biographical texts that could enhance innovative input to contractors' concepts of social sustainability to include issues of integration and differentiation of the type of poverty that impact contemporary Sweden.

Keywords: contractor's business concept, social sustainability, urban renovation, discourse analysis

## INTRODUCTION

Sustainable development is a widely used term which has become increasingly influential during the last 20 years (Boström 2012, Dempsey et al 2011). In the building sector, however, the term sustainability has been mainly employed in relation to energy performance linked to climate change (Johansson 2012). Moreover, if a social dimension to sustainability is commonly accepted, the term is being contested and its scope is expanding. Colantonio and Dixon (2010) show how new soft themes, such as greater wellbeing and social capital are becoming central to the social sustainability debate, together with the more traditional hard concepts including basic

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needs, equity and employment. They also demonstrate that successful implementations are strongly context dependent. It is thus more constructive to think of social sustainability as a contextual process rather than a set of end-goals (Boström 2012, Dempsey et al 2011).

While the themes addressed by social sustainability have traditionally been left to the care of public or non-profit organisations, this is no longer the case. The development of new public management has reshuffled the division of tasks between public and private actors, and led to restructuring within and between the two sectors. Public-Private Partnerships (PPP) is one example of these transfers aiming to provide public infrastructures and services through a new constellation of private players. We are witnessing a shift in public administration beliefs in government regulation towards a more governance-oriented approach (Koch and Buser 2006). More precisely, Sweden has developed and maintained a private sector for the social housing sector, and advocates that social housing should be viewed as a business (Törnquist et al 2012).

Several large Swedish contractors have now integrated social sustainability in their strategy and work plans. Their entering into the broader set of urban renewal tasks is a combined push-pull, an attempt to combine developing new businesses with the new conditions in urban renewal. This is, and will further continue initiating a search for collaborative constellations to explore opportunities and constraints for private companies to deliver what were previously seen as public tasks.

Previous research on urban regeneration projects has shown that social sustainability tends to be translated as participation in building projects (Valdes-Vasquez 2013), that this participation is often problematic in a Swedish context (Öresjö 2012), and that citizens can be instrumentalised through quantitative survey (Swyngedouw et al 2002). Another common translation is the development of mixed housing, even if, in the Swedish context, this has to date not generated social mixing (Olsson 2012, Törnquist et al 2012). There therefore exists a need for appropriate innovative approaches to contemporary challenges in social sustainability. In order to identify new possibilities of including social sustainability in urban regeneration, inspiration could be taken from current approaches to social innovation (Dawson 2010) and user-driven innovations that emphasize the local experiences of neighbourhoods by giving voice to their users. Here, through the accounts of three former inhabitants two questions will be explored:

What are the qualitative characteristics of the deprived suburb neighbourhoods as perceived by former inhabitants?

How do these accounts contribute to the understanding of social sustainability?

The empirical material presents how the inhabitants experience these areas and which markers are associated with the different places. Individual accounts are compared with new research contributions on social sustainability (Boström 2012, Colantonio and Dixon 2011 a.o.). The three accounts are localized in suburbs, parts of “Miljonprogrammet” in Sweden, and provide lived, bottom-up perspectives of these neighbourhoods. The Miljonprogrammet is a national initiative implemented between 1965 – 75 to address the housing shortage by building one million dwellings. Around 700 000 dwellings were completed during these 10 years. The dwellings are now in need of physical renovation, and in some areas there are also important social issues to deal with. Each of the three stories is located in a different suburb. The present paper

represents the preliminary and exploratory phase of a project on the role of private contractors in renovation of the miljonprogrammet.

## METHOD

The overall theoretical, empirical and analytical approach is interpretive sociology. Theoretically, we review approaches to urban regeneration and social sustainability. Empirically, a self-biography (Lagercrantz 2012), a biographical account structured as a diary (Alakoski 2012) and a novel (Olsson 2012a) form the material to be analysed. These texts were chosen mainly for two reasons: First, they provide a common, strong critique of life in Miljonprogrammet areas as a contrast to the contemporary discourse on the renovation of these suburbs, and second, their newness as they were all published in 2012.

Olsson (2012a) is a novel about a girl, Miira, with Finnish parents. Her story roughly spans her life from ages 8 to 16 in the 1980's. The style is autobiographic and the chosen period corresponds to the author's own childhood (Olsson born 1973). A dramatic style is used where almost every chapter is short and involves some kind of striking event.

Lagercrantz (2012) is a biography of Zlatan Ibrahimovic, born in 1981 and living his childhood and adolescence in Rosengård in Malmö, to which he has returned regularly during his international career. Lagercrantz is a well-established biographer who organises Zlatan's life story. The book presents a very positive picture of the main character.

Alakoski (2012) use a mix of biographical material - even directly quoting a number of texts such as medical records of her parents hospitalisations - contemporary political commentary and referencing of other authors and researchers, all compiled into the form of a diary, covering the month of October 2012. Alakoski's youth was spent in the southern Swedish town of Ystad (known through the "Wallander" films). She was born in 1964 and educated as a social worker. She has written a series of successful novels.

The narratives are analysed looking at concepts such as urban-area identity, poverty and segregation using discourse analysis (Fairclough 1993). Using critical discourse analysis on novels is unusual but straightforward, as the texts are central objects. We argue that the three texts are part of the discourse of the renovation of the Miljonprogrammet in Sweden. The approach adopted parallels Hassard and Halliday's (1998) set of analyses of films and novels representing discourse on organisations. Hassard and Halliday (1998) claim that the strength of literary accounts is that the full energy of people's lived lives is included in the narratives of the phenomena, as contrasted to the more dry, clinical and distanced scientific genres. The limitations relate to the strong personal approach the text represents. The selection of events and their presentation is beyond the reader and researchers discretion. The claims from such an analysis are therefore modest. Moreover, all three authors look back to periods in the past, whereas the upcoming transition of the Miljonprogrammet is a contemporary process. Alakoski (2012) appears very conscious on this and establishes the link by using manifest intertextuality (Fairclough 1993) between the contemporary commentary of political manifestos and the biographical accounts of her youth. Alakoski, Olsson and Zlatan are all exceptions in their neighbourhood and see themselves as such. Their social ascent both limits and enables the value of their accounts.

The analytical limitation encountered is that the present pieces use text only, neither including broader social discourse and discourse practice nor how the readers would receive and interpret similar texts to the ones analysed here.

## **THEORETICAL FRAMEWORK**

Colantonio and Dixon (2011) suggest the following definition of social sustainability:

“...concerns how individuals, communities and societies live with each other and set out to achieve the objectives of development models that they have chosen for themselves, also taking into account the physical boundaries of their places and planet earth as a whole”, Colantonio and Dixon (2011: 8).

The authors (2010:21) add that social sustainability should be “interpreted as a socio-historical process rather than an end state”. They propose the following eight characteristics of a sustainable community: Active inclusive and safe, well run, environmentally sensitive, well designed and built, well connected, thriving – with a flourishing and diverse local economy, well served and fair for everyone. We find these characteristics both inspiring and comprehensive, and we use them in the analysis below.

Olsson suggests understanding social sustainability in two main dimensions: welfare and problem-solving capacity. The welfare dimension consists of a justice and a satisfaction element. Justice is further conceptualised as equity, democracy and diversity. Olsson mentions segregation as a key problem in Sweden, but downplays exclusion. The problem-solving capacity of a society depends on its various social systems and how these tackle societal challenges (Olsson 2012b). It relies on the single persons' initiative, cultural values and control mechanisms within politics and societal institutions. Boström's discussion (2012) distinguishes between content and process. In terms of content, he refers to a large number of criteria including basic needs, access to infrastructure, social cohesion and inclusion largely compliant with the Bristol accord. In terms of process, he mentions participation in the sustainability project, empowerment, an accountable governance and management. To summarise, social sustainability is a multifaceted concept that should be viewed in a contextual and processual manner. Whether a neighbourhood is socially sustainable or not in the Swedish suburb context could then be discussed using Colantonio and Dixon's dimensions and their counterparts, combined with Olsson's (2012b) idea about problem-solving capacity. A dimension like “active, inclusive and safe” is thus seen here as segregation and violent experiences. And “fair for everyone” is discussed along with problem-solving capacity related to unfair events.

### **Critical Discourse Analysis**

Critical Discourse Analysis (CDA) studies texts to reveal the discursive sources of power, dominance, inequality and bias (Fairclough 1993, Sheyholislami 2002). It examines how all types of text, written, spoken and materialised are maintained and reproduced within specific social, political and historical contexts (Fairclough 1993). Where early CDA tended to focus on texts alone (Ferguson 2007), later versions extend the focus to communicative interaction, trying to understand the production and consumption of text, including the relation to an audience of the text and also pursuing phenomena of intertextuality (Chuliarakis and Fairclough 1999, Ferguson 2007).

Fairclough (1993) suggests that sentences in a text are analysable in terms of their representations, relations and identities. Representations reveal possible relations to social practice and can involve a particular (re-)contextualization of the social practice (Fairclough talks of an ideational function). Relations refer to a particular construction of the relationship between writer and reader, and identities to the constructions of the writer and reader. Linguistic analysis is also concerned with framing, i.e. inclusion and exclusion of elements, of all three types in the text/discourse.

Intertextual analysis is, in contrast to linguistic analysis, more interpretive and less descriptive. This type of text analysis is sensitive to texts containing mixes of several texts, importing elements from different sources, viewing this as traces of the discourse practices in the text (Fairclough 1993).

To summarise, critical discourse analysis views language and discourse as a social practice through which the world is represented involving the exercise of power and domination. Our analysis aims at identifying the discourse in the three texts using the part of critical discourse analysis specifically directed towards written texts. Discourse has purposeful content; it produces, exercises, and reproduces power relations, inclusion and exclusion. All speakers and writers exercise discursive practices that originate in special interests and aims. Discourse is historical in the sense that texts acquire their meanings by being situated in specific social, cultural and ideological contexts in time and space. This implies that there is no such thing as the right interpretation since both authors and readers actively participate in the creation of meaning.

## CASES

The three cases are presented below, structured according to themes occurring in the discourse that echo and/or contrast the social sustainability dimensions mentioned above. This includes basic needs, violent experiences, segregation, poor education, segregation versus centre-periphery, justice/problem-solving capacity. But we open with the first characterisation the authors give of their respective neighbourhoods:

In Olsson (2012a: 25) the main character Miira describes her home area Gårdsten, Gothenburg (the translations from Swedish into English are ours);

“.. this place is called Gårdsten (the stone yard) because the places are covered with asphalt, the high-rises with concrete, and there are stones on them everywhere and the facades are hard as stone”.

Alakoski characterises the building blocks that constitute the neighbourhood of Nya Fridhem in Ystad as the ”pigrow” referring to where pigs would be placed in a farmhouse.

### Basic Needs

Alakoski (2012) continually mentions homelessness and begging in the street when referring to the present. She is emotionally disturbed by people “sitting on their knees” in the street and often gives them money (Alakoski 2012:13). However, the biographical part of her story in Ystad is different. There poverty is mixed with a series of other issues the family has to tackle.

Olsson (2012a) portrays her family as covering the basic needs. The parents have jobs, the father at a car factory and the mother as a cleaning lady. The teenage daughter has

her own room in their apartment. Nevertheless, the young teenager steals to get herself clothes.

Similarly, the Ibrahimovic family has the same types of jobs, but also have to struggle with drug and alcohol addiction. The empty fridge of Zlatan's father is a recurrent issue that forces the boy to find other places to eat at. Stealing bicycles is quite mundane: Zlatan even accidentally steals the bike of one of his trainers.

### **Violent experiences**

Olsson (2012a)'s main character Miira sends a bomb threat to her school, witnesses a teenager getting beaten to death, sets fire to a forest, fakes a fire alarm in her school. Alakoski's father is an alcoholic; her mother gets beaten up on several occasions and both of them become hospitalised in a psychiatric ward (Alakoski 2012). Her friends, especially the boys, are in the process of becoming drug addicts and small time criminals, and one even becomes a murderer.

Zlatan's father is beaten in a long tunnel connecting the suburb to the main town. The passage becomes a source of anxiety for the boy, who cycles through at full speed whenever he has to pass through it.

### **Segregation between centre and periphery**

Miira and her close friend take the bus, changing to a tram to get to the centre of town. Miira feels her body language changing and becoming stiffer:

”Looked at the people. They were a shitty lot. Most of them snobs. The snobs were smarter and boasters and grown-up minis that had become older.... The jeans fitted perfectly on the snobs. Slim. They had waist length leather jackets with shoulder pads and some of the leather jackets had fringes. Their hairdos were fresh, they had hair highlights done at hairdressers and it was finely sprayed. The makeup sat like on models and lips were elaborately painted with lipstick or gloss without glitter. They moved their hands smoothly. She looked discreetly down at herself. The college pants were not a perfect fit. No clothes were a perfect fit on her. They were floppy.....” (Olsson 2012a: 125). “In Gårdsten nobody moved their hands smoothly. There hung down from under arms as if the wrists had disappeared” (Olsson, 2012a).

Zlatan also experienced living in the periphery. Rosengård is described as being outside Malmö, though the area is actually only four kilometres from the city centre:

"...but I had no clue where the football stadium, or anything else for that matter, was in the town. Malmö was rather close. But it was another world. I was seventeen before I visited the centre, and I understood nothing of the life there” (Lagercrantz 2012:86):

### **Justice and problem solving capacity**

Olsson (2012a) provides quite a few examples of society's provision of services to the young school children, and some of them fail while others meet with some success, e.g. systematized feedback to the parents (Olsson 2012a:85). Zlatan's singular personality and way of playing football were a problem for the other children's parents, who would have liked their sons to possess the ball as much as he did (Lagercrantz 2012:87): "There were already some foreigners, Tony among others. Apart from them it was only Swedes and some were Limhamn types, upper class kids. I felt like I came from Mars. Not only because my father did not have a nice villa... I talked differently". “It began smouldering amongst the Swedes. Their parents wanted me out... Some idiot of a father gathered signatures. Zlatan has to go it said. All kinds

of types signed that list. The coach Åke Kallenberg just stared at the piece of paper. What kind of weird shit is that! He tore it apart.”

Alakoski (2012:37-38) describes how her brother “escaped into [drug and alcohol] abuse for thirty years. “He cost society” a lot. But “then the miracle came”, somebody cared; a social worker made the difference and dragged the brother out of his self-abuse.

### **Displacement and its decay**

All three narratives concern families that had moved far from their homelands to seek work and/or flee from war. Olsson’s (2012) and Zlatan's parents have long-lasting feelings of displacement, listening to music from their homelands (Finland and Bosnia). Zlatan refers to “papa and his Jugge music” (i.e. Yugoslavian music, Lagercrantz 2012), Olsson refers to Finnish and Russian music, Finnish grilled sausages as well as other symbols of Finnish culture (Olsson 2012a). The parents follow the development of their countries through national TV (Lagercrantz 2012). However, when it comes to the second generation, their socialisation has progressed in a different manner. They appear to build their identity not on their country of origin, but on the areas they live in. Even if this leads to the decay of feelings of being away from one’s homeland, it still defines them as part of a segregated minority. Zlatan describes it like this:

“In Rosengård we had various yards, and no yard was worse than the other well the one with the gypsies had low status... It was the yard that counted, not which country your parents came from” (Lagercrantz 2012:82) And he makes up the slogan “you can take a boy out Rosengård, but never take Rosengård out of a boy” (Lagercrantz 2012:62), which is now proudly and officially printed on the front archway at the mouth of the tunnel leading to Rosengård.

Olsson (2012a:85) on the other hand describes about eighty national groups living in the neighbourhood. They did not relate much to each other and each with a strong sense of belonging to specific minorities.

## **DISCUSSION**

Alakoski, Olsson and Zlatan's accounts are very personal and involve love stories and friends as social networks, and these are described as very important to the main characters. When it comes to basic needs/poverty they all show that employment did not prevent a harsh environment from developing. Neither did the presence of schools and other social infrastructures. The main characters have parents with employment and as children they had their own rooms in the apartments they lived in.

Olsson and Zlatan describe how theft and stealing can be a reaction to a lack of resources. Olsson (2012a) recurrently recounts how friends share their rare goods, be it cigarettes, alcohol or more illicit stuff. That Zlatan cannot afford to pay for a pizza or a Coke after training also marginalises him from his football team-mates.

The mechanisms of segregation are at simultaneously outspoken and subtle, and are strongly experienced in all three accounts. Gårdsten is described as sheltering not only the Finnish, but also a number of other minorities. Rosengård is an ethnic melting pot, where belonging to the area is a stronger definer of identity than is nationality. To both Zlatan and Olsson the use of a particular language, saturated with slang, underlines a cultural, discursive segregation. The Finnish minority is treated in a paternalistic manner (a finding similar to that of Kalonaityte 2010). The Finnish

children are streamed into special classes, where their Swedish language abilities remain less developed compared with their native Swedish counterparts. The social heritage is thereby reproduced rather than broken, and this is also expressed in the choice of (no)-education.

The main characters describe the city centres as "another world". It is a distance experienced rather than a natural one: Gårdsten is 30 minutes by tram or buses from Gothenburg; Rosengård is four kilometres from Malmö's central station; and Nya Fridhem is situated less than one kilometre away from Ystad centre. But the feelings of an unknown world and of cultural difference are very strong.

Concerning problem-solving capacity, Olsson (2012a) recurrently gives examples of extra resources offered to the inhabitants, though these are not able to exploit the possibilities given to them. The offers do not match the social culture of the residents. There is a clash between a "good will" discourse from the providers and a discourse of "us and them" - that views all institutions as parts of an adversarial system - from the youngsters who should benefit from these offers. When the problem-solving capacity is successful, it seems to build on civil-societal efforts, even down to single persons such as Zlatan's coach, Alakoski's brother's social worker or Miira's substitute teacher.

The overall discourse presents a complex picture of the characteristics of the deprived neighbourhoods. As Öresjö (2012) remarked, these neighbourhoods do not automatically encompass social environments that are not sustainable. Transition projects focusing on energy renovation risk eroding or even destroying social networks in these neighbourhoods. If energy renovation is done on a business basis, real estate owners are likely to strive to upgrade neighbourhoods and raise rents, which tend to result in pushing the lower income groups out (Öresjö 2012).

Over the last thirty years, the city councils and a range of other players have continually launched public initiatives to handle these issues or at least to create the impression that actions have been taken. Currently, a whole range of such initiatives are on-going in both Göteborg and Malmö, and Ystad is actually demolishing Nya hem and replacing the dwellings there with new social housing of today's standard. Öresjö (2012) reports that due to too much focus on new build as well as the real estate companies' vested interests, a remarkably large proportion of such improvement and renovation projects fail. Therefore, the lived experiences discourse presented here seems to stand in contrast to the urban planners' helicopter view discourse, including privatization and half-hearted participation schemes. Nevertheless, Colantini and Dixon (2010) and Törnquist (2012) find examples of social sustainability improvement in neighbourhoods in a series of European cities. Friesen et al (2012) and Öresjö (2012) tried to establish such examples in the Miljonprogrammet context, but used less deprived areas as their basis.

The renovation of large areas such as the "Miljonprogrammet" neighbourhoods involves the large contractor companies. The research on these companies' contribution to social sustainability is scarce. A small body of literature addresses business models for energy renovation and sustainable buildings (Mahapatra et al, 2013), but very few discuss the integration of broader social issues. Valdes-Vasquez et al (2013) are a rare exception: they point at corporate social responsibility and stakeholder management as possible tools in building processes for construction projects. Likewise Friesen et al (2012) provide an (counter) example of an energy-oriented renovation of Miljonprogrammet's social housing in Sweden, where the architects and general and specialized contractors took on traditional roles using a

partnering agreement, letting other parties in the project work with social sustainability issues. However, there are indications that these large contractors are moving towards innovative concepts, extending their understanding further than partnering, stakeholders' management or Corporate Social Responsibility perspectives: for example PEAB with its "Bolyftet" concept is developing new initiatives such as offering jobs to the residents during the renovation process or shaping the dwellings so that they will cover the inhabitants' needs through the different periods of their lives. NCC has a business developer attached to social sustainability, who is in charge of integrating issues such as social segregation and exclusion in the company's renovation projects.

Creating cities sustainable in all three dimensions: economic, environmental and social requires an unusually broadly orchestrated set of efforts and resources. Along with Colantonio and Dixon (2010) the analysis here has pointed to the soft aspects of social sustainability: leveraging social capital and changing local cultures. More instrumental solutions, i.e. mixed housing or functions, can trigger such developments, but cannot stand in isolation of other actions.

## CONCLUSIONS

This paper set out to scrutinize what are the qualitative characteristics of the deprived suburbs by giving voice to former inhabitants through their own stories, and to compare these stories with recent research contributions on social sustainability.

The analysis has revealed cultural and social poverty and feelings of being different and peripheral. Basic needs are covered, but the people experience poverty and alienation. These feelings of exclusion cannot be measured in the number of bus and tram connections and/or kilometres. The distance experienced is cultural. Violent experiences become part and parcel of this culture. Justice and problem-solving capacities are limited for a number of reasons. Many societal efforts seem to fail for the intended receivers.

The accounts call people in charge of urban transition to better understand the complex and largely culturally-oriented set of challenges for creating social sustainability. It is a long and multifaceted process that requires a broad alliance of public and private players. If contractors want to engage and involve a representative set of citizens in the renewal projects, it should engage the inhabitants, not only in term of housing preferences and street furniture, but also in terms of connection and belonging to the broader community. The specific area should not be seen as a closed space to dwell and work in but rethought in relation to its meaning for the city as a whole. The accounts analysed here, however, indicate that offers perceived as coming from outside are not readily accepted. Private players and others will have to invest more time and rigorous sets of improvements to enable acceptance. So, Swedish poverty is not yet an oxymoron as so far only the criteria for poverty have changed.

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# IMPOSING GREEN BUILDING REGULATIONS IN DUBAI

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In 2008, Dubai announced its plan aiming to introduce mandatory green building regulations for all new buildings starting 2014. So far, Dubai has only voluntary rating systems such as LEED and BREEAM. This research aims to investigate the anticipated benefits and implicated challenges from imposing the green building regulations on the construction industry in Dubai; primarily seeking to facilitate the planned move through effective recommendations on how to proactively manage the identified challenges. The literature review aimed to compare and contrast the implementation practices for the mandatory regulations versus the voluntary rating systems, and the implicated challenges from imposing the green building regulations in general, and specifically in Dubai. The study applied a stepwise methodology embracing an online survey utilising a questionnaire sent to 150 professionals in Dubai who are involved in regulating and implementing the green regulations. The second step comprised a set of interviews with experts to discuss the findings of the survey and suggest recommendations to address the identified challenges, proactively. A statistical analysis was applied to the survey dataset whereas a content analysis was applied to the interviews dataset. The key findings of the study indicated that experts within the construction industry are still sceptical about green practices due to the perceived higher costs. This reflected the lack of awareness besides the minimal involvement of private sector in setting the green building regulations, amongst other challenges. Many Professional preferred the voluntary systems due to the perceived rigidity of the intended regulations and the reviewers from the regulatory bodies. The study concluded that the government, in order to can enhance the implementation of the green building regulations in Dubai, needs to introduce effective measures to promote the green building initiative to all categories of stakeholders; both the supply side and the demand side meanwhile increasing the involvement of the private sector in the consultation process leading to the release of the new regulations.

Keywords: Dubai, green building, regulation, sustainability

## INTRODUCTION

Over the period 2005 till 2009, the consumption of electricity in the Gulf Cooperation Council (GCC) countries, witnessed a significant upward trend with a fast rate of 12.5% due to the rapid development in construction activities (Landais, 2009). Gas was not enough to substitute the reliance on Oil. Lands in the GCC countries are basking in solar energy equivalent to 500–600 W/m<sup>2</sup> per year which is equivalent to 1.5 million barrels of crude Oil This triggered the exploration of renewable solutions

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(Alnaser & Alnaser, 2010). Dubai was the first to initiate a serious move toward sustainability with clear regulations based on LEED (Leadership in Energy and Environmental Design) & BREEAM (Building Research Establishment Environmental Assessment Method) voluntary systems but the implementation was significantly limited. In 2009, only six buildings were LEED accredited and 450 structures were still awaiting their accreditation (Landais, 2009).

Despite announced in 2008, the implementation of green building regulations was delayed until 2014. Starting 2013, the real estate market in Dubai has started to show a cautious upward trend. Amid this critical period of economic turbulence and the efforts towards recovery, the impact of imposing new regulations on the real estate market and the building industry in general remains unclear. This paper aims to investigate the impact of imposing the green building regulations on the construction industry in Dubai. Through the critical review of current practises and the benefits as well as the challenges of voluntary system versus the imposed regulations, this study aims to suggest recommendations for the effective implementation of the green building regulations in Dubai construction market.

## **LITERATURE REVIEW**

“Green strategy” is defined as “the approach that developers adopt to improve and gain sustainable competitive advantage by contributing to environment protection, ecological responsiveness and social responsibility” (Zhang, 2010). To stay competitive in the new market, project stakeholders realize the need to adopt new skills, experience and knowledge base. Generally, the lack of clear regulations was recorded as a challenge facing the implementation of green systems in different countries such as in Malaysia (Papargyropoulou, 2012). Stakeholders, particularly project developers, can enhance their competitive positions when adopting the right green strategies. However, the significantly high level of governments’ involvement in the Middle East; 62%, compared to 45% in Africa, 43% in Latin America and 20% in Europe (Iwaro & Mwasha, 2010) raises the question whether this extensive reliance on government might limit the private sector role and can therefore result in less coordination and development. On the one hand, the knowledge about the green building systems is still immature and needs yet to develop and evolve (Korkmaz et. al., 2010). On the other hand, there is lack of experience amongst project stakeholders, particularly the regulatory personnel; compared to the advanced techniques in the market (Beerepoot, 2007). This can be an obstacle to the efficient implementation of the imposed regulations.

Regarding the obstacles facing the green building initiative, project designers identified the lack of education and awareness as the most significant factor that follows the perceived higher initial investments (Chan et. al., 2009). In addition, occupants may lack the necessary experience to utilize and operate the green features. The counter argument builds on Total Life Cycle Costing which supports the view that the savings in utilities and maintenance bills can reach up to 25.6% over 20 years against the premium cost of 7.5% (Kansal & Kadambari, 2010). The project type and size are important factors which support the previous argument. When implementing LEED standards, prestigious projects were found to be less costly than low quality buildings (McAuley, 2008). Mandatory government regulations should embrace incentives for green projects that can reduce the initial cost difference in addition to the tariff charges that can impact the long term savings. The participation of private sector in issuing the rules is vital. “Regulatory process that emphasis stakeholder’s

participation, transparency and predictability will be more credible than one without these features” (Berg, 2000). Collaboration models may not be very common in many countries such as the UAE and the gulf region in general (Vidican et. al., 2012) despite its importance to achieve the government strategy and long term plans. Collaboration through formal partnering agreements between stakeholders includes training programs to share lessons learned and overcome the lack of experience (Morrison-Saunders & Bailey, 2009). Partnering may also include the appointment of third party reviewers with adequate resources to overcome the lack of reviewers’ experience. Injecting voluntary approaches such as third party certification and incentive programs can overcome mandatory challenges by achieving best compromise technically, economically and managerially (Rizzi et. al., 2011). Mixing both voluntary and mandatory systems can help to overcome the challenges for the energy efficiency program implementation as proposed by Peterman et. al., (2012). Injecting voluntary approaches can be done through offering incentives (as shown in figure1) and implementing Cap-and-Trade strategies. Industries may trade their surplus for future reduced prices.

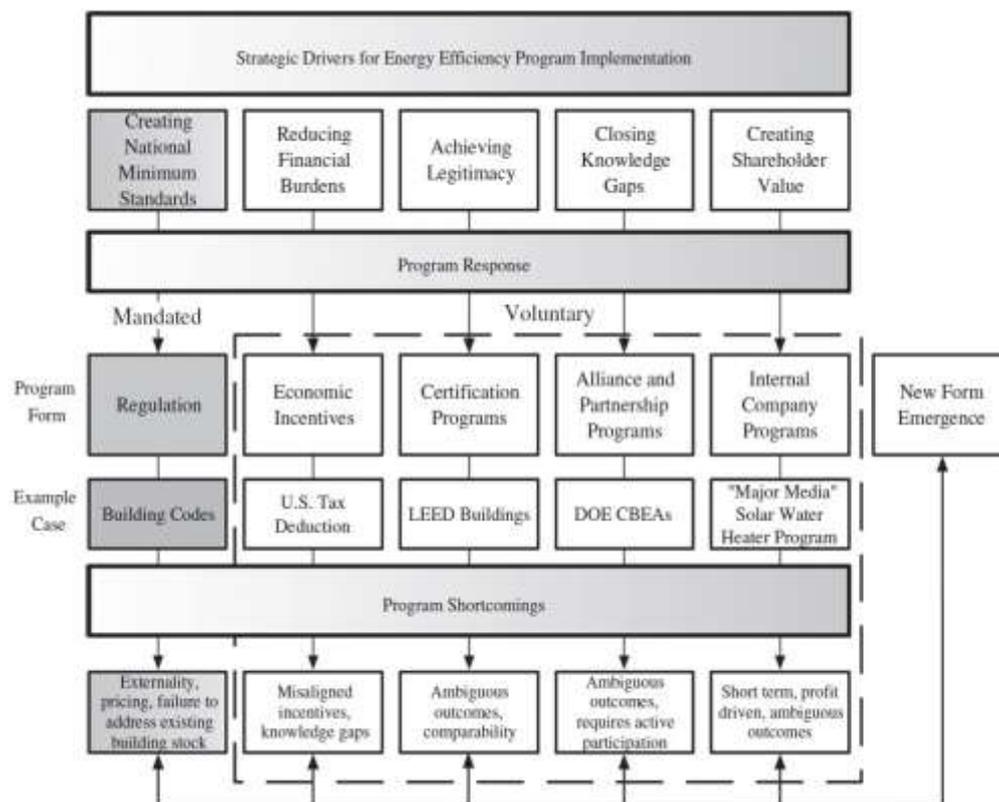


Figure1: A roadmap for voluntary and mandated programs for building energy efficiency. Source: Peterman et. al. (2012)

### Dubai Green Building Regulations

In 2008, the implementation of the green building regulations project was planned to be in phases in coordination of WSP consultant, Dubai Municipality and DEWA (Roberts, 2010). However, the first set of regulations planned to be issued in January 2009 has been delayed by more than four months. There has been a cautious attitude due to the anticipated increase in cost; about 5% compared to the traditional building approach, despite the identified long term savings ranging from 30% to 40% (Remo-

Listana, 2010). Other reasons could be the shortage in renewable energy suppliers in Dubai which are due to the relatively low water and electricity tariffs (Vidican et. al., 2012). In 2011, the decision to enforce the green codes was put on hold until 2014 to avoid disruptions within the still-to-recover construction industry amid the prevalent aftermath of the financial crisis (Tedorova, 2011). In 2012, it was announced that green building regulations which are currently applied to governmental buildings shall be enforced industry wide by 2014. Regulations aim to help existing buildings improve the current electricity and water consumption (CW Staff, 2012).

Comparing the proposed green buildings regulations in Dubai to the LEED system available in UAE the key differences are highlighted in Table 1. On the one hand, LEED is more comprehensive in terms of explaining the measures and providing guidelines for innovation. On the other hand, Dubai regulations portray tailoring the measures to suit Dubai needs in landscaping local types and glazing orientations. In addition, LEED provides standards for verification after occupancy such as IEQ Credit 7.2 for Thermal Comfort whereby buildings must be verified under thermal comfort survey within 6 to 18 months after occupancy. If the survey results indicate that more than 20% of occupants are dissatisfied with thermal comfort, corrective actions must be developed. LEED also provides a reference for minimum energy cost savings percentage for each point in new and existing buildings. There is no sign of such a structured approach to verify buildings after occupancy in the new regulations.

## **METHODOLOGY**

This study was conducted over two stages; a survey of a sample of stakeholders followed by a set of interviews with experts. At the outset, the key benefits and main challenges were identified from the literature and secondary sources. Both sets were utilised to construct a questionnaire that was distributed to a random sample of 150 professional in the construction industry in Dubai. In total, 57 responses were collected with a response rate of 38% comprising different stakeholders' groups of consultants, contractors, DEWA, Dubai Municipality, Project Developer, Suppliers and others. The aim of the survey was to verify and furthermore rank the identified benefits and challenges in the context of Dubai construction market. In the following step, the findings of the survey were utilised to conduct semi-structured interviews with experts in green buildings and sustainability in Dubai. A purposive sample of 20 experts who are currently involved in the green building initiative in Dubai was contacted but only 8 interviews were conducted. The interviews primarily addressed the second objective of the study; to suggest effective measures to enhance the implementation of the intended regulations reflecting on the current practice within the public sector meanwhile providing in-depth expert opinion on the findings of the survey.

### **Anticipated Benefits and Identified Challenges**

The data collected from the Survey Monkey website were analyzed using the Statistical Package for the Social Sciences (SPSS version19). A ten point likert scale was used with a neutral middle point of 5. The score 0 represents strongly disagree, 5 neither disagree nor agree and 10 strongly agree. The results were classified into two main categories; the regulations' perceived benefits and the perceived challenges. The relative importance of the factors among the attributes as perceived by stakeholders was tested using mean scoring and Kendall's coefficient of concordance. The latter was used to understand respondents' extent of the agreement with the factors identified in the literature (Lam et.al., 2010 and Ahsan & Gunawan, 2010).

The data collection resulted in 57 responses; the majority of respondents were between the ages of 30 to 49 with an average experience of 10 green building projects. In total, 43 respondents had previous experience in green building out of which 29 have been involved in less than 5 projects. The maximum responses were received from contractors with 22 responses followed by the consultants, developers, regulators and suppliers.

*Table 1: A glimpse Comparison between LEED and Dubai regulations*

	Green Building Regulation	LEED
Applicability	All buildings in Dubai (new, existing, refurbished..etc) but not temporary.	All buildings with regional solutions, while recognizing local realities.
Innovation	Encourage Innovation and alternative methods	Innovation in design, Exemplary Performance and Pilot Credit up to 5 points credit
Parking	Building with more than 20 parking, 5% of total cars to be designated parking for low emitting fuel efficient and carpool vehicles	5% of the total vehicle parking for low-emitting and fuel-efficient vehicles, 3% for alternative-fuel fueling stations , 3% for full-time equivalent (FTE) occupants
Landscaping	25% of total planted area should be adapted to Dubai climate	No specific reference in LEED
Exterior lights	shielded with automatic controls. prevent the lighting of the night sky. Wall washing lights must spill no more than 10% of the lighting past the building façade.	Exterior lighting power densities shall not exceed those specified in ANSI/ASHRAE/IESNA with controls.. maximum initial illuminance value no greater than 0.10 - 0.20 horizontal and vertical foot-candles
Roof	75% of the roof area. minimum SRI * $\geq 29$ for steep sloped roofs and $\geq 78$ for flow and low sloped roofs. Unless 30% of roof is vegetated	75% of the roof surface. Low-sloped roof minimum SRI 78 Steep-sloped roof minimum SRI 29. Unless 50% of roof is vegetated or meets specific criteria
Orientation of glazed façade	50% of glazed façade should be north oriented with 150 degree angle from east to north	provide connection to the outdoors via vision glazing between 30 inches and 90 inches above the finish floor for building occupants in 90% of all regularly occupied areas
Hardscape	50% of hardscape with minimum SRI 29	50% of the site hardscape materials with SRI of at least 29.
Thermal comfort	HVAC must be applicable for 95% of the year dry bulb temperature of 22.5 low to 25.5 high. Relative humidity 30% min to 60% max	(HVAC) systems and the building envelope to meet the requirements of SHRAE or ISO 7730
Acoustical control	follow approved document E 2003 UK	must comply with AHRAE or CEN Standards (part of indoor quality)
Envelop/energy performance	$U = 0.3 \text{ W/m}^2\text{k}$ for roof and $0.57 \text{ W/m}^2\text{k}$ for external wall. $U$ for glazing vary between 1.9 to $2.1 \text{ W/m}^2\text{k}$ if less the 40% glazing. SC between 0.25 to 0.4 max if less the 40% glazing.	building envelope and systems to meet baseline requirements using Whole Building Energy Simulation, Prescriptive Compliance Path: ASHRAE
Timber	25% of used timber for temporary or permanently must be certified.	minimum of 50% must be certified in accordance with the Forest Stewardship Council's principles and criteria, for wood building components
Recycled content	5% of total materials in construction	10% or 20%, based on cost
Regional Materials	building materials available regionally must comprise at least five percent (5%) of the total volume of materials used in the construction of the building	Use in construction between 10% or 20%, based on cost, of the total materials value

The mean scores, as shown in Table 2, are presented in an ascending order for the anticipated benefits as well as the expected challenges upon implementing green building regulations. The average mean scores for benefits vary between 7.36 and 6.13 which indicated that respondents, in general, agree on the listed benefits of imposing building regulations in Dubai. The same was also confirmed by respondents in a direct question regarding their preferences for regulations against voluntary system. The results indicated that 71% were in favour of imposing regulations against 19% who preferred voluntary systems and 10% were neutral. For the challenges, the mean scores indicated that the lack of education followed by the lack of awareness and experience are the most significant challenge as perceived by respondents. This was also observed when respondents were requested to evaluate their understanding of the new regulations. Almost 29% were not aware of the availability of new green building regulations and only 10% indicated clear understanding of the intended changes.

*Table 2: Mean Scores for Identified Benefits and Challenges*

	Benefits	Mean	Standard Deviation	Challenges	Mean	Standard Deviation
1	Sustain Profitability	7.65	2.002	Lack of Education	8.85	1.633
2	Alternative resources	7.57	2.325	Lack of stakeholder Awareness	7.15	2.129
3	Support government and investment plans	7.55	2.120	Balance the needs	7.00	2.106
4	Enhance competitive advantage	7.39	2.103	Premium Cost of green	7.00	2.211
5	Minimize risk	7.37	2.280	Economical conditions	6.77	2.460
6	Improve quality	7.36	2.107	speed of Implementation	6.30	2.216
7	Assure Compliances	6.94	2.809	Low Tariff of utilities	6.00	2.708
8				Project Delays	5.91	2.888
9				Extensive reliance on government	5.89	2.730
10				Extensive reliance on government	5.18	3.099
11				Incorporate Innovation	4.98	3.385
12				Lack of Experience	4.98	2.595

Correlation analysis carried out among different variables indicated significant correlation between experience and understanding the regulations which means that the more stakeholders are experienced in green building, the more they understand the regulation (Zikmund et. al. 2011, p. 510). On the other hand, correlation analysis showed that there was no significant correlation between each of the variables; age; experience and stakeholders' understanding, and the anticipated challenges. A one way analysis of variance (ANOVA) has been carried out to understand the impact of stakeholders' group on the results. Leven's test for homogeneity of variances in scores among the groups was conducted and the results confirmed that there were no

significant differences among the stakeholders' groups regarding the regulations' perceived benefits. However, in the case of the challenges, ANOVA indicated some variations among stakeholder groups particularly regarding the two factors; low tariffs of utilities and speed of implementation. The statistical analysis could not shed more light on the details and causes of this variation. Hence, the interviews aimed to further investigate and clarify this finding.

Out of the 20 experts sampled for semi-structured interviews, only 8 were available and agreed to participate. The findings indicated a general belief among interviewees that regulations are important to implement the green standards. The majority indicated that imposing green building regulations is a good step for Dubai and the construction market. Some experts expressed the benefits as "will cover the demand for electricity and water in the future" while others indicated that the new regulations will facilitate creating "more job opportunities". Comparing the intended regulations to the voluntary systems such as LEED, experts stated that the former has the advantage of being tailored to the specific needs of Dubai. Regardless the category of experts, most of the interviewees believed in the green building ability to sustain profitability. Consultants confirmed the long term cost savings whereas developers indicated "high aspirations for energy and water conservation". Some interviewees believed that suppliers need to work harder to gain competitive advantage in the market following the implementation of the new regulations.

Reflecting on the anticipated challenges, the lack of awareness and education were identified during the interviews as the main challenge. One of the interviewees stated that green building causes "unnecessary variation". The perceived higher cost was identified by almost all interviewees to be a barrier for implementing green building regulations. On the one hand, some interviewees indicated that the higher cost is due to the supply chain with a limited number of suppliers currently specialised in green building materials meanwhile there is an anticipated increase in green building materials prices following the imposition of the green building code. On the other hand, some interviewees justified the perceived higher cost due to the anticipated rise in the fees of consultants and contractors overheads in order to develop the needed competences and practices for the design and execution of the green buildings. Most of the interviewees identified the changes in the economy as a barrier to implementing the regulations. There was a general belief that the transformation into a green market might affect investment opportunities and that the market was not ready for this change. Experts indicated that the private sector role was limited in the development of green building regulations whereby a few experts and a limited number of construction companies were involved.

The identification of the anticipated benefits and expected challenges was achieved over two stages that embraced the analysis of the survey data then was further explained, confirmed and verified by experts in the Dubai construction market. In the third stage, the interviews aimed to investigate the way forward in order to smoothly implement the intended mandatory green building regulations starting 2014. In the following section, the findings of the interviews will be discussed leading to recommendations thought to facilitate the planned change.

### **Towards Effective Implementation of Building Regulations in Dubai**

Five key themes emerged through the interviews that need attention; 1) the current position on the learning curve; 2) the involvement of the private sector; 3) the mechanism for the evaluation and updating of the regulations; 4) including voluntary

regulations and finally 5) the impact on the market which includes three markets; the construction market, the market of building materials and the real estate market in Dubai.

The Dubai construction sector is still in the infant stage with regard to green building practices. Experts believe that there is urgent need for learning and developing skills in order to progress on the learning curve. On the other hand, some stakeholders have gained experiences from working in LEED and ISTEDAMA (Arabic term for sustainability) projects in Abu Dhabi. On the positive side, most of the interviewed consultants have LEED specialist or Sustainability department. Others would refer to a third party as required in some areas like Jebel Ali Free Zone Authority (JAFZA), in Dubai. Most of the interviewees think that education is most needed through degrees courses and workshops and that it will take time to adopt best practices and for people to gain experience.

Due to the perceived pitfalls of the suggested regulations that were highlighted in the comparison provided in Table 1 above, experts expressed their concern about the need to have an evaluation and updating mechanism to review the regulations, periodically, in order to reflect on the lessons learned, consider the changes in the market and ensure continuous improvement. Embracing voluntary systems such as LEED, will complement and further address the pitfalls of the suggested regulations and can provide an incentive and be a driver for innovation over and above the minimum mandatory hurdle set by the regulations.

The delay in the imposition of the regulations since it was first announced in 2008 was primarily due to the ambiguous impact it might have on the market amid the financial crisis which had detrimental consequences on the real estate market and subsequently the construction industry. So far, these concerns prevail despite the cautious upward trend that started to show in the real estate market in Dubai in the first quarter of 2013. The perceived higher initial investments coupled with the lack of awareness of the benefits of green buildings, particularly among consumers, fuels the fears of developers who are trying to recover from the significant losses incurred over the past few years. In addition, there was no clear evidence that the supply chain has started adaptive measures towards an efficient and competitive green building materials market.

## **RECOMMENDATIONS**

In order to facilitate the implementation of the green building regulations in Dubai by 2014, the local authorities need to address the identified concerns. In the following section, the suggested recommendations were derived from the findings of the survey and the interviews with experts meanwhile embracing the findings of previous research on green building in other countries.

Despite the current attempts to promote the green building initiative, those efforts are not clearly recognised by experts. Hence, there is a need for more intensive campaign that would reach out to a wider range of audience from the different categories of stakeholders; consultants, contractors, developers, suppliers and customers. This should be coupled with effective workshops tailored to the needs of the market and professionals in Dubai. In addition, regulators can enforce a minimum level of qualifications for professionals as a pre-requisite for trade licenses issued to contractors and consultants.

Providing incentives and trade-offs is imperative to drive the change toward green building. Trade-offs may include flexibility in allowable floor area, site coverage or height; resulting in more saleable area. Incentive schemes such as priority for loans, help obtaining environmental licenses and quality certificates can attract investors, builders and consumers. Regulators can test the new system within the public sector prior to the release of the intended regulations to the wider domain of the building industry.

The change towards green building needs to be coupled with a move towards a green culture and innovation. Both need an infrastructure that should be provided by the local authorities meanwhile involving the private sector and various categories of stakeholders. Establishing systems and regulations that embrace voluntary systems meanwhile reward green practices and innovation besides promoting the benefits to the general public will help to develop and foster the green building market. For example, LEED is offering grading incentives of innovative designs proposing new measures.

## **CONCLUSIONS**

The real estate market and subsequently the construction market in Dubai have started to show an upward trend during the first quarter of 2013. Meanwhile green building regulations will be mandatory starting 2014. In general, there is lack of awareness among stakeholders about the green building practice. The prevalent perception of the higher initial investment associated with green building and the ambiguity regarding the impact of this factor on the market is a key challenge. There are concerns about the impact of the intended regulations on the recovery of the market. In addition, the results indicated that the market will need time to adapt to the change. There is an urgent need for various categories of stakeholders to join forces in order to facilitate the move towards green building. Indeed, the government has a crucial role in regulating the market, not just by introducing regulations, but also through effective measures that should set the direction for market forces; mainly the demand and the supply. The demand is the driving force in the real estate market which in turn drives the construction market and the building materials market. The government has to promote the green building culture with emphasis on the direct benefits to the consumer meanwhile providing tangible incentives to create demand for green buildings. On the supply side, the government should enhance the learning and development among the supply chain by setting minimum qualifications as pre-requisite for trade licenses. Other measures include integrating a voluntary system as the basis for grading buildings as a differentiating factor to be rewarded. This will help the green building initiative to take off beyond the minimum hurdle set by the mandatory regulations. Developers, contractors and suppliers will be motivated to seek innovative solutions in pursuit of competitive advantage. Once the benefits of green buildings are appreciated by the customer, the demand will rise and the building materials market will start to enjoy economies of scale, thus pushing prices down.

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# UAE GREEN BUILDING STRATEGIC MODEL

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Green Building and Sustainable development is a relatively new trend within the construction industry in the UAE whereby organizations seek economic development approaches that benefit the local environment and improve the quality of life. This paper aims at developing a Strategic Model that would guide the local authorities and practitioners embarking on the challenging journey in pursuit of sustainable construction in the UAE. The model was developed over three stages. Stage one produced the theoretical framework based on two of the existing models published in the literature meanwhile building on the findings of previous work of the authors on the subject matter. The second stage witnessed the development of the initial model through the analysis of the data collected via in-depth interviews with 20 experts from the various categories of practitioners representing clients, consultants, project managers, contractors and suppliers. In the third stage, the developed model was refined and verified through a second round of in-depth interviews with experts. The results indicated the satisfaction of the interviewed sample with the suggested model as an effective tool towards the implementation of the green building initiative in UAE.

Keywords: green building, strategic model, sustainability, UAE

## INTRODUCTION

The construction industry in the UAE has recently started setting the stepping stones towards sustainable development. In general, the level of awareness of green building in the UAE needs enhancement as this initiative is still in the infant stage (Salama et al., 2010). Accordingly, the building industry is now working on developing and marketing products and processes that are more environmentally and economically viable to facilitate the move towards green building. It is argued that using these products and/or processes may result in higher initial project costs but with lower long-term operational costs (Kats, 2003).

Realising the significance of sustainable construction and green building in the UAE, The Emirates Green Building Council (EGBC) was established in July 2006 making the UAE the 8th country in the world to establish such a council. The UAE became a member of the World Green Building Council in September 2006 (Wilén, 2008).

EGBC adopted LEED (Leadership in Energy and Environmental Design) as a green building rating system, for the UAE in general and Dubai in particular. It was slightly

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modified to suit the local conditions. For example, in water usage, the UAE moved from a 5 point system to a 12 point system, as water issues are very important in the country (Wilen, 2008). On the other hand, Abu Dhabi launched the sustainability program, Estidama, in May 2008 whereby the Pearl Rating System was drafted for new buildings in 2007 and complemented in 2008 by the Interim Estidama Community Guidelines (IECG).

## **CONTEXT AND RATIONALE**

Reviewing the literature, it was clear that there were many models addressing various issues in the context of sustainability and green building and all of them were mainly related to the developed world; there were no comprehensive models developed to provide the correct path towards the ‘green building’ concept in the developing countries including the UAE. In addition, the green initiative in the UAE is still in its infant stage (Salama and Hana, 2010). Hence, this paper addresses the need to develop a strategic model which guides the local authorities and the construction industry towards the implementation of the green building initiative. Further more, the model can be considered by the construction industries in developing countries within the Middle East; outlining the road map towards ‘sustainable construction’.

## **AIMS AND OBJECTIVES**

This study aims at developing a Green Building Strategic Model for the UAE (UAE GBSM) that outlines and combines the main features and measures of the road map towards the ‘green building’ notion. The aim of the model is to provide guidance and direction to the local authorities and the construction industry, and to assist them in ensuring the successful implementation of the green building initiative in the UAE.

## **LITERATURE REVIEW**

The suggested strategic model was initially drafted based on the combination of two theoretical frameworks. The first theoretical framework builds on the work of Vanegas et al., (1996) and Huovila and Koskela (1998) with regards to the evolution and challenges of the sustainable construction concept in a global context, known as ‘sustainable belief systems’ model. This has the shape of a triangle where the 3 corners represent: environmental, social, and economic sustainability. The traditional design and construction, referred to as the current belief system, focused primarily on delivering a building to the client with the best possible balance of cost, time and quality (economic objectives). Sustainable design and construction adds to these criteria the minimization of resource depletion, minimization of environmental degradation, and creating a healthy built environment (Kibert, 1994; Crowther, 2006). The shift to sustainability could be seen as a new paradigm where sustainable objectives are reflected within the building design and construction throughout the various stages of the life cycle of the building / facility (Vanegas et al., 1996). This should be in line with environmental sustainability and would expand upon the economic objectives to include major sustainable goals such as minimizing depletion of resources, conserving biodiversity, and reducing harmful emissions. The new paradigm was further developed by Huovila and Koskela (1998) where these sustainable goals would then sit within a ‘global context’, also referred to as ‘sustainable beliefs system’

The second theoretical framework builds on the work of Richardson and Lynes (2007) on the key ingredients for success, exploring the barriers and motivations to the construction of green buildings at the University of Waterloo (UW) in Canada. Their

overview on the barriers and motivations to the implementation of green buildings revealed two recurring themes: financial and organizational. They concluded that the successful implementation of green buildings requires four key ingredients namely 1) leadership, 2) sustainable targets, 3) financial vision and 4) communication & collaboration.

In addition, the literature review identified the four-pillar model of sustainability includes four interlinked dimensions namely 1) environmental responsibility, 2) economic health, 3) social equity, and 4) cultural vitality (Hawkes, 2001). In addition to the triple bottom line of sustainability that reflects on the economic, environmental and social dimensions, the cultural bottom line was included due to the crucial role that culture plays in defining the attitudes, values and behaviours of a society (Kingston, 2010).

## **METHODOLOGY**

### **UAE Green Building Strategic Model (GBSM) Configuration**

A first draft of the UAE Green Building Strategic Model (UAE – GBSM) was configured by combining both theoretical frameworks mentioned in the literature review. The proposed Strategic model consisted of four key pillars namely 1) Leadership, 2) Financial Vision, 3) Sustainability Objectives/Targets and 4) Communication & Collaboration, and their relevant measures. Each pillar has the shape of a triangle and pointing towards the ‘Green Building in the UAE’ circle which is in the centre of the model as shown in Figure1(see p.8). In addition, the model proposed that the four pillars should be embraced by a UAE Federal Legislation. This will bestow support to the areas in which the UAE needs to improve and will endorse the forward-looking approach towards sustainable construction as well as ensuring the successful implementation of green building projects.

### **Two-Stage Semi-Structured Interviews**

The qualitative data collection technique was conducted through two-stage semi-structured interviews with a total of 26 interviews. The main objective of the 1<sup>st</sup> round of the semi-structured interviews was to examine and evaluate the themes underlying the development of the proposed UAE Green Building Strategic Model (UAE GBSM) as shown in Table 1, while the 2<sup>nd</sup> round of semi-structured interviews sought to verify the modified model that was based on the findings of the first round.

### **Sampling & data collection**

A purposive sampling approach was considered, for both interviews. In the 1<sup>st</sup> stage of data collection a set of ‘20’ interviews were conducted with the construction key stakeholders, in Dubai and Abu Dhabi, covering the five categories and the distribution was as follow: 4 clients; 4 project managers; 4 consultants; 4 contractors and 4 manufacturers and suppliers. The 2<sup>nd</sup> stage of data collection comprised a set of 6 interviews with 2 clients and one from each of the other 4 categories. The informants were chosen based on three criteria: a) having expertise and recognized experience in the green building practice, b) working for organizations which are active members in the Emirates Green Building Council (EGBC) and c) being an active representative of his/her organizations to the EGBC. The interviews were carried out in the informants’ offices.

*Table 1 Interview’s Themes and Purpose*

1 <sup>st</sup> Round of Interviews – Themes	Purpose
Q1 – Leadership	UAE Government Vision & Leadership with regard to sustainable development.
Q2 - Financial Vision	The financial dimension being an essential ingredient for the success of green buildings in the UAE.
Q3 - Sustainability Targets & Objectives	Sustainability targets are important pre-requisites to the construction of green buildings in the UAE.
Q4 - Communication & Collaboration	Communication among construction industry key stakeholders, collaboration with Emirates Green Building Council (EGBC) and worth of integrative design process (IDP).
2 <sup>nd</sup> Round of Interviews – Themes	Purpose
Q1 - Impression	Getting the feel of the construction industry on the model
Q2 - Suitability and Applicability	Identifying the suitability and applicability of the model in terms of being comprehensive and practical.
Q3 - Challenges and Barriers	Identifying the challenges and barriers that could face the using of the Model as a road map towards the successful implementation of green building in the UAE.
Q4 - Recommendations and/or Modifications	Spotting any recommendations and/or modifications that might make the model more efficient.

## DISCUSSION & FINDINGS

### 1st Round - Discussion & Findings

All the interviewees agreed that the UAE federal government should lead the transition towards sustainable construction and lay the foundation for environmentally, socially, and economically sustainable development throughout the UAE. Five attributes emerged: 1) vision, 2) green legislation, 3) leading by example, 4) education & media and 5) financial incentives. All 20 informants agreed that the financial dimension is a key pillar for the successful implementation of green buildings in the UAE. Primarily, this dimension aimed at minimizing the initial investments as well as the operational costs of buildings. The local authorities are requested to introduce regulations that reward building designs with lower energy costs and higher savings on water and emissions. During the interviews, the following nine factors were thoroughly discussed: 1) initial investments, 2) short-term budget horizons, 3) energy cost, 4) life-cycle cost, 5) operation and maintenance cost, 6) pay-back period, 7) return on investment (ROI), 8) financial incentives and 9) credit crisis impact.

The results indicated that sustainability objectives (targets) are important pre-requisites to the construction of green buildings in the UAE. Experts stressed that quantitative sustainability targets should be identified, clearly set and closely monitored from the outset and throughout the project life cycle various stages. The majority pointed out that the stakeholders of green projects required these targets to be identified, well communicated and clearly explained from the outset. This should provide guidance through the design process and should facilitate the effective monitoring of the project progress. Ideally, these targets should be guided and further embraced within the governments green legislation and regulations reflecting the most significant environmental, economical and social issues to the UAE such as energy

efficiency, water efficiency, building materials, waste management, gas emissions, renewable energy, etc...

The majority of the informants agreed that effective communication and collaboration amongst stakeholders is a key element for enhancing the awareness of the green culture initiative particularly that the UAE green building culture and knowledge is still in the infant stage. In other words, all should be involved and committed from the inception stage of the project to attain the required green targets. A few informants stressed that once the legislation and regulations are in place, the construction industry will be regulated by the new laws and subsequent chains will be developed. This will enhance communication to the required level.

The majority of the informants acknowledged the importance of the role of the Emirates Green Building Council (EGBC) in endorsing green building principles and practices to achieve high performance buildings that utilize environmentally friendly technologies. In addition, the results indicated the need to work closely meanwhile effectively exploiting EGBC expertise and knowledge in sustainable construction. Both will endorse and further enhance the communication and coordination amongst all the parties.

There was a common consensus that the Integrative Design Process (IDP) is a whole building approach which is very important to green building since it leads to simpler yet high-efficiency buildings and improves the economic and environmental performance. It was agreed that IDP enhances green building decision making through clear understanding of sustainability goals and economics from the inception stage. In this pursuit, integrated multidisciplinary design team comprising owners, architects, engineers, technicians, contractors and suppliers should be active and effective.

### **Verification of the modified UAE Green Building Strategic Model (GBSM)**

The analysis of the findings of the 1<sup>st</sup> round of 20 interviews was instrumental in refining the initial model in the context of the UAE green building initiative. Hence, a modified strategic model was developed to embrace the findings of the interviews. An additional level indicating the need for sustainability policies and quality monitoring body through appropriate KPI's was introduced based on the findings of the interviews as shown in Figure1. The modified model was verified through a second round of 6 semi-structured interviews with experts. The informants were generally satisfied with the suggested draft of the Green Building Strategic Model and reflected that it is comprehensive and practical. They stated that the 'cultural vitality' dimension should be indicated as the fourth bottom line of sustainability although the 'cultural heritage' dimension is cited in one of the main three corners of the sustainability global context referred to as 'social equity and cultural heritage'.

In addition, the following comments were raised on the applicability of the model: a) the model should present a dynamic process that accommodates different circumstances, which allows the interaction amongst the four pillars, b) the model should be flexible; i.e. the legislation should have flexibility in terms of being reviewed, meanwhile allowing for adjustments and interaction with the four pillars, c) the model should embrace the different target groups with emphasis on the government, developers and building owners, d) the model can be used as a guide line for the UAE different local governments to check whether all aspects of sustainability are covered, e) the majority of the informants agreed that legislation is indeed the

main driver for sustainability and e) the model needs to identify a base-line and a benchmark for the financial measures pertaining to pillar 2.

Furthermore, the informants identified some challenges that could face the use of the model as a road map in Abu Dhabi and Dubai such as a) financial barriers and the credit crisis impact, b) the culture and knowledge of society – the informants conceded that the UAE society experiences a lack of culture and knowledge with regards to sustainability in general and ‘sustainable construction’ in particular and c) the subsidized price of electricity and water. At the moment, the low cost of energy / water is not going to encourage firms / individuals to minimize consumption. This is obviously a massive political issue which has many far reaching consequences and is unlikely to be resolved in the near future.

Reviewing the model layout, the following recommendations and modifications were highlighted from the interviews and helped looking into refining the model:

- The arrows should not only be clockwise but anti-clockwise. In addition, vertical and horizontal arrows should be indicated to emphasize on the dynamism of the process and ensure the flexibility of the model.

- There were two opinions on the pillars’ weighting. The proposed model introduced equal weights since the four pillars are claimed to be equally important as a basis for sustainable design. However, the weights should not be static but rather dynamic in response to particular projects / policies. The first opinion suggested that the pillars should carry similar weight. Whereas, the second opinion suggested that different stakeholders would be allowed to give different rankings / weights. The implications of this second opinion were not clearly justified by the interviewed experts. In addition, the first opinion left the door open for different weights on case by case basis if and when needed based on the merits. Further comments on the pillars included the following:

- *Pillar (1)*: The vision of the UAE government should be clear and concise resulting in definitive long-term and short-term strategies where all stakeholders should be aware of their role. These strategies need to be holistic in nature with the various authorities working together rather than acting on parallel routes. This hinders collaboration.

- *Pillar (2)*: LCC is vital for future developments in order to establish ‘best value’. However, best value may not necessarily mean reduced upfront capital. Detailed LCC will identify the most appropriate design, construction and facility management practices. In addition, a base-line should be identified whereby the financial targets of a green building as mentioned in pillar ‘2’ measures, are set and compared against the odds.

- *Pillar (3)* – Sustainable Objectives/Targets need to adopt the top-down approach; to be driven by UAE Leadership through a clear vision / strategy as clarified above. The following points were raised: a) the correct infrastructure, policies and support need to be in place before these objectives are set, otherwise confusion / incorrect practices will emerge diluting intent of objectives; b) how the objectives are going to be monitored and measured using the appropriate key performance indicators (KPI’s) which need to be set and c) the question of mitigation if objectives are not met.

- *Pillar (4)* – Effective collaboration and communication should adopt the top-down approach. This will need to then cascade down through different levels of business /

society / agencies / companies and should be encouraged at grass-root level. Effective aims for this collaborative working have to be set and monitored through clear policies and drivers. In fact, the majority of the informants emphasized the importance of working intensively on increasing the cultural awareness and knowledge level of the society (end users) with regard to sustainability and green environment in general. In addition, the educational aspect should be considered to raise awareness amongst the construction industry key stakeholders and ensure their active participation, including the operators and facility management companies.

- The 'cultural vitality' dimension should be introduced to each pillar of the model being the fourth bottom line of sustainability since it encompasses the 'cultural heritage' theme which is one of the main three corners of the sustainability global context, referred to as 'social equity and cultural heritage'.

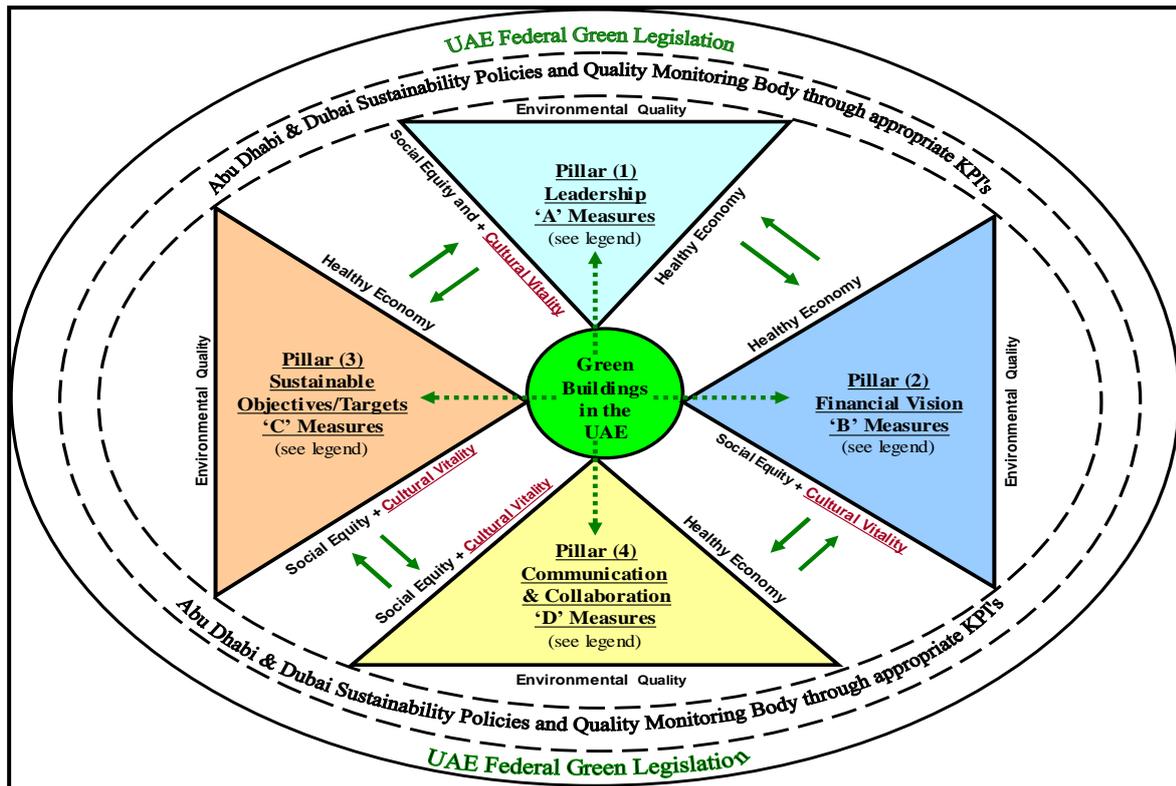
### **The UAE Green Building Strategic Model (UAE GBSM)**

Given the above-mentioned recommendations and modifications spotted by the interviewees, the modified Strategic model was reviewed and amended to produce the UAE Green Building Strategic Model (UAE GBSM) as shown in Figure 1.

The UAE Green Building Strategic Model (UAE GBSM) consists of four key pillars namely 1) Leadership, 2) Financial Vision, 3) Sustainability Objectives/Targets and 4) Communication & Collaboration. Each pillar has the shape of a triangle pointing towards the 'Green Building in the UAE' circle which is in the centre of the model. Each pillar has a triangular shape outlining the three main corners of sustainability namely environmental (environmental quality), social (social equity and cultural vitality), and economic (healthy sustainable economy) The model embraced the evolution and challenges of the sustainable construction concept in a global context which includes minimizing depletion of resources, conserving biodiversity, and reducing harmful emissions besides the traditional view focusing mainly on economics in terms of handing over a building with a balance of time, cost and quality. The four pillars are embraced by 'Abu Dhabi & Dubai Sustainability' Policies under the umbrella of a UAE Federal Green Legislation supporting the areas in which the UAE, with emphasis on Abu Dhabi and Dubai, need to improve and endorse the forward-looking approach towards sustainability as well as ensuring the successful implementation of the green building initiative.

The implementation of these policies, adopted by Abu Dhabi and Dubai authorities, should be monitored by a qualified regulatory body, through appropriate Key Performance Indicators (KPI's) in order to ensure that the construction industry is abiding by the rules and regulations and pursue the anticipated positive and negative alterations resulting from adopting the sustainable construction concept on projects in both emirates. Despite the tendency towards top-down approach as aforementioned in the analysis of the interviews data, it is argued that the combination of bottom-up approach will ensure the active participation of various levels of stakeholders. This will add value and will result in a more practical set of KPI's, accepted by all parties. The clockwise and anti-clockwise arrows as well as the vertical and horizontal ones emphasize the dynamism of the process and ensure the flexibility of the model. The four pillars complement each other and should work in parallel and not in a sequential manner.

Figure 1 UAE Green Building Strategic Model (UAE GBSM)



**LEGEND**

**Pillar (1) - Leadership - 'A' Measures**

- Clear and concise vision of the UAE Government.
- Holistic definitive strategies.
- Collaborative working amongst Authorities.
- Strong Leadership from the UAE Government and Authorities.
- Open attitude towards innovative designs.
- Financial and non-financial incentives from the local governments.

**Pillar (2) - Financial Vision - 'B' Measures**

- Minimizing both the upfront capital and lifetime operation costs of a building against a conventional one.
- Setting an operational structure that rewards building designs with life-cycle cost, long-term budget horizon, lower energy costs and higher water and emissions savings.
- Life cycle costing (LCC) as a contribution to sustainable construction.
- Financial incentives
- Payback period and return on investment (ROI)

**Pillar (3) - Sustainable Objectives/Targets - 'C' Measures**

- Quantifiable targets set by the UAE Government addressing the most pressing sustainability issues to the UAE and reflecting on Estidama (Abu Dhabi) & LEED (Dubai).
- Quantifiable targets to set goals and to assess the success of the building once it is operational (quantify progress).
- Key Performance Indicators (KPI's) to be set to monitor and measure the progress towards achieving these objectives.
- Green project stakeholders to use these targets/objectives for educational purposes, to give guidance through the design process and monitor and quantify progress.

**Pillar (4) - Communication & Collaboration - 'D' Measures**

- Effective communication amongst construction industry key Stakeholders (clients, designers, facilities management, contractors and suppliers) / Holistic Approach - Worth of Integrative Design (IDP).
- Effective communication and collaboration between the construction industry key stakeholders and the EGBC making effective use of its expertise and knowledge.
- Effective communication and collaboration between the construction industry key stakeholders any green Non Governmental Organization (NGO), i.e. the Emirates Environmental Group (EEG).
- Culture Vitality – a cultural input should be reflected in evaluating the impacts of the environmental, economic and social initiatives that are implemented in Abu Dhabi and Dubai communities.
- Education of the construction industry to increase knowledge and awareness on sustainability in general and sustainable construction (green building) in particular.
- Education of the society (end users) about sustainability is paramount to implant the right values and sense of responsibility towards the environment and the planet's limited resources.

The relative weights of each of the four pillars attracted a debate amongst experts. Given that the green building initiative is still at the infant stage in the UAE, this study recommends that the four pillars would carry equal weights. However, this can be changed in the future with the development of the green building practice in the UAE. It is expected that, over time, the weight of the Leadership pillar can be relatively reduced as the green building regulations and procedures become more established. On the other hand, the financial pillar is expected to attract relatively higher weight. This will be reinforced once the current ambiguity about the claimed higher costs associated with green buildings is clarified through practice and economies of scale. It is important to note that the weights are dynamic rather than being static. This will depend on the nature and priorities of the entity (category) looking at the model and in response to particular projects. The ‘social equity and cultural heritage’ corner of the global context sustainability (the triangular shape) is replaced by ‘social equity and cultural vitality’ since the culture heritage is an element of the culture vitality, which comprises four themes namely 1) arts, creativity and environment, 2) history and heritage, 3) active citizenship and 4) diversity (Focus Kingston, 2010). The ‘cultural vitality’ dimension is underlined and indicated in bold to stress on the key role it plays and the core influence it has on the triple bottom line of sustainability: environmental, economic and social. The measures of each pillar of the model were modified as shown in Figure 1.

## CONCLUSIONS

This study aimed at developing a Strategic model that would guide the government, local authorities and construction practitioners in the UAE. The results indicated the satisfaction of the interviewed experts with the developed model where all features pertaining to the sustainable construction concept were well thought of. There was a general consensus on the suitability of the model to the context of UAE. In addition some recommendations were raised emphasising three main dimensions: 1) the ‘cultural vitality’ dimension should be included as a fourth bottom line due to the vital role it plays in considering the attitudes, values and behaviours of the society. 2) the ‘life cycle costing’ (LCC) approach should be applied as an integral dimension of the green notion. 3) The end users’ culture and awareness of sustainability should be developed through education to change the current mindset and increase the sense of responsibility towards the environment.

The developed model was re-examined and amended accordingly; generating the UAE Green Building Strategic Model (UAE GBSM). Subsequent to the findings of this study, the next step would aim at investigating, in further depth, the way forward towards the effective implementation of the green building concept in the UAE, having identified the coordinates of the current position, with emphasis on the Initial Capital Cost, Life Cycle Costing (LCC) and Insurance and Risk Management Benefits of Green Buildings. In addition, further direction includes the attempt to validate this model in a practical context through contacts with the industry and local authorities. The most recent announcement by the government of Dubai about imposing green building regulations starting 2014 will provide an attractive opportunity in this pursuit.

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# THE ROLE OF BENEFICIARIES' PARTICIPATION IN SOUTH AFRICA LOW-INCOME HOUSING OCCUPANTS' SATISFACTION

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The purpose of this paper is to present findings from an investigation conducted in South Africa subsidised low-income housing, on how beneficiary's participation could influence residents' satisfaction with their houses. The study was conducted amongst South Africa housing practitioners' and the low-income housing occupants'. Data used in the study was obtained from a Delphi and field questionnaire study. Using Structural Equation Modelling software EQS, the influence of beneficiaries' participation was investigated. The finding was that beneficiary participation influence on the residents' satisfaction was statistically significant and hence exacted a direct influence in the prediction of the residents' satisfaction with their houses. The research was conducted in South Africa three metropolitan and one district municipalities. Therefore due to the idiosyncratic dataset used in the study, it remains to be seen if the evaluated relationships between beneficiary participation and residents' satisfaction can replicate to other cross-cultural datasets. If this is the case, the paper makes a significant contribution towards understanding residential satisfaction on subsidised low-income housing projects. This study provided significant insight into how beneficiary participation influence residents' satisfaction and how residents' satisfaction with their houses could be improved.

Keywords: residential satisfaction, beneficiary participation, influence, South Africa

## INTRODUCTION

The failure of many government housing projects is as a result of the lack of knowledge and understanding on the determinants of Residential Satisfaction (RS) concept (Salleh, 2008). The success of housing programmes does not only depend on merely provision of housing units, but also on other factors that should have been considered during the housing developmental process. The achievement of government housing programmes does not only depend on bulk quantitative delivery of housing units, but also on the understanding of the factors that influence's the needs of residents and the eventual satisfaction they derive from the housing product. Hence, RS deals with housing occupants' satisfaction with housing products, with the aim of informing housing policy and planning intervention (Yiping, 2005). RS has been credited as one of the most significant concept which should be considered in design

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and planning process for different nations housing policies. Nevertheless, RS is a subjective concept because of the multifaceted nature between other concepts (Ge & Hokao, 2006). Research in residential satisfaction is a valid way to assess the overall performance of the housing system (Francescato et al., 1987).

Despite the various measures to improve low-income housing satisfaction in South Africa state, the standard has remained a persistent and divisive social issue among the practitioners of social housing studies, academia, non-governmental organizations, government, and the affected citizens amongst others in South Africa (Aigbavboa & Thwala, 2012). The beneficiaries of low-income housing in South Africa desire to live in a conducive housing environment, but the housing condition has been gradually deteriorating without due consideration to the active participation of the beneficiaries by the housing providers in the development process. There is the continual formulation and implementation of housing policies and programmes without any meaningful consultation with the eventual beneficiaries of the low-income houses. The achievement of occupant's satisfaction in terms of their participation in the housing process is a key factor that contributes to the ultimate success of that project, as their contributions would highlight areas that need consideration during the development process thus leading to housing satisfaction.

Therefore, it is useful to explore the meaning of satisfaction from the residents' perspective in order to have a holistic view of the housing system. Studying satisfaction requires the real understanding of beneficiaries' meaningful participation, as housing issues affect an entire community or group of people who in the present context are the low income and disadvantaged groups of the South African society. Beneficiary's participation offers an opportunity to engage those who are affected by housing issues in a dialogue; defining problems and creating solutions. The inclusion of community stakeholders in the housing process helps ensure appropriate housing strategies and policies are developed through more efficient evaluation, development and implementation to guarantee the satisfaction of the beneficiaries'. Inadequate beneficiaries' participation in the process can lead to community conflict or as a worst case scenario, anti-development initiatives and ultimately housing dissatisfaction, which impacts on the quality of life of the beneficiaries. Successful beneficiaries' participation is important because a mixed cross section of the population that has a housing need can be involved in defining the housing problem and in crafting community sensitive solutions. However, there is disagreement among planners and professionals about the contribution of beneficiaries' participation in improving the lives of the people, particularly the poor and disadvantaged (Rifkin & Kangere, 2002). Some completely dismiss its value altogether, while others believe that it is the "magic bullet", (Rifkin & Kangere, 2002), that will ensure improvements especially in the context of poverty alleviation, and community ownership.

Too frequently, development initiatives have been designed by those who have no real knowledgeable understanding of the real needs of a specific community. Hence, most times, the produced 'housing plan' is based on the different stakeholders' perceived needs of the low-income groups instead of the beneficiaries' true needs. Kotze and Kellerman (1997) attribute this to the fact that the idea that development consists of a transfer of skills or information creates a role for the expert as the only person capable of facilitating the transfer of these skills from them to the community or society. In order to create developmental efforts that echo the real needs and expectations of specific groups, inclusive of development that will satisfy the people, a paradigm shift is needed in the current conceptualization of residential satisfaction research. This is a

shift from the so-called blueprint approach to development toward a more process and people-centered development that should produce beneficiaries' participation. According to Oakley (1991) the role of beneficiaries' participation in South Africa cannot be undermined or may not override economic, personal or technological aspirations in the South Africa public sector as the country's past governance situation should compel the government to correct injustices by actively involving the affected in policy development.

Therefore, this research present finding from an investigation conducted in South Africa subsidised low-income housing, on how beneficiary's participation could influence residents' satisfaction with their houses. The paper starts with an overview of the literature on this topic. Then, the methodology adopted for the study is presented followed by the results of the questionnaire survey analysis and findings of the research. Finally, the paper draws some conclusions. The paper makes a significant contribution towards understanding residential satisfaction in subsidised low-income housing developments. This study provided significant insight into how residents' satisfaction with their houses could be improved through the active involvement of the housing beneficiaries. Thus, the next section of the article presents an overview on the theoretical framework of beneficiaries' participation in housing development process.

## **BACKGROUND ON BENEFICIARY PARTICIPATION**

Participation is a rich concept that varies with its application and definition. The way participation is defined, depends on the context in which it occurs. For some scholars, it is a matter of principle; for others, a matter of practice; for even more it is an end in itself as described above. Most times, the term participation is modified with adjectives, resulting in terms such as community participation, citizen participation, people's participation, public participation, popular participation or even beneficiary participation as used in the current research.

The Macmillan English Dictionary (2002:1032) defines participation as "to have a share in" or "to take part in," thereby emphasizing the rights of individuals and the choices that they make in order to participate. Whilst, Arnstein (1969) states that the idea of citizen participation is a "little like eating spinach: no one is against it in principle because it is good for you". Also, Mathbor (2008) defined beneficiaries participation as a process by which beneficiaries' act in response to public concerns, voice their opinions about decisions that affect them, and take responsibility for changes to the community. Likewise, citizens' participation may also be referred to as a response to the traditional sense of powerlessness felt by the general public when it comes to influencing government decisions. This is because citizens often feel that housing development issues are beyond their control because the decisions are made outside their community by unknown bureaucrats and technocrats. Hence, beneficiary participation is the direct involvement of the citizenry in the affairs of planning, governance and overall development programmes at local or grass roots level.

Beneficiary participation requires recognition and use of beneficiaries' capacities and avoids the imposition of priorities from the outside. It increases the odds that a programme will be on target and its results will more likely be sustainable and satisfactory to meet the needs and expectation of the beneficiaries. Ultimately, participatory development is driven by a belief in the importance of entrusting citizens with the responsibility of shaping their own future. Likewise, participation is a process through which stakeholders influence and share control over development initiatives

and the decisions and resources which affect them. In this perspective, the benefits of participatory development are perceived to be self-evident.

The significance of beneficiary participation is said to draw from three main factors. Primarily, it is alleged to allow for cost reduction through the utilization of local labour and expertise (Davidson et al., 2007). Secondly, it potentially leads to the implementation of appropriate responses through the involvement of locals in collective decision-making, through the assessment of their needs and expectations, (Davidson et al., 2007) thus guaranteeing housing satisfaction. Thirdly, it helps in directing scarce resources towards the more needy, identified by fellow locals (Davidson et al., 2007). Beneficiary participation is perceived as an undertaking that results in the empowerment of the local population. However, it also has numerous non-benevolent political significances. It is referred to as a curious element in the democratic decision-making process. While the roots of beneficiary participation can be traced to ancient Greece and colonial New England, its significance reflects a contemporary recognition that societies are simply too remote to be truly “of, by and for the people” without their involvement in the development that affects them. Beneficiary participation in the public sector organisation has undergone a significant change. Prior to this, people were more tolerant of poor service deliveries; more patient in long queues and enduring inefficient public administration than they are now (Olivier, 2003). Nowadays, people are expecting quality delivery of public services and are beginning to hold elected representatives increasingly accountable, when their expectations are not met. Hence, the origin of beneficiary participation can probably be traced to three root sources, which are: participation as good development project practice; participation as good governance and participation as political empowerment.

## **LEGISLATIVE FRAMEWORK OF BENEFICIARY PARTICIPATORY IN SOUTH AFRICA**

Since 1994, the South African government has put in place policy and legislative frameworks that seek to promote participatory governance. The notion of beneficiary participation is embedded in the South African Constitution. Recognizing the adverse impact of Apartheid on adequately housing the majority of South African citizens, the democratic government in 1994, from the outset, placed emphasis on the provision of housing, as a basic human right. The principles of citizen participation are clearly articulated in the Housing White Paper and further advanced in the Development Facilitation Act of 1995, of which the policy goals were later given legal effect by the 1996 Constitution.

In harmony with the Restructure and Development Programmes, the 1994 Housing White Paper committed the government “to a development process driven from within the communities” (Section 4.4.4.), which would promote “the participation of affected communities in the planning and implementation of new developments” (Section 4.5.1). This viewpoint was also advanced in the 1997 National Housing Act which emphasizes, in Section 2(1) that national, provincial and local spheres of government must: “give priority to the needs of the poor in respect of housing development; consult meaningfully with individual and communities affected by housing development; ensure that housing development ... is administered in a transparent and equitable manner, and upholds the practice of good governance”. The South African Government’s commitment to consultation, public participation transparency, and the adherence to agreed norms and standards is further evident in the 2008 Social Housing

Act (Act No. 16 of 2008), which, in Section 2.1, states the need to: “consult with interested individuals, communities and financial institutions in all phases of social housing development. Moreover, the South Africa constitutional requirements for beneficiary participation is further found in its mandate for local government, but more specifically in Chapter 10, Section 195, which states that: “public administration must be development-oriented; people’s need must be responded to, and the public must be encouraged to participate in policy making and good human resource management and career development practices must be cultivated to maximize human potential”.

## **METHOD**

The study was conducted using both qualitative and quantitative data collection methods. For the qualitative data, a Delphi technique was used, while field questionnaire survey was used for the quantitative aspect. The Delphi survey was conducted with 15 sustainable human settlement experts drawn from the nine provinces of South Africa. The output from the Delphi techniques was a refinement of conceptual variables for beneficiaries’ participation (BNP) features. With regards to the quantitative aspect of the study, a face-to-face administered questionnaire survey was conducted among 751 low-income housing residents’ in three metropolitan and one district municipality in the Gauteng Province of South.

SEM software- EQS software Version 6.2 was used to assess the factor structure of the constructs. The conceptual variables were thereafter tested as a priori using the questionnaire survey results. Due to the limited space in current paper, the Delphi process is not discussed.

### **Model analysis**

Confirmatory factor analysis (CFA) using EQS Version 6.2 (Bentler & Wu, 1995) was used to test the beneficiaries participation features priori which were determined from the literature and further validated via the Delphi survey. The construct parameters were estimated using the Maximum Likelihood method. Since psychometric data have a tendency to be not normally distributed, consideration was given to the Mardia coefficient. Meaning, if the Mardia values showed significant deviation from normality, the Satorra-Bentler Scaled statistics (Robust) would be used as these have been found to perform adequately under such conditions (Bentler, 1988). In establishing the score reliability, construct validity for the variables was conducted to demonstrate the extent to which the constructs hypothetically relate to one another. This is also referred to as the test of measurement invariance (MI) between indicator variables. Measurement invariance is a very important requisite in SEM. It attempts to verify that the factors are measuring the same underlying latent construct within the same condition. MI ensures that the attributes relate to the same set of observations in the same way. The MI for the BNP features was determined based on examination of the residual covariance matrix from the CFA output result as opposed to the correlation matrix. Covariance matrix establishes the variables that adequately measure the BNP construct.

Hence, preliminary Confirmatory Factor Analysis (CFA) was performed to measure the neighbourhood variable indicators to identify which items appropriately measures the neighbourhood features. Indicators variables with an unacceptably high residual covariance matrix ( $>2.58$ ) were dropped, because they do not sufficiently measure the BNP features regardless of their importance in other cultural context and past research

studies. Residual covariance matrix values greater than 2.58 are considered large (Byrne, 2006). Therefore, in order for a variable to be described as well-fitting in measuring a construct like BNP, the distribution of residuals covariance matrix should be symmetrical and centered around zero. This procedure was adopted as a means to ensure that the indicator variables were measuring the same latent construct.

## RESULTS AND DISCUSSION

### Measurement Model for Beneficiaries Participation (BNP)

The number of cases that were analysed for the BNP construct was 751 cases. No case was skipped. From the initial CFA statistical analysis one indicator variable (BNP5) had an unsatisfactorily high residual covariance matrix factor loading (2.60), hence it was dropped. Inspection of the Bentler-Weeks Structure representation for the construct revealed that the BNP construct has 4 dependent variables, 5 independent variables and 8 free parameters. The number of fixed non-zero parameter was 5. Therefore only four indicator variables passed the test and were used for further assessment of the measurement model goodness-of-fit. Analysis of the Mardia values showed that the data deviated significantly from normality (Mardia = 56.0118).

*Table 1: Robust fit indexes for beneficiary participation construct*

Fit Index	Cut-off value	Estimate	Comment
$S - B\chi^2$		2.104	
$df$	$0 \geq$	2	Acceptable
CFI	$0.90 \geq$ acceptable $0.95 \geq$ good fit	0.955	Good fit
SRMR	$0.08 \geq$ acceptable $0.05 \geq$ good fit	0.006	Good fit
RMSEA	$0.08 \geq$ acceptable $0.05 \geq$ good fit	0.008	Acceptable fit
RMSEA 90% CI		0.000:0.073	Acceptable range

The sample data on beneficiary participation measurement model yield the  $S - B\chi^2$  of 2.104 with 2 degrees of freedom. The chi-square value advocated that the difference between the sample data and the hypothesised construct was insignificant. From these values, the normed chi-square value was determined to be 1.052. The normed chi-square is the procedure of dividing the chi-square by the degrees of freedom. The normed values of up to 3.0 or 5.0 are recommended (Kline, 2005). The ratio of  $S - B\chi^2$  to the degrees of freedom was lower than the upper limit value of 3.0 suggesting an acceptable fit of the data to the construct. However, the chi-square statistics is only indicative of fit and therefore, other goodness-of-fit indexes were reviewed.

The goodness-of-fit indexes are presented in Table 1. The robust comparative fit index (CFI) of 0.955 was higher than the minimum value of 0.95 set for good fit criteria. A model is said to be a good fit if the CFI is above the cut-off value of 0.95 (Hu & Bentler, 1999). The robust root mean square error of approximation (RMSEA) with 90% confidence interval was found to be 0.008 (lower bound value = 0.000 and the upper bound value = 0.073). This value was below the maximum value of 0.08 for a good fit model. Hence, this was considered as an acceptable model fit. In addition, the absolute fit index, standardised root mean square residual (SRMR) was found to be

0.006. This value indicated a very good fit because a good fitting model is expected to have an SRMR index lower or equal to 0.05, whilst an index of 0.08 is sufficient to accept the postulated model. The absolute fit index SRMR accounts for the average discrepancy between the sample and the postulated correlation matrices and therefore, it represents the average value across all standardised residuals and ranges between zero and 1.00. Evaluation of the SRMR, RMSEA (90% CI), and the CFI fit indexes indicated an acceptable fit of the measurement model for the BNP features factor.

### **Analysing the influence of beneficiary participation on residents' overall satisfaction**

In order to determine the internal consistency of the composition of the measurement model the Rho Coefficient and the Cronbach's Alpha Coefficient were examined to establish reliability. According to Kline (2005), the reliability coefficient should fall between zero and 1.00, while values close to 1.00 are desired. The Rho Coefficient of internal consistency was found to be 0.939. This value was above the minimum required value of 0.70. Similarly, the Cronbach's alpha was above the minimum acceptable value of 0.70 at 0.938. Both of these values indicated a high degree of internal consistency and homogeneity. Therefore, the neighbourhood factor satisfied both internal reliability and the construct validity criteria.

*Table 2: Reliability and Construct Validity of BNP Model*

Indicator Variables	Standard Coefficient ( $\lambda$ )	Z-Stats	R <sup>2</sup>	Total Variance	Factor Loading	Sign. @ 5% level
BNP1	0.835	**	**	0.698	62.55%	Yes
BNP2	0.922	41.280	41.280	0.850	64.84%	Yes
BNP3	0.924	40.218	40.218	0.854	64.89%	Yes
BNP4	0.888	36.359	36.359	0.788	63.98%	Yes
RS1	0.797	**	**	0.635	61.45%	Yes
RS3	0.510	13.527	13.527	0.260	50.50%	Yes
RS5	0.391	9.122	9.122	0.153	43.88%	Yes
RS7	0.617	14.956	14.956	0.381	55.24%	Yes

*Cronbach's Alpha = 0.938; Rho Coefficient = 0.939;  $p < 0.05$*

*(Robust Statistical Significance at 5% level)*

*\*\* SEM Analysis Norm (Kline, 2005) - One variable loading per latent factor is set equal to 1.0 in order to set the metric for that factor. \*Parameter estimates are based on standardized solutions*

Similarly, the construct validity was determined by examining the magnitude of the parameter coefficients. High parameter coefficients of greater than 0.5 indicate a close relation between the factor and an indicator variable. A parameter coefficient of 0.5 is interpreted as 25% of the total variance in the indicator variable being explained by the latent variable (factor). Therefore, a parameter coefficient has to be greater than 0.5 - 0.7 or greater to explain about 50% of the variance in an indicator variable (Hair et al., 1998). Hence, the inspection of the standardized factor loadings revealed that all values were generally large and statistically significant (values ranged from 0.835 to 0.924). The estimate of 0.835 suggested that the measured factor accounts for 62.55% of the variance in predicting RS. The total variances accounted for in each indicator variables by the endogenous variable revealed that the scores were significance at 5% level.

Also, the interfactor correlation (R<sup>2</sup>) values were large and statistically significant (values ranged from 0.698 to 0.854) as shown in Table 2. The interfactor correlation

( $R^2$ ) test statistics need to be greater than 1.96 based on the probability level of 5% before the hypothesis can be rejected. The test statistics is the parameter estimate divided by its standard error and therefore, it functions as a Z-statistics to test that the estimate is statistically different from zero. Inspection of the correlation values, standard errors and the test statistic, reveal that all standardized coefficient correlation values were not greater than 1.00; all test statistics (*Z-values*) were greater than 1.96 ( $p < 0.05$ ) and the signs were appropriate (positive) and found to be statistically significant. Therefore, the score results suggested that the influence of beneficiary participation in determining beneficiaries overall satisfaction with their subsidised dwelling units was direct and statistically significant.

## DISCUSSION

The finding was that BNP variables satisfied both internal reliability and the construct validity criteria. The Rho value was above the minimum value of 0.70 and the construct validity criteria was justified by the magnitude, and statistical significance of all parameter coefficients.

The SEM results revealed that the standardized factor values and interfactor correlations for the beneficiary participation latent factor were large and statistically significant. Inspection of the total variances accounted for in each measure by the BNP variable revealed that the scores were also significant. The relationship between beneficiary's participation indicators and residential satisfaction is found to be statistically significant. The parameter with the highest standardised coefficient for this factor was the indicator variable BNP3. The indicator variable BNP3, which asked the beneficiaries of their level of agreement, if owners should be consulted about the construction of their houses, was found to be mostly associated with overall residential satisfaction than all other indicator variables. Thus, the overall results suggested that the influence of beneficiary participation in determining beneficiaries overall satisfaction with their subsidised dwelling units is direct and statistically significant.

Findings suggest that when beneficiary participation is incorporated into the housing development process, the outcomes are more likely to suit local circumstances, ensure community 'ownership', and increase the sustainability and eventually the satisfaction with the housing development. Developing and maintaining the participation of beneficiaries can often be a challenge requiring various strategies and considerations. However, participation can encompass many activities. It can be beneficiary involvement in the initial planning stages of a project, the development of action plans, or being a member of working groups, reference groups and focus groups. It could mean receiving project updates in the form of a newsletter, or providing reflections or feedback about the implementation of a project strategy from a project recipient's point of view. Most times, the promotion of beneficiary participation in both project planning and implementation are implemented especially with regard to: project location; type of land tenure; type and level of services; house design; position of the house within the housing location; choice of material supply; and house construction methods, etc.

The SEM results advanced that the beneficiaries' participation in a housing development project that concerns them, could potentially lead to the implementation of appropriate responses through their being consulted about the housing location, house design, house construction and selection of the internal finishes of the house, which can be incorporated into the development process and eventually lead to their

satisfaction and sustainability of the housing project. Hence, the findings from the study did not concur with the work of Lizarralde and Massyn (2008) where it was found that the performance (satisfaction) of low-cost housing projects does not depend on community participation. Also, Davidson et al. (2007) previously found that community participation can easily become rhetoric in its implementation if it is not well guided. However, in the study done by Lizarralde and Massyn (2008), it is further reported that community participation was wrongly implemented in the reported case studies. In other words, the principle is 'good' but the implementation failed, hence the statement that the performance of low-cost housing projects does not really depend on community participation. In reality, the performance of low-cost housing projects depends on a complex interaction of participants' interests, objectives, resources and processes that go beyond the benefits of the participation of the beneficiaries alone. Hence, it should be stated that the participation of the beneficiaries is not positive; in fact it is crucial. The SEM results thus suggest that when beneficiaries have control over resources affecting their lives, it can lead to changes in knowledge and skill and their needs and expectations would have been taken care of through their activate participation in the development process.

## CONCLUSIONS

This paper presented findings from an investigation conducted in South Africa subsidised low-income housing, on the influence of beneficiary's participation in the prediction of residents' satisfaction with their houses. The finding was that beneficiary participation influence on the residents' satisfaction was statistically significant and hence exacted a direct influence in the prediction of the residents' satisfaction with their houses.

The findings further revealed that when the beneficiaries' are made to participate in the housing process, they will understand what the housing project entails and it will limits misunderstandings with regards to the overall project aims. Hence, in order for subsidised low-income housing development to be truly sustainable in South Africa, it is recommended that the government and other stakeholders should practically encourage participation in the housing development process; educate the beneficiaries' on various issues such as sustainability, empowerment, capacity building, self-reliance and effectiveness. Government support is critical in starting any form of beneficiary participation policies; which should be drafted to create a regulatory framework and an enabling environment that facilitate active participation in line with the principle of democracy as have been firmly entrenched by legal frameworks in South Africa.

Also, it is recommended that municipalities, who mostly are responsible for the housing development, should develop a culture of public participation by building the capacities of local communities as specified by the Municipal Property Act of 2004.

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# DECISION SUPPORT FRAMEWORK FOR LOW IMPACT HOUSING DESIGN IN THE UK

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There is an increasing drive to achieve sustainability agenda, as well as climate change challenges. For UK buildings, design is believed to be the key in delivering the low impact agenda. Hence, a fundamental change to designers' approach in designing for low impact buildings is needed. However, existing design- decision support tools had not addressed in full the expectation of architects to design such buildings. The tools, specifically the Building Performance Energy Simulation (BPES) tools are not fully integrated into the design process, to enable UK architects to make informed decision at the early stage of the design process. Thus, this study seeks to provide a decision support framework that defines the required characteristics of BPES tools for architects to achieve low carbon housing (LCHs) design in United Kingdom (UK). It sets out to determine how UK architects can achieve the design; what the needs of architects are in BPES tools to deliver the design; and what design decision tasks are required, towards development of the framework. Consequently, the research examined low impact housing design. Existing statutory and non-statutory regulations, as well as design and decision support tools, which relate to the design and its delivery, were identified. These were used to frame the questions for the qualitative semi structured, face-to-face and in-depth interviews with architects in practice and in the academia. Data analysis revealed that there is lack of fitness between existing decision support tools, in form of Building Performance Energy Simulation (BPES) tools, and the various stages of the design process. It emerged that architects use BPES tools, primarily at the later stage of the process. Support for the early design stage remains poor, especially at the conceptual stage of the design process. The findings confirmed that design decisions for low impact housing design vary significantly in terms of level of accuracy, flexibility, and detail. At the earlier stages of the process, as relatively little information is available, flexibility and approximation in BPES tools is more relevant to support design decisions. As the design develops, and more information becomes available, precision and higher level of detail is required in BPES tools.

Keywords: architect, building performance, energy simulation, early design stage, design decision, low impact housing.

## INTRODUCTION

Buildings account for approximately forty per cent of carbon emissions in the UK and across the European Union (Carbon Trust, 2010). They have been described as complex entities involving a wide range of stakeholders drawn from a large number of disciplines (Dibley et al., 2012). Within the building industry, the housing sector alone was responsible for over a quarter (twenty-eight per cent) of the total carbon emission (DEFRA, 2005). The current trend is that this will increase due to new technologies, such as digital radios, plasma TVs, and air conditioning requiring higher energy inputs

(CLG, 2007; Seyfang, 2008). Forbes (2007) posits the existence of environmental concerns in light of anthropogenic climate change have impact on the housing sector, because it is the major energy-consuming, and carbon dioxide producing sectors. Despite some buildings having green credentials, Scofield (2002) observed, they were found to be responsible for as much energy consumption and pollution as comparable to conventional buildings.

This is because, environmental design decisions are taken late in the design process to validate design after critical decisions have already been made (Dunsdon et al., 2006). Early in the design, architects often make decisions regarding the building form, orientation, fenestrations and construction materials with little or no support (Hong et al., 2000). These issues have been observed to have important implications in achieving the low impact building agenda. The way design decisions are made have great influence on the outcome of the design. Fundamental design decisions taken early in the design process have far reaching environmental impacts later on. Better informed design, from the earliest conceptual stage, will improve the design of individual buildings, and help achieve low impact buildings. For this reason, tools have become a necessity for the early and on-going consideration of environmental performance and an important delivery mechanism to aid architects' design and decision making to deliver the low impact buildings.

However, in the traditional design process, it is the energy engineer who uses simulation tools for equipment sizing and code compliance, after the architect has completed the architectural design (Ellis et al., 2008). This is because; existing decision support tools had not addressed in full, the expectation of architects. Design-decision support tools, specifically the Building Performance Energy Simulation (BPES) tools are not fully integrated into the design process, to enable the UK architects make informed decision necessary at the early stage of the design process. From the RIBA Climate Change Toolkit 05, all design tools, from simple calculation procedures to complex simulation models, are means of estimating the approximate performance of a given design (RIBA, 2009). Hence, BPES tools for architects' decision making should complement the designer's own knowledge by quickly confirming whether proposed changes to a design are likely to make the performance of the design better or worse, and by indicating the relative effects on performance of different design features (Royal Institute of British Architects, 2009). They should provide different degrees of confidence, depending on the quality and amount of the input data as well as the complexity of the calculations. Canada Mortgage and Housing Corporation (2004) defined; Decision Support Tools (DSTs) as any tool(s) used as part of a formal or informal decision process or that, which informs the decision-making process by helping to understand the consequences of different choices. Decision makers such as the architects, need the right tools and data at the right time to identify and assess potential low energy design solutions (Dunsdon et al., 2006).

Thus, the study seeks to provide a decision support framework for architects to achieve low impact design in the United Kingdom (UK). It sets out to determine how architects in the UK can achieve the design; what the needs of architects are, in BPES tools characteristics, to fit their design and decision making. It finally maps out a Decision Support Framework (DSF) that includes the use of Building Performance Energy Simulation (BPES) tools, fit for architects' design and decision making to deliver the low impact housing design in the UK.

### **BPES Tools and Approach adopted for the Decision Support Framework**

Application of computer based tools in building design can be broadly categorised as computer-based drafting and design tools such as AutoCad and computer-based Building Performance Energy Simulation (BPES) tools such as Autodesk Green Building Studio, Building Design Advisor, Design Advisor, DOE-2, ECOTECT, ESP-r, Energy 10, Energy plus, eQUEST, and Integrated Environmental Solutions (IES). BPES tools, according to Hong et al. (2000), are tools that are used to simulate: Energy performance analysis for design and retrofitting; Compliance with building regulations, codes, and standards; Passive energy saving options; Building Energy Management and Control System (BEMCS) design; Cost analysis; and Computational Fluid Dynamics (CFD)

A brief summary of ten different building performance simulation tools were described and compared in Attia et al (2009). A more extended report on different energy performance simulation programs can also be found in Crawley et al. (2005). Another overview is accessible on the building energy software tools directory from the U.S Department of Energy (2012). Building Performance Simulation (BPS) in general is supposed to calculate, through predictive simulation, a variety of outcomes of the proposed design, such as energy consumption, performance of heating and cooling systems, visual and acoustic comfort, dynamic control scenarios for smart building technologies, smoke and fire safety, distribution of air borne contaminants and others (Augenbroe et al. 2004).

However, Morbitzer (2003) stated that the best established use of simulation for architects in design of low impact housing in the UK, is after finalising the design, hence it is for performance verification and commissioning (Morbitzer, 2003). This is not supposed to be the case, as building design is perceived to be the key to deliver the low carbon agenda. Design decisions made at the early design stages, especially at the conceptual stage of the process, have greater benefits for the construction industry to achieve low impact building design and delivery in the UK. Thus, this research, from the architects' perspective becomes necessary towards contribution to achieve the low impact housing design agenda in the UK.

Strategic decision-making in the design and construction of buildings is a knowledge and information intensive process. Some related reviews in the United States (US), which influence this particular study, include Canada Mortgage and Housing Corporation (CMHC, 2004) from the International Energy Agency (IEA, 2001). They organised tools by stage in the building life cycle and developed the Green Matrix website, which combines the LEED categories with the phase in the design/build process. Keysar and Pearce (2007) also developed Decision Support Tools (DSTs) for green building to facilitate selection among new adopters on public sector project for architects and engineers working for United States Army Corps of Engineers (USACE). Other influencing reviews include Dunsdon et al., (2006), who proposed a computerised framework to map the design process, which integrate energy analysis at the appropriate decision points. A process framework for building design was further proposed in Loh et al., (2010). They developed an ICT system to support multi stakeholder decision-making which facilitates inclusion of energy issues in the early design phase of buildings.

Consequently, the approach adopted in this study involves the integration of simulation, in form of BPES tools fit for architects' decision making, with design-decision tasks of architects from the early to the technical design stage of the Royal

Institute of British Architects (RIBA) outline plan of work. This is towards contribution to reduce carbon usage in buildings, especially from the onset of the design process for architects to deliver the low impact housing design in the UK. The RIBA Outline Plan of Work was established over fifty years ago in the form of Plan of Work for Design Team Operation (Royal Institute of British Architects, 1963). It is widely used by those in the building industry ( Royal Institute of British Architects, 2008 ) and has been referred to by several publications (Mackinder and Marvin, 1982; Imrie, 2007 and Adeyeye et al., 2007) within the scope of this study. The stages of design in the RIBA Outline Plan of Work are familiar to architects, as well as being widely recognised by the general construction industry in the UK. It is a model with set of procedures for building project administration. Hence, it is used in this study towards achieving the low-impact housing design because of its familiarity to architects and the general construction industry in the UK.

## **RESEARCH METHODOLOGY**

Achieving the decision support framework and implication of the research, towards recommending the findings to software developers as well as the research communities necessitates the qualitative elements to answer the following research questions: Why are UK architects not using the existing design -decision support tools? What are the requirements of architects in decision support tools, at the different stage of the design process?

Thus, qualitative in-depth, semi structured interviews; desk study of literature review and analysis of case- based documents on integrated design processes (IDP) on low energy/sustainable housing designs were used. The logic of qualitative research defined by Henn et al. (2008) is not so much to test out given theories about what guides human behaviour, but to develop an appreciation of the underlying motivation that people have for doing what they do. In relation to this particular research, it involves interviewing experts (see Table 1) in the field. Pilot interview was carried out, to assess whether questions were clear, understandable and whether the structure and flow were acceptable. A sample of ten architects was finally interviewed. The interviewees were with diverse qualifications, years of experiences, and past sustainable housing projects in UK. Details of their profiles and years of experience are shown in Table 1.

The approach was informed by three major publications (Mackinder and Marvin, 1982; Imrie 2007; Isiadinso et al. 2011). Mackinder and Marvin (1982) used interviews with architects to understand the role of information, experience and other influences on the design process. Open-ended questions were used at intervals in the interview process and architects were encouraged to lead the discussion. Imrie (2007) involved a sample of practicing architects from the Royal Institute of British Architects (RIBA) database and combined the analysis from the interview with other web-based information of a sample of architectural practices primarily based in London. Finally, Isiadinso et al. (2011) conducted an online survey and interviewed experts who were construction professionals with substantial records of accomplishment or linking expertise in sustainable design in both industry and academia.

*Table 1: Interview Profile*

Interviewee	Academia	Practitioners
A		A practicing architect in the UK. He has 20 years of experience and a wide knowledge of different areas of sustainability issues especially as related to low impact housing design in the UK
B	An architect in academia with 18 years of experience	
C	An architect in academia with 10 years of experience and vast knowledge of sustainable practices.	
D	A practicing architect but is now in academia. He has 16 years of experience and participated in design of a notable low carbon energy village.	
E		An international architect in practice. He has thirty (30) years of experience and a world record of sustainable past projects using sustainable materials.
F		A practising architect with 25 years of experience in design of sustainable housing.
G		A young, dynamic, and enthusiastic architect with strong ideas and innovation on sustainability. He has three (3) years of experience.
H		An international architect with a dynamic record of past sustainable projects and publications. He has thirty-(30) years of experience.
I		A practicing architects of 10 years' experience.
J		A practicing architect of 15 years' experience.

Hence, the following issues were investigated in the study: Design and decision support tools to deliver low impact housing design in the UK; Characteristics/requirements of BPES tools, fit for architects design-decision making at the various stages of the design process; and Presentation of the Decision Support Framework (DSF) in a manner that will enable UK architects to achieve the design.

## **RESULTS AND DISCUSSION**

### **Architects' Perceptions of existing BPES tools**

The interviews show the diverse nature and experience of the architects who participated in the process. All subjects acknowledged the importance of design and decision support tools in the delivery of low impact design. Interviewee E specified 'Integrated Environmental Solutions (IES) tools'. Although, he does not believe the tool will necessarily deliver the design. However, in his opinion, 'This is the best at the moment'.

To know the architects' perception about existing design-decision support tools and the importance of using them during design stages, calculation; simulation; energy

calculator; carbon embodiment; code compliance; and checking tools /software were all confirmed by more than half of the interviewees as being necessary to the design and delivery of low impact design in the UK. Interviewee B stated, 'The tools, at various stages of the design process, should link with ventilation strategy, air tightness, energy calculator, carbon embodiment, code compliance and checking of results'. Interviewee C further stated, 'Tools for decision support should be easily accessible and less complex'.

Interviewee E specifically said, 'It will be good to have a tool that starts from when the client writes a brief to the management level, and it should include health and safety issues.' Interviewee D stated, 'Architects understand U-Value Calculator, since it is the basic thing, it is therefore definite. However, carbon embodiment is useful but there is not enough data to produce reliable prediction'. He further said, 'Code compliance and checking tools are okay, but it will be good if confidence can be tested against post occupancy evaluation. Hence, a degree of prediction against reality of the design and confidence in the use of tools for decision support were added to the list of requirements for recommending tools that fit into the way architects work.

Nevertheless, Interviewee A categorically made this statement in response to his own general view on low impact design and delivery of housing in the UK. He stated, 'We are the clients' servants: we can only do what we are asked. Very few clients want to have low carbon homes. Those that do, (owner-occupiers, by and large, and how many 'self-builders' are there in the UK?) frequently stop wanting them as soon as the additional costs become apparent. Developers and I include many social housing providers here, unfortunately, only want to do an elegant sufficiency to comply with statutory requirements. How many 'tools' can you be using when the total fee for designing a dwelling is frequently only a couple or three hundred pounds?'

### **Required Characteristics of BPES Tools for Architects**

In relation to requirements of architects' friendly BPES tools, to deliver the low impact housing design in the UK, the following were acknowledged from the interview analysis, for the early and detail stages of the design process.

Degree of approximation /accuracy as related to design stages

Early Design Stages: As minimal details are available; Approximation and flexibility are paramount; Accuracy is less important; Low input to avoid hampering creativity and design thinking; Quick output in a language understood by architects.

Detail Design Stages: As much details are available; Precision and specification are paramount; Higher level of Accuracy is required; Higher level of detail input required; To produce 'Realistic' or 'as built' output.

## **DISCUSSION**

Thus, the first major finding of this study suggests, within the design process, architects are more concerned with design issues, such as : geometry; orientation; comfort; aesthetic; natural ventilation and day lighting, while engineers are more concerned with mechanical systems and control, hence, the difference in the type of tools important to each profession and in their requirements.

The state-of - the-art on design and decision support tools such as environmental assessment and BPES tools is that these tools are used at the later stage of the design process. It specifically reveals how the tools are used in only one discipline such as

engineering or one design phase by majority of the architects, despite the attribute to cater for the whole design process specified by software developers and the various marketers. Emphasized in this study is that most BPES tools are easier to use by architects in only one phase, which is: the design development phase. Thus, the function becomes to help designers in improvement of their basic concepts but not to create the basic concepts towards the design of low impact housing design.

In relation to building modelling software, this study revealed that all software are not created equal; some simulation software is not even intended for design. However, design decisions stem from building simulation by which the right tool must be chosen to optimize the design from the early stage of the design process. Hence, discovered in this study is that: existing BPES tools claim to perform one or too many functions by which the required geometrical detail are not allowing the tools to perform the required function for architects in terms of required flexibility and other characteristics for the various stages of the design process. Consequently, this study made some recommendations for characteristics required of architects' friendly BPES tools in Figure 1.

### **Presentation of the Decision Support Framework (DSF)**

Based on the reviews within the scope of this study and the analysis from the interview findings, a holistic approach was adopted to develop a DSF for UK architects to achieve the low impact housing design. It cross references the RIBA Outline Plan of Work (being the most familiar to architects and the general construction industry in the UK) with sustainability and environmental design decision tasks and the required characteristics of BPES tools that fit the intrinsic way of architects' decision- making for the different stages of the design process (Figure 1).

Stages of design		Some Design Decision Tasks		Characteristics of BPES Tools
Earlier Design Stages	A and B	<p>Building orientation (appraisal);                      Topography (appraisal);                      Site usage (appraisal);                      Sun path (appraisal);                      Air change rate (appraisal);                      Building Shape;                      Insulation of building envelope; and                      glazing (optional)</p>	<p>A typical site analysis in the design process, the interplay of the building mass and natural features, such as trees, sun path, wind patterns, and the form of the land are important items to consider. It helps to ensure that the site is utilized to maximum advantage.</p> 	<p>Flexibility of BPES tools to accommodate rapid design changes, and to avoid hampering design creativity;</p> <p>Low input to minimise disruption to design creativity;</p> <p>Fast output in a language that designers understand primarily based on approximation;</p> <p>Interoperability to seamlessly integrate BPES tools with design tools;</p> <p>Interactive to enable designers to interrogate the design model performance;</p> <p>Intuitive and easy to use</p>
	C	<p>Shape of building;                      Orientation (small adjustment);                      Insulation and mass;                      Attribution of building zone;                      Window size in different façade and orientation;                      Solar control requirements;                      Summer ventilation requirements;                      Glazing and Types (detailed analysis);                      Air change rate (detailed analysis);                      Materials selection and adjustment;                      Artificial lighting strategy, daylight utilisation, visual comfort and cooling; and                      Fuel Type/ Renewable Considerations</p>	<p>During this early stage, designers rapidly explore and refine ideas by engaging in free-flowing, collaborative brainstorming sessions, during which a wide range of designs- in the form of sketches, 2D drawings and layouts, 3D models and renderings- are considered and evaluated until a final concept design is chosen</p> 	
Later Design Stages	D	<p>Finalised material definition;                      Finalised building orientation;                      Finalised ventilation strategy;                      Finalised window properties (size, type, solar control);                      Lighting strategy, daylight utilisation, visual comfort and cooling.</p>		
	E	<p>Detailed technical analysis such as:                      Assessment of passive cooling system (Ground cooling);                      Assessment of passive heating systems (solar preheat of air);                      Ventilation studies; and                      Test and refinement of heating and cooling control strategies</p>		

Figure 11: Decision Support Framework

## CONCLUSIONS

This paper has led to some practical results (especially from the interview analysis) towards making recommendations for software developers to develop architect-friendly tools that fit the intrinsic way of architects' design-decision tasks. At the early design stage, as minimal details are available, approximation and flexibility are paramount while accuracy is less important. At the detail design stage, as much details become available, precision and specifications are paramount while higher level of accuracy is required. Thus, the framework was developed. It defines the sustainability and environmental design decision support tasks along with the required characteristics of BPES tools, for architects to achieve the low carbon housing design in the UK. It is different from the RIBA Green Overlay, because it integrates the use of simulation tools into the whole design process, and especially from the early design stage.

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# GREEN CHOICES: THE INFLUENCE OF SOCIO-TECHNICAL PARAMETERS ON HOUSEHOLDER DECISION MAKING IN GREEN RETROFIT PROJECTS

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Although the uptake of green retrofit measures (GRM) in the UK is increasing, empirical data often reveals significant shortfalls in the energy performance realised by domestic green retrofit projects. Such results pose a threat to UK emissions targets and are particularly problematic for the credibility of the government's flagship scheme: The Green Deal. The energy performance of a dwelling may be influenced by both its physical properties and the energy behaviours of its occupants and, whilst the retrofitting of GRM seeks to improve energy performance through physical alteration, the way in which users interact with these measures is likely to influence the extent of that performance. It is theorised that greater consideration for these socio-technical factors by those selecting GRM may yield more predictable energy performance in-use whilst better accommodating the needs and expectations of the occupants. A series of qualitative interviews were used to explore the decision-making processes and in-use practices of early adopters of domestic GRM. The research concludes that those currently realising exemplary energy performance demonstrate a level of technical understanding and interest which is not representative of social norms. Furthermore, acknowledging that the installation of multiple, interoperating GRM may lead to higher energy performance, it is evident that a lack of technical understanding may currently inhibit the effective operation and maintenance of such systems, regardless of users' willingness to interact with them. As such, a better understanding of the technical abilities and in-use expectations of UK householders is required to aid the development of more intuitive and intelligent green retrofit solutions. Where this could be achieved, improved predictability and superior energy performance would likely follow.

Keywords: building performance, energy, green building, refurbishment, sustainability.

## INTRODUCTION

The UK is committed to an 80% reduction in CO<sub>2</sub> emissions by 2050 (DECC 2011b). Approximately 27% of these total emissions derive from existing domestic building stock (Uttley and Shorrock 2008) of which approximately 70% may still remain in 2050 (Stafford et al, 2011). As such, refurbishment of existing dwellings attracts significant focus in current policy, most recently with the introduction of the Green Deal (DECC 2011a)

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As DEFRA (2007) recognises, we can improve energy efficiency in two ways: through technological improvements, or changes in behaviour. Although the adoption of green retrofit measures (GRM) by householders may primarily be recognised as technological improvement, the way in which these are used is also consequential to potential success. Thus, success through technological improvement may always be limited by user interaction.

Taking forward the idea that these micro-level socio-technical factors could potentially restrict or even reduce energy performance, it is imperative that we understand and minimise their impact during the early planning and decision making stages of green domestic retrofit projects.

## **SOCIO-TECHNICAL FACTORS**

There is a good understanding of the main drivers and barriers to the adoption of energy efficiency and renewable energy measures among householders (Achnicht and Madlener 2012; Poortinga et al 2003; Jakob 2007; Caird et al 2008), yet it is not entirely clear whether adopters consider socio-technical factors when selecting GRM for their homes.

Caird et al (2008) identify that consumer adoption decisions and user behaviours are influenced by four key groups of variables: socio-economic context; communication sources; consumer variables and properties of the product or system itself. The latter group contains socio-technical factors such as functional utility and it can be seen that, setting aside socio-economic factors, homeowners favour those measures with least impact on lifestyle, i.e. with the least reliance on long term effort or behavioural change (Poortinga et al 2003). Although this suggests that adopters consider likely use-related behaviour when making purchasing decisions, it is less clear whether the measures chosen as a result do actually perform as expected. For example, where technical measures are adopted over passive or behavioural change measures, on the basis of minimum required effort, it seems pertinent to question the extent to which potential adopters consider the level of operational input or reactive behavioural change required in order to operate these measures efficiently.

The above theory identifies a general tendency towards minimum effort by society; however a qualification can be made: Commenting on earlier work by Hamrin (1979), Van Raaij and Verhallen (1983a) postulate that energy consciousness is interrelated with active involvement, whereby more energy conscious consumers achieve better savings from measures requiring their active engagement, whereas consumers with low energy consciousness are better suited to systems requiring less user interaction. This suggests that, as energy consciousness increases, householders may find it more acceptable to actively pursue increased energy performance.

## **AIM AND OBJECTIVES**

The aim of this research was to identify whether increased acknowledgement of socio-technical factors during the decision making process could improve the energy performance realised in domestic green retrofit projects. As such, the following research questions were explored:

- Are socio-technical factors considered by householders and/or energy advisors during the decision process leading to the adoption of energy retrofit measures?

- Is there a disparity between the level of socio-technical interaction expected by the user, and that required in-use?
- Would enhanced consideration for socio-technical parameters result in the adoption of energy measures different from those currently predominating in the green retrofit market?

In answering the above, it may also be possible to theorise whether measures with lower energy saving potential could, in reality, offer superior overall performance than those with greater potential but which are chosen without regard for socio-technical factors.

## **RESEARCH METHOD**

The study sought to investigate whether socio-technical factors are considered by householders undertaking green retrofit projects. In recognising that such projects are still essentially voluntary, an element of bias is expected. The use of judgemental sampling was therefore deemed appropriate considering both the bias and scoping nature of the research (Fellows and Liu 2008).

Qualitative interviews were undertaken on the basis that respondents were able to discuss, in detail, their decision making process from their point of view encouraging divergent, exploratory discussion where it may reveal factors deemed relevant and important to their specific decision making process (Bryman 2012). Although flexibility was required in order to expand on any specific areas of interest, semi-structuring the interview allowed the interviewer to ensure discussions stayed relevant to the area of investigation. Asking the same background questions at the outset of the interviews was also found to be a useful way of obtaining some basic demographic data for consideration.

In all but one case, interviews were conducted by telephone and recorded with the permission of respondents for accuracy and objectivity of recording responses (Fellows and Liu 2008). Interviews were typically 60 minutes in duration.

## **DATASET SELECTION**

Initiated by the Sustainable Energy Academy, the SuperHomes network showcases over 150 green domestic retrofit projects from around the UK, offered a well-defined respondent group for data collection.

Considering time constraints and the breadth of examples available, a small group of 12 respondents were selected. The following criteria were applied to the initial data set in order to identify those projects most representative of domestic green retrofit fit in the UK:

### **Tenure and Type**

According to the English housing survey (DCLG 2013), owner occupied properties account for 65% of the domestic stock; of which 92% are houses. Detached and semi-detached housing are the primary house type within this sector.

### **Property Age**

Within the owner occupied stock, properties built between 1919 and 1980 predominate, accounting for approximately 60%. Although pre-1919 dwellings account for 20% of the total stock (DCLG 2013), it is thought that a quarter of these properties are either listed or within conservation areas (Boardman et al 2005). Preservation of heritage often influences building alteration decisions, i.e. through

planning restriction; therefore it was considered prudent to disregard these properties for the purpose of this study.

It should be noted that hard to treat (HTT) properties (e.g. solid walled) are still well represented within the sample considering that pre-1919 properties represent less than half of such dwellings (Beaumont 2007).

### **Energy Efficiency**

The energy efficiency and heat loss associated with new dwellings has been improving steadily over recent decades (Uttley and Shorrocks 2008), but Stafford et al (2011) predict that 40% of the 2050 domestic stock will still pre-date the introduction of Part L of the building regulations.

In summarising empirical data in previous research, Stafford et al (2011) highlight that discrepancies between actual and predicted heat loss in dwellings was more pronounced in adjoined properties (terraced and semi-detached) than in detached properties. Such properties therefore appear to have a greater need for performance certainty.

### **Chosen Dataset**

In considering the above criteria, the selected respondent group consisted of completed 'SuperHomes' projects on terraced, semi-detached and detached properties, of traditional construction, dated between 1919 and 1985.

In order to elicit responses representing the products currently predominating within green retrofit market, all selected respondents had employed a minimum of three GRM, consisting of both energy efficiency measures and technological measures. In line with the findings of SDC (2006), the specific energy efficiency measures considered were: Internal insulation, external insulation and cavity wall insulation. The technological measures considered were those with the highest adoption rates within the SuperHomes network: solar thermal water heating (STWH), photovoltaic panels (PV) and mechanical ventilation heat recovery (MVHR). Table 1 shows the adoption rates of these GRM within the overall sample of 153 and within the respondent group of 12.

*Table 1: Adoption of Green Retrofit Measures*

Green Retrofit Measures		Frequency	
		Total Dataset (n=153)	Sample Dataset (n=12)
Energy Efficiency Measures	Cavity Wall Insulation	58	10
	External Wall	42	3
	Internal Wall Insulation	73	3
Technical measures	Mechanical Ventilation Heat Recovery	41	5
	Photovoltaic Panels	99	12
	Solar Thermal Water Heating	104	12

## RESULTS AND FINDINGS

### Respondent Background - Technical Understanding and Ability

All interviewees were found to be from a technical background and/or highly motivated by energy efficiency and conservation. Of the 12 respondents interviewed, 9 professed to have an engineering background or specialist knowledge of the subject by way of their occupation. The remaining 3 respondents all had prior experience or knowledge of green retrofit measures.

While this trait was clearly and knowingly communicated by all respondents, the extent to which they considered this to be representative of wider society was wider ranging. In particular, when questioned more specifically on the level of on-going user input that had been required to get their homes performing to a high level, there was a tendency to assume that such behaviour was not beyond the realms of that acceptable to wider society. In fact, as conversations progressed and respondents reflected on the process leading to their current energy performance, they often became more aware of the extent to which their enthusiasm, motivation and technical ability had influenced its eventual performance.

Furthermore, 10 respondents had been actively involved in the design process and 4 had undertaken some or all of the physical works themselves. The extent of the respondents' design involvement ranged from specification of GRM to detailed design of their mechanical or electrical systems. Respondents falling into the latter category usually had subsequent practical involvement as well.

It seems apparent that those currently achieving high levels of energy performance from domestic green retrofit projects have a distinct technical understanding, ability or a combination of both, whether or not this trait is recognised by the users themselves.

### Selected Measures - Solar Dominance

It is interesting to note that all respondents interviewed had installed both PV and STWH technologies and all had insulated the external walls of their property to some extent. The adoption rates for mechanical ventilation systems and heat pumps were slightly higher in the sample than for the SuperHomes network as a whole, with a little less than half of respondents having installed these particular GRM.

When questioned on the decision process leading towards installation of solar renewables, such a choice appeared almost unquestionable. In all cases, grant funding or feed-in tariffs (FITs) had had some bearing on their selection, but prior experience,

the advice of installers and external advertising tended to influence decisions the most. Although not probed specifically, the early predominance of solar technologies in the GRM market also appeared to have influenced a number of respondents' decisions, reflecting the relative infancy of some current alternative GRM.

### **Ease of Use - Interoperating Technologies and the 'Average user'**

Ease of use, or more specifically ease of optimising performance, was not a significant consideration for the majority of respondents when selecting GRM, although all had a good understanding of the behavioural characteristics required to maximise the energy performance of the systems e.g. using appliances when PV generation was high or staggering use of appliances to better match generation capacity.

10 respondents revealed that they held a particular enthusiasm for monitoring and optimising the energy performance of the project. Furthermore, a small number of respondents consciously accounted for this when selecting what were, in some cases, innovative and bespoke solutions. The challenge associated with getting the building to perform as efficiently as possible was often cited as being a driver for continued user input; it was also relevant for subsequent adjustment or alteration to the measures themselves.

It was particularly evident that the level of user input had been significantly higher where respondents adopted multiple, interoperating technologies. Such systems had often been designed and/or installed by the respondents themselves allowing homes to reach a higher level of performance by combining the different strengths of the technologies. Discussions on this topic were extensive; one particular respondent for example recognised, on reflection, that a good level of technical knowledge had been critical to the optimum performance of his home due to the nature in which various systems operate in conjunction with each other. As such, it is also plausible to suggest that lay-users would find it much more difficult to recognise and diagnose performance losses in such a system. In a traditional gas central heating system for example, where such a system fails to operate as expected, the number of possible causes and failure points is relatively small. Where the user is unable to undertake maintenance or repairs themselves, it is realistic to assume that they would instinctively call a plumber for assistance. Conversely, where a dwelling contains a number of inter-operating technologies, identification of optimum performance is much more difficult; the relative contribution of each technology may be influenced by variables such as external temperature (ASHP) or time of year (STWH) yielding a multitude of possible operating modes and performance outputs. In addition, fault finding may also be more difficult: Where performance was deemed to be unsatisfactory, at least a basic knowledge of the system as a whole would be required to diagnose the potential cause.

It follows that a user may not even know who to call for assistance where it is unclear which system element is at fault. So, where high performance is realised primarily by the installation of interoperating GRM (to account for limitations of the individual technologies in isolation), an understanding of the basic system principles would still be required to maintain such performance.

Taking this principle further, where respondents were seemingly undervaluing the influence of their technical ability on the performance of their homes, they were asked how easily a new user purchasing the property would be able to yield the same performance that they had come to realise. The majority recognised that a certain

amount of knowledge transfer would in fact be required and that it would take some time to explain how the house should be operated. The implications of a new user on energy performance of a house containing GRM is beyond the scope of this paper but reveals an interesting area for further work.

### **Installers - The Weak Link?**

A number of respondents cited difficulties in finding or working with installers/contractors from different disciplines who were familiar with how different GRM should interoperate. This was also reflected in the number of respondents who had needed to design and/or install such systems themselves and suggests a current need for multidisciplinary installers who can provide turnkey solutions incorporating a number of technologies. Another common installer issue cited was a lack of attention to detail in reference to air tightness treatments, and a clear lack of understanding of thermal performance, often evident in the over-specification of boilers.

### **'Show Home' versus 'Hobby Home'**

There was some evidence of a relationship between motive for undertaking the project and the extent of user input cited: Where the large majority of respondents held a specific desire to design in user control and monitoring (to allow them to optimise the system) the level of on-going input and effort was considerably higher than those respondents whose motive, at least in part, was to engage society with the idea of green retrofit. Importantly, all those falling into the latter group used their projects to promote professional services in the field of domestic green retrofit and therefore showed a clear understanding of the expectations of wider society.

As such, it appears that an inherent personal interest and in energy efficiency and green technology appears to influence and facilitate the adoption of more complex solutions which are more heavily reliant on user-input. It is unclear from this study whether this level of user input is entirely necessary or whether this has been built-in, to some extent, by the user. For example, this may be the result of a lack of standardised interoperating solutions on offer in the market, or as a result of the users' inherent desire to control and optimise the system manually.

### **Social Expectations - Think Smart**

A particularly succinct analogy developed during the interview period was that of the recent emergence of the smart phone. Those users who wanted to showcase attainable and socially acceptable projects also asserted that, whilst recognising that a user's technical understanding or ability may have a bearing on performance, it is for the market to deliver solutions which are not adversely affected by shortfalls in user knowledge – much like that of the smart phone. A small number of respondents suggested that society had come to expect intuitive products which enable them to undertake processes more efficiently without needing to invest specific effort in learning to do so.

The car was also offered as an example of offering better performance and improved efficiency without a reliance on enhanced user knowledge. Nowadays, few vehicle users expect, or are expected to, undertake maintenance themselves or even to understand which component may be causing reduced performance in order to resolve it; this is the job of the engine management system which recognises and communicates to the user when attention is required. If this principle was taken forward, one would imagine a building management system which monitored and

optimised building performance based on how the building was being used and which was able to communicate to the user when performance was compromised, either as a result of user behaviour or due maintenance and repair.

It should be recognised that some users may also reject systems which prohibit detailed control and customisation. Such users are well represented by the majority of the respondents questioned as part of this study, but may not necessarily be broadly represented in society.

## **DISCUSSION**

This section aims to address the research questions posed at the outset of this exploratory study:

### **Q1: Were socio-technical factors considered by homeowners and/or energy advisors during the decision process leading to the adoption of GRM?**

Responses to questions regarding ongoing user input and ease of use fell into two distinct categories. While a large majority of users accepted or even preferred measures requiring ongoing input and/or behavioural change, a small minority of respondents set out to demonstrate socially acceptable environmental building practise which did not represent a significant lifestyle change. As such, only the decision processes of the latter group appeared to consider ease of use or level of input required. It can be noted however, that these individuals demonstrated a detailed appreciation for the effects user behaviour on energy performance and for the use-related expectations of wider society as described by Portinga et al (2003). As such, it is not possible to conclude whether users without such knowledge would identify such factors as being important to the success of their project.

It is also noteworthy that very few respondents sought the professional advice; seemingly as their own expertise was often deemed to be greater than those able to offer such a service. Half did seek or consider the advice of installers and manufacturers despite the majority of respondents expressing dissatisfaction with the level of knowledge held by installers; especially with regards to interoperating technologies.

### **Q2: Was there a disparity between the level of socio-technical interaction expected by the user, and that required in-use?**

The level of user interaction with GRM was, in the large majority of cases, notably higher at the outset of the project whilst systems were being optimised than in subsequent periods where the user felt satisfied with performance. As previously identified, respondents generally held a modest view of the level of initial ongoing effort required and were evidently content with such involvement as a result of a general interest in energy saving and building performance. Those who felt input was minimal, confessed that significant effort had been required to get the building operating in such a manner and that a good level of technical understanding had lead them towards that point.

It is likely that the relative expertise of the respondent group in question influenced the level of user input applied. The responses suggest that better understanding led to better acknowledgement of relative potential performance which, in turn, led to increased socio-technical interaction. This process would repeat until either maximum performance was achieved or maximum acceptable level of input is reached. It is suggested that, for SuperHomes respondents, the latter limit is likely to be beyond that

acceptable to wider society (i.e. Poortinga et al 2003), perhaps going some way to explain why performance among the SuperHomes projects was generally high. Of course, where a user's level of technical understanding is limited, user input could be expected to plateau, perhaps as early as one cycle into this process, on the assumption that performance is maximised.

**Q3: Would enhanced consideration for socio-technical parameters result in the adoption of energy measures different from those currently predominating in the green retrofit market?**

It is suggested above that energy consciousness and technical understanding have a bearing on the amount of user input both acceptable to, and ultimately undertaken by, the user. As a result, where energy performance is reliant on user input, these social factors should be explored during the decision making stage. It is reasonable to assume however that at least a basic level of technical understanding would be required even to assess the likely operational and maintenance requirements of a new technology.

Two responses to this are suggested: That professional advice needs to encompass an assessment of energy consciousness and technical understanding at the decision making stage; and that the market needs to work to develop solutions which reduce the level of user knowledge or input required to operate buildings efficiently.

## **CONCLUSIONS**

The paper sought to identify whether the influence of socio-technical factors needs to be better addressed during the decision making stages of green retrofit projects. Qualitative data gathered from interviews with 12 early adopters of green retrofit measures showed a clear interrelationship between technological understanding and interest, and level of user-input applied in-use. It was also identified that such input had clearly been influential on the performance realised, especially where multiple, interoperating technologies were employed. Within the responses gathered, ongoing effort was rarely considered to be unacceptable, except where an appreciation for wider social preference is held.

We acknowledge an inherent bias in the high levels of technical literacy of our sample, but maintain that this research has elicited valuable new insights into the role of socio-technical factors in green domestic retrofit projects.

Further supporting research is required to investigate understanding of, and consideration for, socio-technical factors by occupants who better represent social norms. Where a reliance on user-input and technical knowledge is found to be unacceptable or unrealistic within wider society, it is crucial that industry moves towards providing solutions which better address this.

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# THE ROLES OF SUSTAINABILITY ASSESSMENT SYSTEMS IN DELIVERING SUSTAINABLE CONSTRUCTION

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Sustainable development in construction has increasingly gained momentum over the years due to a growing public concern and enforcement of government policy. A variety of sustainability standards and systems have therefore emerged in the current construction industry to provide a means for assessment, ranging from Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), National Australian Building Environmental Rating System (NABERS) to ISO14001. In Hong Kong, LEED and Building Environmental Assessment Method (BEAM Plus) are the mechanism preferred by practitioners for their sustainable buildings certification. This paper will review and examine the roles of the sustainability performance assessment standards in delivering sustainability in construction. Interviews were conducted to explore various viewpoints on sustainability rating systems from different stakeholders. Apart from serving as a guideline for practitioners, sustainability systems can help to gauge the sustainable performance of individual buildings by using transparent and objectively comprehensible metrics. Nevertheless, there is a lack of focus on the post occupancy evaluation and soft issues in the current sustainability assessment systems. By taking into consideration soft issues and those performance goals in operational management, a more holistic and comprehensive assessment approach can be provided for evaluating sustainable construction performance. The potential of the green building rating systems being abused for marketing purpose can also be reduced with a series of periodic assessments during the operational life cycle. These improved sustainability assessment systems can therefore help to reframe the expectations and the strategies of construction stakeholders in pursuing the true goals of sustainable development in construction.

Keywords: sustainability assessment system, sustainable development, construction.

## INTRODUCTION

Sustainable development has gained increasing momentum in the past decades due to a growing public concern on the environmental and social development (Robichaud and Anantamula 2011). Global phenomena such as the depletion of natural resources, carbon emission, climate change, and ecological development have triggered the alarm on the importance of pursuing sustainable development. United Nations Environmental Program (UNEP) (2007) indicated that although primary energy use will increase by almost 50% from 2005 to 2030, the share of different energy sources

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are not expected to change significantly in the near future. The necessity for immediate action has therefore been increased to prevent any unexpected catastrophic consequences on the future generations (Alyami and Rezgui 2012).

Significant effort should go to the construction sector for improving sustainable development since the construction industry has accounted for a large amount of natural resources exploitation, land use, waste production, energy use, and carbon emission (Alyami and Rezgui 2012; Robichaud and Anantatmula 2011; UNEP 2007). The building sector takes a large share of the world's energy consumption and it accounts for about 30 - 40% of the worldwide primary energy (UNEP 2007). The construction sector hence offers the largest single potential for improving the performance of sustainable development significantly.

The revolution of sustainable development has also evolved in the construction industry for decades (Lee and Yik 2004). Numerous national and international initiatives have also emerged to address sustainable development issues in the built environment and one of the mechanisms is the extensive development of sustainability rating standards and systems. The emergence of a variety of sustainability systems in the current construction industry provides a means for assessment, ranging from Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), National Australian Building Environmental Rating System (NABERS), Green Mark, Three Star to Hong Kong Building Environmental Assessment Method (BEAM Plus). In parallel to the sustainable revolution, the standardization issues pertaining to environmental buildings have also improved where International Organisation for Standardisation (ISO) and The European Committee of Standardisation (CEN) have actively provided definitions for the standardized requirements for the environmental assessment of buildings (Alyami and Rezgui 2012).

## **SUSTAINABILITY ASSESSMENT SYSTEMS**

Various assessment tools and methods have focused on different perspectives of sustainability and different targeted projects. Project performance is benchmarked against a set of prescribed qualitative and quantitative criteria and a single score will subsequently be used after balancing all achieved criteria in a designed weighting scheme. Table 1 summarises the use of various existing sustainability performance tools that are commonly used in the construction industry. BREEAM, which was developed in the United Kingdom in 1990, was the first environmental building performance measurement tool (Larsson 1998). Scores are awarded for each criterion met in the assessment and the collected scores determine the rating of "Pass", "Good", "Very Good" or "Excellent" in the overall building performance (Fowler and Rauch 2006). Nine categories are used in the rating: management, health and well being, energy, transport, water, materials, land use, ecology and pollution and innovation (Kajikawa et al. 2011).

In the United States, rating systems include LEED, BREEAM and Green Globes. LEED is currently the principal building evaluation system, after its formulation in 1994 under the efforts of the American Society for Testing and Materials (ASTM) and U.S. Green Building Council (USGBC) (Kibert, 2008). Instead of a single rating system, LEED is compounded by a suite of building rating systems which including LEED – EB (Existing Building Operations), LEED – CI (Commercial Interiors Projects), LEED – CS (Core and Shell Projects), LEED – H (Homes), and LEED - ND (Neighborhood Development). Similarly, LEED standard also adopted single number

rating system of “Platinum”, “Gold”, “Silver” and “Certified” based on accumulation of points scored in various impact categories, which are subsequently totaled to produce an overall score (Kibert, 2008). Six main categories are used for evaluation: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality and innovation in design.

*Table 1: A summary for existing sustainability rating tools in construction*

Regions	Rating Systems Used
U.S.	Leadership in Energy and Environmental Design (LEED); Green Globes; DOE’s Energy Star; ASHRAE Green Guide
U.K.	Building Research Establishment’s Environmental Assessment Method (BREEAM)
Europe	Eco-labeling
The Netherlands	GreenCalc
Canada	Canada’s Green Globes (GBI); Sustainable Building Tool (SBTool)
China	China’s Green Olympic Building Assessment System (GOBAS); LEED; Three Star
India	TERI-GRIHA
Australia	Green Star; Australia’s Building Greenhouse Rating (ABGR)
Japan	Comprehensive Assessment System for Building Environmental Efficiency (CASBEE 2006)
Korea	Green Building Rating System (GBRS)
Hong Kong	Building Environmental Assessment Method (BEAM Plus); LEED
Singapore	Green Mark

In Hong Kong, a localized sustainable building assessment system - BEAM was developed in 1996 based on the United Kingdom Building Research Establishment Environmental Assessment Method (BREEAM). It sets criteria and serves as a measurement system by adopting local climate and industry needs. BEAM has undergone a number of revisions from BEAM 4/04 and BEAM 5/05 to BEAM Plus version 1.1 and version 1.2 for the refinement and improvement to adjust to the market needs. BEAM Plus provides a guidance for local practitioners in fulfilling their sustainable tasks. It is currently a voluntary scheme and adopts four categories of “Bronze”, “Silver”, “Gold” and “Platinum” in rating the building performance. Similar to LEED, BEAM Plus also uses six areas in assessing the building performance: site aspects, material aspects, energy use, water use, indoor environmental quality, and innovation and additions.

Most sustainable rating tools have taken into consideration eight main goals of sustainable construction, i.e. reducing carbon footprints, ecology and environmental protection, healthy indoor and outdoor environment, water use reduction, energy efficiency, eliminating environmentally harmful materials, improve resource efficiency, and conserve resources (Chong et al. 2009). Nevertheless relatively few of the comprehensive sustainability performance assessment tools incorporate the features of triple bottom line – environment, economy and society, in the system. An overly emphasis on environmental protection would ultimately lose the balance of triple bottom line and hence fail to pursue the real goals of sustainable development.

## **THE ROLES OF SUSTAINABILITY ASSESSMENT SYSTEMS**

Sustainability assessment systems facilitate the certification process by a third party eg. UK Building Research Establishment (BRE), US Green Building Council (USGBC) and HK Green Building Council (HKGBC) that buildings satisfy specified sustainable criteria pertaining to the building types and functions. The assessment systems set the standards and help to evaluate the extent to which buildings advance the goals of sustainable development.

Ding (2008) believes sustainability assessment systems have enhanced the awareness of sustainability building practices and provided a structured and objective way to measure progress towards sustainability. In addition, the systems also lay down a fundamental direction for the construction industry to move towards sustainable development (Ding 2008). The market for sustainable construction can be stimulated and promoted by applying the systems in the construction practices. Besides, sustainability assessment systems have also furthered the promotion of higher sustainable expectations and are directly or indirectly influencing the sustainable performance of buildings (Cole 2005).

## **METHODOLOGY**

Interviews can help to obtain firsthand knowledge about people's perceptions while the data's reliability can be improved by gathering supplemental information through observations. Interviews were therefore employed to explore various viewpoints on sustainability rating systems from different stakeholders. The interviews were semi-structured interviews that contain open ended questions to allow more flexibility for interviewees in expressing their views without external restrictions. Interview questions were sent to interviewees prior to the conduct of interview for the interviewees' reference.

Ten face-to-face interviews and one email administered interview were collected in the study. Purposive sampling was used where all interviewees must possess related exposures to sustainable practices in construction. In purposive sampling, the informants are intensively informative and richer in experiences who can offer large information on subjects or phenomena. A spectrum of construction stakeholders is included comprising of academics, architect, contractor, engineer and developer. The profile of interviewees is shown in Table 2. All interviewees possess more than 10 years working experience in the construction field. Interviewees were asked about their views and impressions on the sustainability rating systems, which include but are not limited to the roles, scope coverage, clarity, and comprehensiveness. In the research, the rating systems are studied and analysed as a group rather as individual tools.

Discourse analysis was conducted to analyse the data. Discourse analysis can uncover the way in which the reality is produced by capturing recurrent patterns in the organisation and context of texts (Herrera and Braumouller 2004; Sarantakos 2005). The perceptions of construction stakeholders towards assessment systems and the associated interactions underlying systems can hence be identified.

*Table 2 The profile of interviewees*

No.	Code	Background	Work Experience
1	A01	Academic & Engineer	23
2	A02	Academic & Landscape Architect	25
3	C01	Contractor	35
4	A03	Academic & Architect	18.5
5	E01	Engineer Consultant	22
6	D01	Developer	40
7	C02	Contractor	12
8	C03	Contractor	15
9	U01	Urban Planner	30
10	C04	Contractor	35
11	E02	Engineer Consultant	16

## RESULTS AND DISCUSSIONS

In Hong Kong, BEAM Plus and LEED are the most popular certification tools employed by local practitioners for their pursuit of sustainable buildings. The adoption of BEAM Plus in Hong Kong buildings has increased drastically recently since it has gained extensive supports from the industry and government bodies. Notwithstanding different climate and local needs, the LEED certificate is sometimes preferred by local stakeholders to gain more international recognition as well as to attract more international investors for the project. No specific focus has been directed on a particular assessment system. Nevertheless, the results are mostly confined to BEAM Plus and LEED due to the higher exposure and familiarity of interviewees towards these two systems.

Although all interviewees have an exposure to sustainable construction projects, the sustainability assessment tools are sometimes complicated, particularly in understanding the content and credits to be achieved. As revealed by most interviewees, training is always required to understand the content of rating tools thoroughly and accurately. Interviewee E01 suggested organisations responsible for the assessment system develop simplified checklists to allow practitioners to get a quick snapshot on the overall pictures on building sustainability.

Mixed responses are found on the sufficiency of scope coverage as well as the comprehensiveness of the rating systems in delivering sustainable building. Nonetheless, a high satisfaction is still found on the overall performance of sustainability assessment systems. Interviewees believed that the understanding and knowledge of construction stakeholders on sustainability issues have been increased in the process of applying sustainability rating systems.

The results also show no reluctance from practitioners in relying on sustainability assessment systems even if there is sometimes a lack of detailed knowledge or consensus on the systems credits. All interviewees agreed that construction stakeholders always tend to use the sustainability assessment systems as major principles in guiding them to design and construct a sustainable building. In the interviewee E02's opinion, the systems offer clients a strong indication in setting the

right priority and goals by providing a sustainable development vision and strategy. The systems hence help to align the construction supply chain and all related efforts towards sustainability. As a result, these assessment tools impose remarkable influences in shaping the development and smoothening the transition of sustainable practices in the construction industry.

Apart from serving as a guideline for practitioners, interviewees also held that sustainability systems can help to gauge the sustainable performance of individual buildings by using transparent and objectively comprehensible metrics. From the interviewees' perspectives, the systems have definitely established a basis for benchmarking and comparison. As described by Alyami and Rezgui (2012), most assessment systems play a significant role in reflecting sustainable development in building performance. By employing the systems, the implementation of building sustainability can be improved by reflecting the performance and diagnosing the problems encountered. The findings are in line with the study of Shen and Tam (2002) which showed the most significant benefits of implementing environmental management systems is the contribution to environmental protection. In addition to offering a methodological framework for measuring and monitoring environmental performance of buildings, the assessment tools also alert building professions on the importance of pursuing sustainable development in the construction process (Ding 2008).

On one hand, most interviewees agreed that sustainability assessment systems are marketing tools. Projects can often gain more people's attention of being "the first sustainable residential building" or "the first sustainable tallest building". By gaining the market recognition on sustainable development, the certification systems can help the buildings to attract more potential investors or tenants into the buildings. In addition, gaining accreditation can also help to build up a good corporate social image and hence improve the competitiveness for the organization (Shen and Tam 2002).

Interviewees also pointed out that sustainability rating systems are self serving and have a focus on the short term view by measuring the technical criteria only. The systems do not determine the real need of builders and clients. As a result, construction stakeholders have a tendency to focus on achieving the sustainability standard and not on fulfilling their needs. Interviewee E02 expressed that it is significant to have a good decision over sustainable practices, rather than merely focusing on the systems' content. Interviewee C04 even felt that the systems are fallible in nature since people can manipulate the credits in order to achieve the higher grading in the certification.

The findings also suggest a lack of focus on the post occupancy evaluation and "soft issues" in the current sustainability assessment systems. According to interviewee A01, more room for improvement exists in the aspects of life cycle costing and material durability. Extra measures need to be taken during the occupancy stage to avoid the abuse of the sustainability assessment systems. As suggested by interviewee C03, the exact building performance should be monitored by frequent review of documents and site visits. Meanwhile interviewee E02 stressed the importance of right data in order to manage sustainability goals appropriately. Data management is critical to visualise the energy consumption, waste production, indoor environment quality as well as carbon emission within the building. A right level of measuring data can hence help end users or operators to make necessary adjustments in achieving building sustainability performance.

The significance of integrating post occupancy evaluation of sustainability assessment systems is supported by Meir et al. (2009) by indicating contributions in terms of (i) bringing conceptions and aspirations closer to the actual practices and performances; (ii) bridging the static performance conceived for the building versus the dynamic functioning when real users interact with and modify the static features; (iii) integrating subjective and objective dimensions of building use and experience, and their measurement; (iv) integrating various tools with the suites of qualitative and quantitative research traditions; (v) merging practice with research; (vi) integrating various building disciplines with one another; (vii) integrating various stakeholders in building process; and (viii) integrating pre- and post-handover phases in building life cycle.

Life cycle assessment is an important aspect that should be integrated into all sustainability assessment tools to realize the real pursuit of long term development. It is important to take future cost and needs into the consideration when constructing a sustainable building. As described by interviewee U01, the application of rating systems is mainly confined to the building design, especially for new buildings. He further added that there is a limited flexibility in changing the building use in future. The findings are in consistent with UNEP (2007) which opined most assessment tools and policy fail to take a life cycle approach, and often target conditions during a specific point only such as in design or construction, or only apply to the building owners or investors but not the end users. Interviewees D01 also felt that the sustainability systems need to learn and improve from past projects and always reflect necessary changes on the systems from time to time.

Lee and Burnett (2008) advocated that HK BEAM always emphasizes environmental issues while neglecting the development of other elements such as social, cultural, economical and life cycle aspects. “Soft issues” such as culture, leadership, communication, attitudes, learning and human issues often have a huge influence in determining the success of sustainable practices. Interviewee E02 experienced a project where the end user opting out the use of advanced sustainable technology, even though the facilities and equipments are all in place. Negligence on soft issues development could therefore impact the ultimate outcomes of sustainable construction to a great extent. As a result, all interviewees stressed the importance of education and trainings of sustainable construction, not only to increase sustainable knowledge of stakeholders but also to cultivate a right attitude in reforming the community towards sustainable development.

By taking into consideration soft issues and the performance goals in the operational management, a more holistic audit and monitoring assessment approach can be provided for evaluating sustainable construction performance. The potential of the green building rating systems being abused for mere marketing purpose can also be reduced with a series of periodic assessments during the operational life cycle. BEAM (2012) has also acknowledged the need of a dynamic assessment system which is able to incorporate periodic changes and updates in responding the continual development of sustainable building practices and it therefore plans for the integration of dynamic assessment systems in the future revisions of BEAM Plus.

Apart from the cost of the sustainability features incorporated in the project, the cost associated with the certification fees are raised as one of the inhibitors for sustainable implementation in construction. As described by interviewee A03 and C03, additional fees are always required for certification documentation and appointing consultants

such as LEED AP or BEAM Pro. Shen and Tam (2002) also showed that an increase in management cost was the top barrier to implementing environmental management in construction in Hong Kong and the contractors are often concerned with short term results in terms of cost and benefits. To increase the momentum of adopting sustainable practice, a simplified setting of assessment systems with an acceptable administration cost should therefore be administered by the monitoring bodies such as HKGBC to avoid heavy financial burdens incurred on sustainable building projects.

## **CONCLUSION**

The construction industry needs a comprehensive and transparent sustainability model with systematic and clear guidance in the path towards sustainable development. However existing sustainability rating systems are found to have flaws in aspects of their use in a marketing role, credits manipulation, self serving attributes, short term technical focus, a lack of post occupancy assessment and soft issues, a lack of life cycle assessment and the imposition of additional costs. A failure to address the identified issues will affect the performance of sustainable buildings and eventually distort real goals of pursuing sustainable development in the construction industry.

Although the existing sustainability assessment systems have limitations which may reduce the effectiveness and full benefits of going sustainable, they have undeniably increased the understanding of construction stakeholders of sustainability issues. They also can offer better interactions between various project parties by laying out a measureable sustainable development framework and requirements. The systems have also provided a vision and strategy to building professions to align the construction supply chains and all related efforts towards sustainability goals. Additionally, the general implementation of sustainability in construction can also be improved by sustainable performance of individual buildings using transparent and objectively comprehensible metrics in the systems.

No matter how well a sustainability assessment tool has been designed, the performance at the end very much depends on how the people behave and apply the provisions. More effort needs to be made to address the holistic needs for sustainable development in the built environment. Improved sustainability assessment systems can therefore help to reframe the expectations and the strategies of construction players in pursuing the true goals of sustainable development in construction.

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# INTERACTIVE VISUALISATION TO SUPPORT SUSTAINABILITY ASSESSMENT IN LAND USE SCENARIO PLANNING

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Real-time interactive 3D visualisation of GIS data is becoming increasingly important in the fields of regional and local land use planning, sustainability assessment and energy efficiency monitoring. Turning expert GIS based data into something useful, recognisable and digestible by non-expert stakeholders is a challenging task as participants from different cultural and educational backgrounds must intuitively access the information presented. Stakeholder engagement in land use planning scenario development is critical to enhancing the sustainability of a given project. The use of decision support tools can provide a solution for engaging both expert and non-expert stakeholders. Various real-time decision support tools (DST) have been developed in the past, and recently using programming libraries and frameworks originally developed for commercial video games. In this paper we present a case study where an interactive 3D decision support tool (LEX 3D - Landscape Explorer 3D), was developed to provide a visual impact assessment of proposed housing developments which users can easily locate and change the components of - i.e. layout of the housing within the development, roads and communal green spaces. Additionally, LEX 3D is able to compute and visualise sustainability indicators (e.g. night time street lighting, energy usage and land use ordnance survey data visualisation). We will discuss the steps necessary to streamline GIS data for display in interactive visualisations. We will highlight the games technology techniques implemented that help promote better stakeholder engagement. We conclude that the use of games based decision support tools for planning and sustainability assessment purposes can potentially benefit engagement of non-expert stakeholders.

Keywords: visualisation; strategic planning; sustainability; computer game; stakeholder engagement

## INTRODUCTION

The use of interactive visualisation based on computer games technology has recently gained widespread popularity for use in scientific, medical, educational, geographical and land use planning disciplines (Bown *et al.* 2010). The flexible and robust nature of game development frameworks and engines allows for rapid application development methodologies to be applied in terms of solving real-world planning and visualisation problems. Participation of both expert and non-expert stakeholders is crucial in any planning process, as is the ability to transparently communicate information between

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all of the involved groups. Active participation of stakeholders in land use planning scenarios can be accomplished through the use of custom interactive decision support tools, allowing the stakeholders to explore, interact and observe the impact of proposed changes of the visualised scenario. Scenarios using 3D interactive visualisations as a means of communication can explore layouts of proposed housing developments, energy usage, green space usage, simulation of artificial night-time lighting conditions and larger scale visualisation scenarios - such as the visualisation of a proposed waterfront development in the city centre of Dundee, Scotland (Isaacs *et al.* 2010). In this paper we will discuss the development and use of a custom interactive 3D decision support tool called LEX 3D (Landscape Explorer 3D). We will also discuss using 3D visualisation to promote wider engagement and discuss how this type of tool can support the planning context and the development of low carbon housing.

## SUPPORTING LITERATURE

Support for wider public engagement and community planning was advocated many years before computer based decision support tools became available. The Skeffington Report (Ministry of Housing and Local Government 1969) promoted the view for helping the general public to participate in key planning stages of proposed town developments. In a published report by (Wynne 1992), the argument for full transparency of the policy making process, involving both experts and non-experts is defined. This argument suggests that scientific fact should be presented to and debated by all involved stakeholders - without being concealed or obscured by those with more knowledge about it. A decision support tool or system can provide a solution to this problem. The main objective of a computer based interactive decision support tool is to be able to visualise complex scientific data, and re-interpret it visually to the stakeholders so that it can be used to identify potential concerns - thus democratising the planning process. An interactive decision support tool can be used to visualise key aspects of development proposals, during various stages of the planning process.

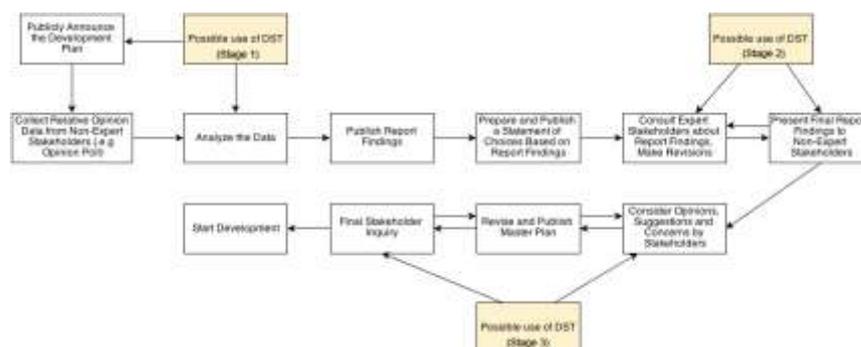


Figure 1: Example of how a decision support tool can be used at various stages during the local planning process.

Expert and non-expert stakeholder use of interactive decision support tools can be implemented during the three stages of planning as outlined by the Skeffington Report: the structured planning stage, the public discussion stage and the local planning stage. Non-expert use of such tools can be especially beneficial during the local planning stage, as the tool can be used to replace dated non-interactive presentation mediums (e.g. drawings, films and videos of the proposed development) -

with a more interactive and engaging experience. This can help create a transparent communication layer between the involved parties, as well as to create a testing protocol for visualising sustainability concerns in the short, medium and long terms. Figure 1 shows an example of local planning stages where a decision support tool, such as LEX 3D, can fit into (and potentially benefit) the local planning process. While decision support tools were originally developed for expert use (Kapelan et al. 2005), over the years a clear need for including users from a wide field of professional, educational and social backgrounds has become evident as a way of further gauging public interest in project proposals for regional and local land development. This creates a wider sense of inclusion, awareness and general interest within the involved communities - and can help strengthen the relationships between the involved development contractors, the local councils and the general public (thus strengthening social, economic and political ties within the community) (Appleton 2004). Research carried out by (Al-Kodmany 1999) highlighted the importance of community engagement with urban planners, and described the use of a decision support system that allowed for the unification and presentation of both expert and non-expert data between all those involved in the planning process. The conclusion of the case study highlighted the benefits of community engagement in the planning process, as well as the use of local expertise that might have otherwise been neglected by expert stakeholders. Research carried out by (Kaatz et al. 2006) describes “three significant outcomes” of building sustainability assessment – which include: integration, transparency and collaborative learning and engagement. The use of interactive decision support tools fits into these three outcomes - as it facilitates integration between ideas, issues and concerns of expert and non-expert stakeholders; provides a transparent communications platforms by means of utilizing interactive non-expert comprehensible data visualisation methodologies; and allows for collaboration between expert and non-expert stakeholders by allowing experts to draw from local knowledge of non-expert stakeholders, and in turn to communicate expert knowledge based results, conclusions and concerns. A good example of early research concerning the benefits of using virtual and interactive 3D GIS systems was covered by (Koller et al. 1995).

The research demonstrated the successful use of their 3D GIS system for visualising the topography of terrain data for operations planning use by the United States Army. This showed that the 3D GIS system could be used to plan critical tasks in real-time. Research by (Bishop et al. 2000) highlighted the importance of then emerging “virtual environments” technology. The reason why this study is of particular interest is because it was published at a time when 3D capable computer hardware was entering the mainstream consumer market (especially after the emergence of interactive 3D games near the end of the 90's). Most average non-expert users at that time were not overly familiar with concepts of 3D virtual environments, thus the fact that the study provided supportive evidence of using a 3D virtual reality system for public engagement creates a good starting point in history for the emergence of what we now refer to as interactive 3D decision support tools. Subsequent research by (Lange 2001) focused on user visual preference and showed that non-expert users assigned a very high visual impact value to simulated 3D scenes in comparison to their photographic reference images. Additionally, research carried out by (Zlatanova 2002) provides a comprehensive review of what we can refer to as the first generation of commercial 3D decision support tools. A decision support tool that is interactive; can be used by both experts and non-experts; can communicate vital planning and sustainability information in an intuitive manner; can optionally support multiple users at the same

time (Ball 2007) and can be used on average consumer level computer hardware – would in no doubt greatly benefit a given land use planning and sustainability assessment process. Recent research by the Abertay SAVE group (Isaacs et al. 2010; 2013) provides detailed evidence for supporting the research, development and real-world use of such tools - using games-based technology.

## **METHODOLOGY OVERVIEW**

### **The Case for Using Games-Based Software Development Frameworks**

With the advancement of interactive real-time 3D rendering technologies around 2001 - mostly based on the introduction of consumer level programmable graphics hardware, - new and easier to use software development tools for developing interactive 3D applications emerged (Wright *et al.* 2007; Moller *et al.* 2008). Most of these software development tools were game engines and frameworks, aimed at facilitating and accelerating the development of 3D games applications. While these games based software development tools were originally designed to create games on various different hardware and software platforms, their general flexibility and robustness soon caught the attention of software developers involved in virtual reality, training and simulation software development (Lewis and Jacobson 2002; Friese *et al.* 2008). By their nature, games engines and frameworks are designed to leverage the object oriented approach of software development (McShaffry *et al.* 2009). A game system can be divided into two distinct component groups – data and logic (DeLoura *et al.* 2000). The logic group contains code components – functional pieces of software code that are executed during the run-time of the application in order to instruct it to compute the desired result. The data group contains the data used by the logic components in order to compute the final desired results. The data components can be anything from 3D CAD models, vector shapefile data or environmental and meteorological data. A given game engine will often attempt to treat the collectively merged code and data groups as single entities. This provides a benefit of using coupled data and logic to dynamically modify the needs of the scenario during the run-time of the simulation, and enables the re-use of these objects in different scenarios. Additionally, a given game engine system that is used to develop an interactive decision support tool is able to implement the requirements for visualisation outlined by (Mach and Patschek 2010). These requirements are defined as the “Five Principals”, and can be summarized as:

*Representative Character* – What important topics/problems does the visualisation address.

*Exactness* – The visualisation should be able to visualise the given scenario to an acceptable level of visual and scientific accuracy.

*Optical Clarity* – Specific aspects that are of visual importance in the given scenario should be instantly recognizable by the viewer/user.

*Interest/Engagement Factor* – The visualisation should be able to immerse and engage the viewer/user.

*Legitimacy* – The need for and the exactness of the visualisation of a given scenario needs to be justified.

The application of games technologies to visualisation of land use planning and sustainability is a beneficial and viable solution for meeting both long and short term project specification requirements.

## Overview of the Research Development Cycle

The Landscape Explorer 3D (LEX 3D) decision support tool was developed using the Microsoft XNA games technology framework. The use of XNA allows for rapid application development of custom games components that could be used to create interactive 2D and 3D games, visualisations and applications. The XNA technology itself is not a games engine - but rather a collection of code functions that eliminate the need to rewrite the minimum requirement components of a 3D application for the Windows platform. The use of previous versions of this games technology had a proven track record - as an older version of XNA was previously used to successfully implement the requirements specification of the S-City VT project (Isaacs *et al.* 2010). One of the initial and major difficulties encountered when the LEX 3D project was started was the problem of dealing with non-standard GIS and CAD data types, which were used to store various 2D and 3D data components required for the interactive scenarios. The solution to this problem was solved by utilizing various pieces of third-party open source and commercial software tools that are used within the GIS and CAD communities. Using these software tools the data was converted into standard 2D and 3D file formats that could be parsed using XNA into the LEX 3D framework. The converted data included ordnance survey data, shapefile overlays, satellite and aerial photography images, 3D models of the houses and the surrounding environment and the corresponding texture images for the 3D models. The second problem that was encountered was calibrating the spatial accuracy of the GIS data. The solution to this problem was accomplished by comparing the spatial properties of the original GIS data, using a specific GIS software tool, to the spatial coordinates of the parsed GIS data in the visualised scene. All of the comparisons were performed visually, thus there is a slight amount of spatial inaccuracy present in the parsed GIS data. However, as pointed out by (Mech and Petschek 2010), this is a normal consequence of trying to visualise (and essentially scale down the complexity) of specific and non-standard GIS and CAD data. Figure 2 illustrates the process model that was followed in order to successfully implement LEX 3D.

## CASE STUDIES

This section highlights two case studies where LEX 3D was used in order to visualise parts of the planning process (stages 1 and 3 of the diagram in Figure 1). LEX 3D was initially developed to meet the needs of the requirements specification that was proposed by the Fife Council Enterprise Planning and Protective Services in mid-2012, and refined during the development cycle of the project through subsequent meetings. The initial project phase lasted around six months, with the first version of LEX 3D being completed in November 2012. The second case study that is outlined describes the use of a more recent version of LEX 3D for visualising smaller scale housing developments - with a focus on visualising solar-gain sustainability indicator models. This version of LEX 3D is currently being developed for use by Lundin Homes, who are acting as the main clients. This provides an interesting perspective on the capabilities of using decision support tools in terms of how they fit in during two different stages of the typical planning cycle.

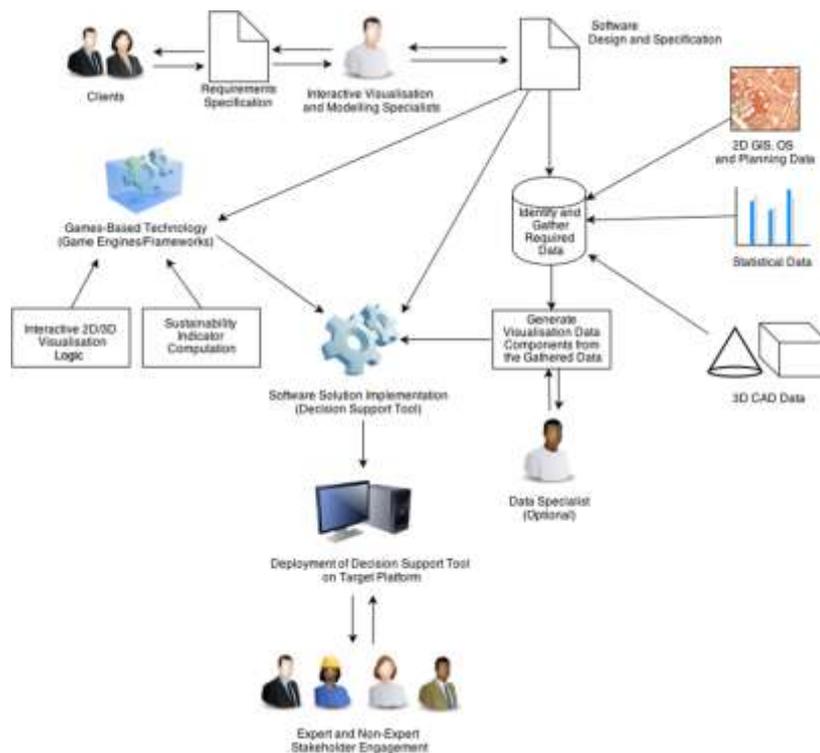


Figure 2: The development cycle model used to create LEX 3D.

### Medium Sized Housing Development

The current version of LEX 3D is capable of visualising different aspects of housing design at pre and post master planning levels. The initial version of LEX 3D was used to visualise the entire region of Fife on a very large scale, and was mostly used to demonstrate the tools interactive visualisation capabilities. After this initial demonstration, a decision was made to refocus the tool and to place emphasis on a proposed suburban development called Dunlin Drive (a suburban residential area in Dunfermline, Scotland). The development at Dunlin Drive is marketed as an affordable housing estate for first time home buyers. The area of Dunlin Drive comprises of several types of eco-homes and the tool allows the construction firm a development view of energy efficiency assessment in terms of U value visualisation. It also guides the estate layout in terms of where to place street lights for a well-lit development that is acceptable to potential residents. LEX 3D can also be used to contextualise the development in terms of access to existing services by merging the 3D view with exiting larger scale GIS data. This could be applied at the master planning stage and post master planning stages for communicating a sense of place. The public housing contractor Kingdom Housing was responsible for the development of the houses on the site, and they provided the team at the Abertay University SAVE group with architectural drawings and relevant ordnance survey data. The development team at Abertay University was composed of one full-time software development staff member working on LEX 3D (the first author of this paper), one part time computer arts specialist (who was responsible for creating the 3D models of the houses and the surrounding environment), and four full-time supervisors who provided feedback and guidance during the development cycle of the project. The

initial release version of LEX 3D took about 400 hours of work to complete between the full-time software developer and the part-time computer artist.

### **Spatial location and type of buildings**

In LEX 3D the users are able to select given 3D objects in the visualised scenario, via the use of a mouse and keyboard, and dynamically alter their spatial values in real-time. Users can change the size, translation and rotation of given 3D objects in the scene that are of importance (such as houses, trees and lamp posts). Another key feature of LEX 3D is the visualisation of the communal play park and green space areas in Dunlin Drive. Research carried out by (Byrne and Sipe 2010) stresses the importance of integrating green-space areas within communities. Planning the location of the proposed communal green-space development requires the input from those who are members of the community. Thus being able to visualise green-spaces and to edit their spatial properties plays a very important role in communicating across points of mutual understanding between the developers and the community. Users can additionally move around the scene with six degrees of freedom (referred to as “flying” around the scene) and walk around the virtual representation of Dunlin Drive (where they can navigate the development from a first person street level point of view). The ability to fly around the scene and to be able to “look into” the proposed development - from a nearby hill for example - was a feature that was specifically requested by the clients. The clients were interested in being able to look into the proposed development and to see how the much of an elevation offset each house had in relation to each other, based on their location at different elevation levels on the development site (essentially simulated line of sight land surveying). The line of sight viewing feature was implemented in LEX 3D by allowing the users to move around the scene and to toggle the “offset value based” vertical positions of the house models in the development site - based on extracted land contour ordnance survey data that was provided by the clients. Additionally a ray vector could be projected from the users view or a specified location, to another location in the scene, allowing the users to observe all of the intersections in-between the two points.

### **Energy Efficiency Visualisation for Different House Types**

The house type specific energy usage visualisation module is able to visualise the U-values and overall heat-loss values of the key construction materials for different parts of the house models in LEX 3D (such as the roof, walls, doors and windows), as well as the overall Standard Assessment Procedure (SAP 2009 v9.90) energy rating for the specific house types. The combination of these energy visualisation methodologies can be used to visualise and assess the impact of various housing energy models (Asseln-Miller and Douglas 2010). The U-value, heat-loss and the standard procedure assessment values were based on empirical test data for various sustainable house construction material specifications (e.g. Passivhaus). The general heat-loss equation used is defined as (Weisstein 2012):

$$Q = U \cdot A \cdot \Delta T$$

In the implemented model, the inside and outside temperature difference  $\Delta T$  is kept at a constant value (but for non-demonstration purposes, this value can be changed dynamically), and the total surface area  $A$  is calculated for each relative polygon group of the 3D house model. The heat loss model material U-values were based on the material U-values and energy ratings data provided by the client. These values

were mapped onto the given object surface using a suitable visual indicator in the form of a gradient map with corresponding values (see Figure 4 for examples).

### **Simulation of Night-Time Street Lighting**

The visualisation of the night time lighting conditions was another feature that was added in order to allow the members of the community (and potential house buyers) to observe and navigate the proposed housing development during different times of the day. This is important as a sense of security, and awareness of ones surrounding during the night time is affected by the lighting conditions (Welsh and Farrington 2008). A common lighting model that is used in real-time rendering to model focused light volumes (such as those generated by street lights), is the spotlight model. In most 3D graphics applications, a spotlight is an entity used to describe a conic light volume. A spotlight is defined as a cone with a variable base and cut off radius, where the intensity of a spotlight is controlled by an exponential control variable (Moller *et al.* 2008).

### **Land Use Shapefile Indicator Overlay Visualisation**

The final feature that was implemented was the rendering of 2D shapefile data overlays. The 2D shapefile and ordnance survey indicator overlays allow expert stakeholders to get a better sense of how well the development is connected to existing services and to highlight possible problematic areas in terms of congestion (and lack of), as well as to communicate with non-expert stakeholders how the proposed development area impacts the current layout of effected and surrounding land areas (Meeda *et al.* 2007; Chan and Bishop 2007).

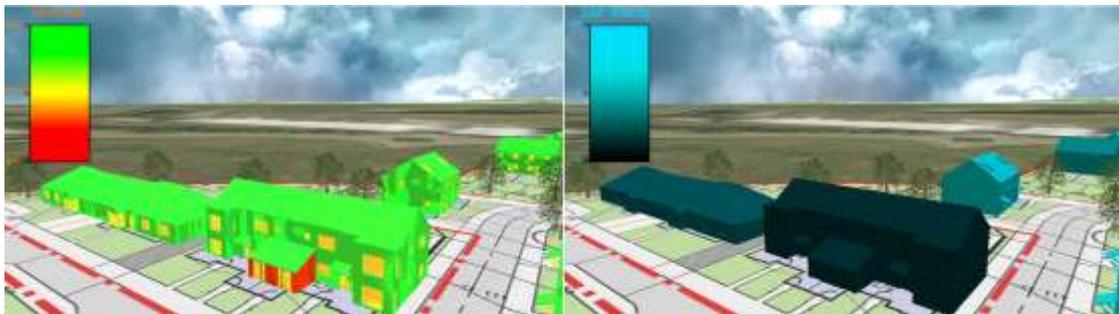
### **Small Low-Carbon Solar Gain Oriented Housing Development**

A new visualization module of LEX 3D is currently being developed for use by Lundin Homes, as part of their low carbon footprint sustainable housing planning process. This version of LEX 3D is being used to maximise and visualise solar energy gain as opposed to energy loss; this tool would be used at the master planning stage. Passive solar gain plays an important role in the development of new sustainable housing, as it can reduce the overall energy usage for a given home (Asseln-Miller and Douglas 2010). Apart from the materials that are used to build sustainable homes that affect U values as described above, two other important factors that affect the overall solar gain are the position and the shape of the houses (Walker 2009; Caldas 2007). Being able to find the optimal shape (via the use of a genetic algorithm) and spatial location to build a sustainable home provides an opportunity to use interactive visualisation tools. This is an emerging area of research as it is only now that games technology tools have become powerful enough to simulate accurately the sun rays and surface exposure as a consequence of landscape topography, neighbouring buildings objects and meteorological data. The interactive visualisation module of LEX 3D has been extended to make use of real-time ray-tracing methods (Moller *et al.* 2008) - in order to accurately model the amount of light absorbed by the houses based on the position of the sun during a specific time of day, as well as to accurately model the resulting shadow volumes.

## **CONCLUSIONS**

This paper has presented the benefits of using interactive 3D decision support tools for expert and non-expert stakeholder engagement. Strong evidence was provided that shows favourable support for using interactive decision supports tools in order to aid

sustainability assessment and town planning applications through expert and non-expert stakeholder engagement. An overview of two case studies shows where the LEX 3D decision support tool has been and is being applied to aid the pre and post master planning stages of the land use planning and development process. The use of game technologies applied to environmental science and planning is a growing field and with the standardisation and mandatory use of the Building Information Model (BIM) specification by 2014, interactive decision support tools may play an even greater role in the planning process. Currently, the next stages of this project aim to address the issues of integrating games-based interactive visualisation methodologies with a more traditional CAD-based approach. This potentially includes the development of an interactive 3D BIM tool aimed at smaller and medium sized civil engineering and architecture firms – who may not always find benefit in making use of all of the stages of the BIM process offered by professional tools such as Autodesk Revit and Bentley Systems Generative Components, especially for less complex projects.



*Figure 4: U-value, heat mapping and Standard Assessment Procedure rating visualisation.*

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# SUSTAINABLE INTERMODAL TRANSPORTATION OF PREFABRICATED CONSTRUCTION MATERIALS

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Non-sustainable transportation is a great part of the stress that human activities put on the environment. Transportation of construction material are today performed all but exclusively by road, a mode that is cheap and fast, but at the same time heavy on emissions. In light of this, the effects of a modal change from road to combined road/rail transportation are studied from the viewpoint of a case company producing prefabricated concrete units. The study includes economic and environmental as well as operational effects. A case study is performed at the producing company by looking at actual invoices and delivery orders for the present mode of transportations. To assess the present operations, an intermodal alternative was created and studied. The comparison clearly shows that the environmental impact of the intermodal transportation is only a fraction of that of the road transportation. However, intermodal transportation is less cost efficient, flexible and reliable. The results imply the construction industry as a whole could lessen its environmental impact by employing intermodal transportation, however, without changes in regulations and policies to negate the economic disadvantage, intermodal transportation in its current state will not be a viable option for the studied company.

Keywords: environment, greenhouse gas, intermodal transportation, prefabrication, sustainability.

## INTRODUCTION

In recent decades, producing companies are striving to reduce overall costs by increasing the number of transports while reducing inventories (Groothedde et al. 2005). This makes cheap, fast and reliable transportation attractive. Road transportation currently fulfils these aspects, especially on short distances (Macharis et al. 2010). Road transportation, however, is arguably not a sustainable mode of transportation as it creates pollution, noise, accidents, congestion and wear on public road infrastructure. Pollution and emissions of greenhouse gases (GHG) are of much concern today, and, eventually, oil reserves used for fossil fuel production will become depleted.

The construction industry is responsible for large amounts of emissions due to the extraction, manufacturing and transportation of building materials, as reported by e.g. Nässen et al (2007) and Yan et al (2010); the latter claiming that 8,4 % of GHG emissions in a construction project stems from transportation (performed by road), making it the second largest contributor to emissions. From a Life-Cycle Analysis

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(LCA) perspective, Nässen et al (2007) concludes that the production phase of a building's life span is heavy on fossil fuels - partly from transportation - compared to the use phase. Since Sweden has little energy production based on fossil fuels, the share of the production phase's energy use is larger than in other countries.

Studies of the environmental impact of the construction industry often focus on material choice and the choice of employing pre-cast or conventional construction and not at all on the choice of transport mode. Yan et al (2010) mentions transport mode, however, and recommend deep-sea transportation instead of road for transporting construction materials to lessen the environmental impact of the project.

To reduce the environmental impact of the material transportation within the construction industry is an important step to reduce the overall impact of the sector. An alternative to transportation utilizing road exclusively is intermodal transportation, where two or more modes of transportation are combined. In this study road and rail are combined; the goods transported by road from the sender (an operation called drayage) to a terminal where they are unloaded from the truck and loaded onto a train (an operation called transshipment). The goods are then sent the major part of the door-to-door distance by rail and following this, the same operations are repeated in reverse order until the goods reach the destination by road (cf. Janic 2008, Dekker et al. 2009).

To address the growing need in all industries (the construction industry no exception) to reduce their environmental impact, a shift from road to intermodal transportation for a case company producing pre-cast units is considered in this study. The company is located close to Katrineholm's Logistics Centre, an intermodal terminal that makes the studied modal change a possibility. If mode of transportation is changed, costs and operational aspects - in addition to environmental impact - are important to consider. It is important that e.g. service levels and costs are not affected negatively. The purpose of this study is thus to analyse the environmental, economic and strategic consequences of a potential modal change for the company producing prefabricated concrete units, formulated into the following research question:

- What effects would changing transportation mode from road to intermodal have on 1) the environment, 2) the costs connected to the transportation and 3) the logistics operations and strategy of the factory?

The paper is structured as follows: first, a brief introduction to the field of intermodal transportation and the connections made to the construction industry is presented, together with known limitations. Following this, the method, the reference scenario and its intermodal counterpart are described. The last two chapters contain a comparing analysis of the two scenarios and a concluding discussion.

## **INTERMODAL TRANSPORTATION AND THE CONSTRUCTION INDUSTRY**

Pollution and other environmental issues that arise from transportation, such as noise, congestion and accidents, are they very urgent problems today, especially in the light of global warming (Forkenbrock 2001). Greenhouse gases (GHG) are a group of gases including carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), carbon tetrafluoride (CF<sub>4</sub>), sulphur hexafluoride (SF<sub>6</sub>) and hexafluoroethane (C<sub>2</sub>F<sub>6</sub>). Carbon dioxide (CO<sub>2</sub>) is the GHG with largest climate impact, together with methane and nitrous oxide. Intermodal transportation often has less environmentally impact than

their road counterpart, mainly due to the reduced use of trucks; however, they can be more or less GHG efficient in themselves. The source of electricity used to propel locomotives has great impact on the level of environmental impact for transportation that involve rail (International Energy Agency 2012). In Sweden, 41 % of the electrical energy is generated by hydroelectric power plants, while 36 % originates from nuclear power plants, 10 % from thermal power and 4 % from wind power. Just below 8 % of the energy is imported from (possibly) less environmentally friendly sources (Swedish Energy Agency and Statistics Sweden 2012). Specifically, that means that 77 % of Sweden's produced energy generates no or close to no CO<sub>2</sub> per kWh (International Energy Agency 2012; Lenzen 2008). However, since Sweden as part of Europe is part of a greater electrical network, there are difficulties to determine the actual source of the electricity. When Sweden's own production is maxed out, electricity has to be imported. Therefore, any extra electricity used, the marginal electricity, can be assumed to come from the least environmentally friendly source Europe can mobilise. To take this into account, several different sources of the electric energy has been considered, and specifically how much CO<sub>2</sub> per kWh is emitted from each source. As can be seen in Table 1, hydroelectric and nuclear power is at the bottom of the list, while coal is, by far, the least environmentally friendly source.

*Table 1: Emission factors for different electricity producing technologies. Truck diesel added for comparison (International Energy Agency 2012 except diesel: EcoTransit 2011).*

Energy source	Coal (OECD max, 2010)	Coal (Sweden, 2010)	Oil (Sweden, 2010)	Gas (Sweden, 2010)	Average (Sweden, 2010)	Hydro-electricity & nuclear	Diesel
CO <sub>2</sub> /kWh (grams)	1230	796	385	209	30	0	230

Combustion of diesel is among the more environmentally friendly alternatives when it comes to GHG intensity. How then, can intermodal transportation be considered better for the environment than diesel propelled road transportation? The answer lies in the energy efficiency, as will be evident below.

Road transportation is often favoured over intermodal rail freight for several reasons. Delivery time is an important aspect of many transports and road haulage is usually faster on short distances since intermodal transportation involves possible waiting time and transshipment at the terminal in addition to the actual movement of the goods (Janic 2008). Connected to this is the delivery time reliability. Since passenger trains are commonly given priority over freight trains on shared infrastructure, a delay anywhere on the connection can cause a significant delay to the intermodal transportation (Törnquist and Persson 2007). Because of time tables, the flexibility of the transportation is reduced since a train cannot be made to wait for a delayed drayage or interruption in production. A certain resistance against intermodal transportation can also be detected among shippers (Patterson et al. 2008). Should a road alternative and an intermodal alternative be all but equal in every aspect, some shippers tend to favour the road alternative, mostly because of prejudices and lack of knowledge regarding intermodal transportation. The cost is a very important aspect of different modes of transportation's competitiveness. Currently, road transportation is a very cost effective mode of transportation and intermodal alternatives are having a hard time being competitive (Janic 2008). In addition, if road transportation costs rise,

so does the cost for intermodal transportation since trucks are involved in the drayage part of intermodal transportation. The length of the drayage operations also have a large impact on the distance where intermodal transportation become preferable to road transportation, called break even distance. The actual break even distance depends on a large number of conditions, aside from drayage length, and can be anywhere between 90 km and 1050 km under certain conditions (Dekker et al. 2009; Janic 2008; Macharis et al. 2010;).

Other consequences of transportation in general are accidents and congestion. The drayage part of intermodal transportation has the same accident rate as the total road freight transportation of the same category (Janic 2008). Congestion, mostly referred to road traffic, can also occur on rail links, where a slow moving freight train or a delayed train can cause congestion on the confined infrastructure.

Construction sites in crowded metropolitan areas often suffer from congestion-like situations on the actual construction area (Jaillon and Poon 2008) and the planning of logistic activities connected to a construction project can be substandard (Said and El-Rayes 2011). Among these activities is the planning of storage areas, material arrival times, presence of heavy machinery at the right time, cranes capable of lifting the required weight for unloading, etc. These factors may in turn impact schedules for transports bound for the construction site. It is therefore important that building material arrive to the construction site loaded in a way that makes insertion into the construction object easy. The delivery precision can be increased by employing the receiving terminal area as temporary storage for the units, as in the case of 'floating stocks' (Dekker et al. 2009, Pourakbar 2009). Thus material for several days' construction can be stored at the terminal and hauled to the construction site as the demand is realised. This would shorten lead times, increase both delivery reliability and flexibility and reduce on-site storage levels. Cole (1999) reports that construction-related GHG emissions are lower when prefabricated concrete units are used instead of cast-in-place. Instead, transportation of material and workers is the largest portion of the emissions for a construction project. Quale et al (2012) reports similar results and show that on average, conventional construction emitted 40 % more GHG than modular construction, even though material for prefabricated construction units needs to be shipped first to the production facility and then to the construction site. Newer buildings are also, once in use, often energy efficient: for a building with optimal energy efficiency, the material production and construction is responsible for 60 % of the energy use of the building from a life cycle perspective (Quale et al 2012).

Many factors that influence the modal choice for a specific transportation are political in their nature and indeed, the European Committee works to induce a modal shift away from road transportation towards more sustainable transportation modes such as rail, inland and short sea shipping (European Committee 2009). Sustainable involves three aspects: environment, economy and society. In this study, the environmental aspect considered is CO<sub>2</sub> emissions, the economic aspects are transportation- and overhead costs (such as increased inventory, delays or operational changes) depending on the selected transportation mode. The societal aspect is not considered here, but instead the strategic aspects of a modal change for the company. Similarly, political aspects such as fuel taxes, kilometre taxes, fees for using less environmentally friendly engines or subsidisations for using sustainable modes are, though of great interest for intermodal transportation in general, not included in this study. Instead, the current rules and regulations are assumed to be kept in place, making this study a worst case scenario for the competitiveness of intermodal transportation. Likewise CO<sub>2</sub> are the

GHG most commonly referred to regarding environmental impact; thus, CO<sub>2</sub> is the only GHG that is considered specifically in this study, while other kinds of negative effects on the environment (e.g. NO<sub>x</sub>, SO<sub>x</sub>, particles, noise etc.) are not.

## METHOD

The case study is performed at a Swedish construction company that has specialized in prefabricating concrete units, Prefabricated Concrete Units Company (abbreviated PCUC). In an earlier paper, the same company's delivery regions were analysed to find if any were suited for intermodal transportation instead of road transportation (Persson et al. 2011). The city of Gothenburg is located in western Sweden and was deemed not eligible for intermodal transportation in the earlier study. However, the data in the previous study was accumulated over entire regions, meaning that individual projects within a region could possibly be favourable for a modal change none the less. Therefore, a specific project - started in 2009 and ended in 2010 - which PCUC performed deliveries to, suitable in scope and with data readily available, was selected for further study. While a single case might not give fully generalizable conclusions, it can still be used to falsify propositions. Deliveries were performed by road transportation exclusively. Data on the transports, including costs, measurements, weight and number of load carriers were obtained from invoices and delivery notes collected on several visits to PCUC's production plant during the case study.

To calculate CO<sub>2</sub> emissions, an online tool called EcoTransit (EcoTransit 2011) was used. As an online tool available to the public, EcoTransit functions such that the starting and end points of the transportation are entered, along with transportation mode (road, rail or intermodal), type of truck (if applicable), transported weight, and handling (if terminals are involved). It then calculates the energy consumption of hauling the cargo from the start to end points. There is, of course, a margin of error in calculations of this type; however, the larger picture regarding emissions is of interest in this study. Therefore, EcoTransit is believed to be accurate enough. In addition, calculations for both scenarios are performed in the same way, arguably making them comparable. There are a number of similar tools to be found online and EcoTransit was specifically selected because of availability and reliability (cf. Fridell et al 2011). To analyse an alternative intermodal transportation, an intermodal scenario was created, where, again, EcoTransit was used to calculate CO<sub>2</sub> emissions from drayage, transshipment and rail haul. Once the energy consumed by the transportation (in kWh) was calculated, the amount of CO<sub>2</sub> released from the transportation was determined. Costs for drayage and transshipment were collected from companies performing these activities today and recalculated to prices of 2009. The cost of the rail haul depends on numerous factors, including: distance, train length, available space, additional freight on the train, and finally, perhaps most important of all; the specific deal, i.e. competition pricing, between the producing company and the rail operator (Button, 2010). Here, only the distance and train length are known and therefore it is possible to provide an estimate of the size of the rail haul costs - provided that the transportation is to remain economically favourable compared to the reference scenario - as shown in equation (1) and (2) below. Let  $C_{im}$  denote the total cost for the intermodal transport,  $C_d$  the drayage cost,  $C_t$  the transshipment cost,  $C_{rh}$  the rail haul cost and finally  $C_r$  the cost for the reference scenario.

$$C_{im} = C_d + C_t + C_{rh} \quad (1)$$

$$C_{im} \leq C_r \rightarrow C_{rh} \leq C_r - (C_d + C_t) \quad (2)$$

## **REFERENCE SCENARIO**

PCUC produces the concrete units on an assembly line. Once complete, the units are stored temporarily in the factory for a few hours to a few days. The loading order for the units is determined by the contractor and the units are loaded onto load carriers by fork lift. The load carriers, which share measurements with a common 20-foot container, are then loaded onto a truck that hauls them directly to the construction site where they are unloaded directly into their correct placement in the building.

Sometimes several trucks leave for the same destination on the same day. Load carriers are then returned as soon as the trucking company has an unloaded vehicle bound for a destination close to PCUC's production plant. The transported distance from PCUC's production plant to the construction site is 330 kilometres. The number of transports per day range from zero to four, according to the needs of the contractor. The 146 deliveries that were made to the specific site were performed on 87 unique dates. Out of these, 38 had a single transport leave PCUC's production plant bound for Gothenburg, 42 had two transports, 4 had three and 3 dates had four transports. Of the 38 dates that only had a single transport, eight also had a single transport the following day. These numbers suggest that grouping of certain transports on a train should not be a problem for either PCUC or the contractor.

The trucks can carry up to 40 tonnes, depending on the shaping of the specific units. The stipulated weight per transport is 33 tonnes, i.e., the transport company charges for 33 tonnes even if the actual weight is less, and for the actual weight, should it exceed 33 tonnes. Hence it is profitable to load the transports as efficient as possible. Even so, 68 % of the transports are loaded with less than 33 tonnes. 16 % of the transports are loaded with less than 20 tonnes. Many of these transports occur on the same day as other transports, indicating that these less-than-20-tonnes transports are used to fill up the demand that did not fit onto the other transports of the day. A fuel charge is added to the transport cost, and should additional waiting time be incurred in the loading or unloading processes, a fee of roughly twice the ton cost is charged per hour waited.

## **INTERMODAL SCENARIO**

The intermodal scenario was created with the goal to have no negative difference for the construction site in terms of service levels. The prefabricated units are assumed to be transported on a standard intermodal wagon, called Sgs, with a wagon weight of 22.5 tonnes, maximum payload of 57.5 tonnes and loading area length of 19.5 meters (Green Cargo 2013). When disposing a freight train, instead of several unique road deliveries performed on the same date, all of a specific day's (or perhaps several days') deliveries would be grouped and hauled on the same day. However, the ability to do so is depending on a number of factors, among which are: (1) production capacity at the producing facility, (2) in the case of several day's deliveries grouped on a single transport, some sort of (temporary) holding area at the receiving terminal and (3) the construction site must not be negatively affected by the change. In the intermodal scenario, all deliveries performed on the same day in the reference scenario are assumed to be grouped onto the same train, which presents no problem for points (1) and (3) and makes (2) void. Train capacity is assumed to always be available. The cargo for each transport was, in a spread sheet, "loaded" onto railcars so that neither length- nor weight limits were exceeded. A fully loaded Sgs railcar has clearance for the entire rail haul distance - 321 km - between the two cities in the

study. A medium length train of 1 000 tonnes (EcoTransit, 2011), with a load factor of 70 %, was used.

The same type of truck as employed in the reference scenario was selected for the drayage operations. Persson et al (2011) considers additional types of truck; however, the other types require additional investments from one or more parts in the transportation chain and are therefore not considered in this study. The distance from PCUC's production site to the terminal is 4.5 km, and from the receiving terminal in Gothenburg the distance to the construction project is 1 km. Despite the short distances, a contact on a Swedish shipping company estimated three hours per drayage operation. Drayage costs are, according to the logistic centre, charged by the hour, where the minimum charge is two hours. To accommodate for uncertainties in the drayage time, two alternatives are considered, where drayage can be completed in 4h for each transport (2h at each end), or 6h (3h at each end). Drayage costs are also subject to e.g. the deal between the customer and the shipper. The number of drayage operations is assumed to be the same as the required number of transports in the reference scenario. Transshipment is performed by a reach stacker at the terminal and charged per movement; the cost depending on e.g. the weight of the goods and, again, the specific deal closed with the terminal. A reach stacker often has a capacity above 40 tonnes and can lift entire containers and trailers, which implies that the weight of the load carrier is not limiting.

## RESULTS AND ANALYSIS

Using EcoTransit, the total amount of kWh consumed was calculated. The reference scenario consumes 352 000 kWh, compared to 42 000 kWh for the intermodal scenario. The intermodal scenario is thus more efficient since it requires only 12 % of the amount of kWh needed to transport the units by road. Combining these numbers with Table 1 shows that the reference scenario, employing diesel powered Euro V-trucks, emits a total of 81 100 kg CO<sub>2</sub>, assuming 0.23kg CO<sub>2</sub> per kWh (EcoTransit 2011). Depending on the electrical technology utilized, the intermodal scenario emits different amounts of CO<sub>2</sub>, as summarized in Table 2. It is obvious that even with the least environmentally friendly source of electricity employed within the OECD the intermodal alternative emits less than half of what the reference scenario does.

*Table 2: CO<sub>2</sub> emitted (in kilograms) per energy source. The road row includes transshipment.*

Energy source	Intermodal scenarios					
	Reference scenario	Coal, OECD max	Coal, Sweden	Oil, Sweden	Gas, Sweden	Hydro / nuclear
Rail (electricity)	-	36 900	23 900	11 600	6 300	0
Road (diesel)	81 000	2 700	2 700	2 700	2 700	2 700
Total	81 000	39 700	26 600	14 300	9000	2 700
Difference	0 %	-51 %	-67 %	-82 %	-89 %	-97 %

The total cost of the reference scenario is set to 100 monetary units, which includes the actual transportation of the units, wait time costs and fuel addition. The costs for the intermodal scenario are divided into three distinct parts: drayage (by road), transshipment (by reach stacker) and the actual rail haul. The drayage and transshipment costs can be considered to be static. The total transshipment cost for the project is

either 10.4 or 20.2 % of the cost of the reference scenario, thus creating a best and a worst case scenario. Together with the two alternatives for drayage times, four alternatives are created and the drayage and transhipments costs (expressed as a percentage of reference scenario costs), as well as the implications for the cost of the rail haul, are summarized in Table 3.

*Table 3: Costs, given as a percentage of the reference scenario, for the different transhipment and drayage cases.*

Case	Transhipment cost	Drayage cost	Total	Rail haul max cost
Best / 4h drayage:	10.4	63.3	73.7	26.3
Best / 6h drayage:	10.4	94.9	105.3	-5.3
Worst / 4h drayage:	20.2	63.3	83.5	16.5
Worst / 6h drayage:	20.2	94.9	115.1	-15.1

## DISCUSSION

Using equation (2), the results shown in Table 3 implicates that the cost of the rail haul should not exceed, in the best case scenario with 4h drayage, 26.3 % of the reference scenario. This translates to 82 SEK per tonne, roughly equal to 10 €. In the worst case scenario with 4h drayage, the corresponding number is 52 SEK or a mere 6 € per tonne. To put these prices in perspective, the cost for an optimally loaded truck (33t) in the reference scenario is 250 SEK or 30 € per tonne. With 6h drayage the intermodal scenario is more expensive even before the cost of the actual rail haul is considered. The cost of the rail part of the intermodal transportation is hard to estimate since rail transportation is underutilised in Sweden, and prices stated from transportation service providers in the rail sector might not be accurate due to competition pricing.

An overall environmentally friendly image - where transportation is an integral part - might well win an order from a construction project that focuses on reducing their environmental footprint. Such a project is likely to choose pre-cast concrete (Quale et al 2012). For PCUC, having streamlined the production process regarding emissions and waste, the next thing to turn to would be the transportation. Using intermodal transportation, PCUC can, in this case, considerably lower their transportations' CO2 emissions. The amount of kWh consumed by the drayage part of the transportation is roughly 18 % of the kWh consumed by the entire transport. As the drayage distance increases, this percentage increases. For a train powered by coal-generated electricity, the environmental break even drayage distance is 160 km, or 30 times the drayage distance of this specific project, indicating that the short drayage distances in this study is not the sole contributing factor to the low environmental impact.

Besides economic and environmental effects, there are other effects of a modal change; the flexibility of both the transportation and production facility will decrease, since rail transportation is inherently less flexible than road transportation. The risk of delayed transports increases by using rail transportation since it is more vulnerable to infrastructure disturbances. A small delay in production may also cause a delivery to arrive hours if not an entire day late, something that can put the whole construction site at a standstill. To lessen this risk, PCUC can still employ road transportation to act as a backup system. This could also be put to use to cope with near-time changes in the requested deliveries, but would undoubtedly increase costs for PCUC. Risks connected to the transportation mode of choice and how to counteract them must be

studied in depth by the company in the light of a modal change. One way of lessening the negative impacts regarding flexibility and delivery time - as well as the risk of delays - would be to employ the floating stock practice as Dekker et al (2009) and Pourakbar (2009) describes; that is, the prefabricated units could be shipped from the factory a few days in advance and stored at the receiving terminal to be called from there by the construction site. Both flexibility and lead time would increase compared to the present practice. This would, however, increase costs since storage area must be rented, as well as require the receiving terminal to have the necessary storage capacity and the long-time planning from the construction project to be even more accurate.

A company considering a modal change must also consider whether the selected mode of transportation is suitable for the business and the products. The choice of transportation mode needs to support the way in which the products compete on the market. Products that compete with short lead times need a supply chain that provides short lead times, while products that compete with low costs (low prices) needs a supply chain that is very cost efficient. The intermodal transportation in this particular case is less flexible, more expensive, and takes longer time than the road alternative. The only positive effect is the lesser environmental impact due to lower emissions of CO<sub>2</sub>. Should PCUC employ intermodal transportation they would probably not still be able to compete on the market, since as of today, no construction company sell their products exclusively due to low environmental impact.

## CONCLUSIONS

The construction industry would benefit, from an environmental point of view, by employing intermodal transportation instead of conventional road transportation. The effects of a modal change on 1) the environment, 2) the costs connected to the transportation and 3) the logistics operations and strategy of the factory, were examined with the following results. 1) Depending on the energy source used to propel trains, GHG emissions from transportation of pre-cast concrete units can be lowered with at least 51 % and possibly as much as 97 %. 2) Intermodal transportation are however more expensive than road transportation and would reduce flexibility, reliability and delivery speed, which in turn may increase costs further. 3) New threats are introduced, such as risks of delays, changes in production schedules and that intermodal transportation do not necessarily support the market strategy of the company. It is obvious that a modal change would not be beneficial for PCUC, despite the environmental advantages. From this case it can be concluded that intermodal transportation in similar settings has a hard time being economically competitive compared to road transportation over comparatively short distances. More generally, it is also clear that intermodal transportation do not favour deliveries that are time or delay sensitive; however, the environmental benefits for the construction industry are undeniable. To become competitive, operations that make up intermodal transportation need to be optimized in terms of precision, time and costs, the latter possibly remedied by regulations and policies. These are areas for future work, in addition a survey about the attitude towards intermodal transportation among companies in the proximity of the logistics centre.

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